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AUTHOR Lee, Valerie E.
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ABSTRACT

About a quarter of all students who either intend to or actually attend college indicate their intention to pursue a major in science. From this group, there is a slow attrition from the science pipeline as students move along in their educational lives. The aim of the analyses for this project is to characterize the science-oriented behavior of students as they move through high school into college. The study concentrates on three educational time points: sophomore year of high school; senior year of high school; and two years after high school graduation. In particular, this report focuses on specific questions on each of the following six issues: (1) persistence in science; (2) predictors of choice of science major; (3) migrants into science; (4) stifled in science; (5) quantitative vs. non-quantitative science fields; and (6) SAT scores and science. An appendix is included entitled "Definition of High School and Background Variables Used in Regression Analysis." Figures include path diagrams for predicting science major choices in high school and college, and quantitative or non-quantitative field for college science majors. (CW)

IDENTIFYING POTENTIAL SCIENTISTS AND ENGINEERS: AN ANALYSIS OF THE HIGH SCHOOL-COLLEGE TRANSITION

by

Valerie E. Lee
University of Michigan

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September 1987

Identifying Potential Scientists and Engineers: An Analysis of the High School-College Transition

Report 2: Multivariate Analysis of the High School Class of 1982

Valerie E. Lee
University of Michigan

A Report to the Office of Technology Assessment
Assessment of Educational and Employment of Scientists and Engineers

Revised September 4, 1987

Background

Focus of Project. As stated in the first report, the aim of the analyses for this project is to characterize the science-oriented behaviors of students as they move through high school into college. The study concentrates on three educational time points: (1) sophomore year of high school; (2) senior year of high school; and (3) two years after high school graduation. The sample of students considered here is a random sample of high school graduates from the Class of 1982, which means that we may generalize results to all high school graduates of that year. In the first report, which was primarily descriptive, the movement of students into and out of science was examined. \In that report, "science" was broken down into four separate fields: health and life sciences, engineering, computer and information sciences, and physical sciences/ mathematics.

Summary of Findings from Report 1. The major finding of the first report relates to the slow attrition of students from the science pipeline as they move along in their educational lives. Even with this attrition, about a quarter of all students who either intend to or actually attend college indicate their intention to pursue a major in science. Of the four fields considered, by far the most popular are the health and life sciences, followed by engineering and computer science. Least popular are the physical sciences. The relative popularity of each of these scientific fields is strongly related to gender. Although there is close to gender parity in the life sciences, women are seriously underrepresented in engineering and the physical sciences, and somewhat less likely than men to major in computer science. Clearly, the more quantitative a science field is, the less likely it is to attract women. Although there has been progress in this area within the last decade, the serious gender balance which favors males continues. While minorities are also underrepresented in the sciences, particularly in the more quantitative fields, this is in part due to the fact that minority students are underrepresented in higher education. That is, minority students seem to be doubly disadvantaged in terms of representatation in the sciences.

Although previous research on this topic has focused on the attrition from the sciences, a quite striking finding is the movement into, as well as out of, the sciences during the transition points examined here. Although the net change is negative, large numbers of students move into science from non-science fields as well as moving out. In fact, movement in and out is more typical than persistence. However, the academic achievement levels of students moving into science is slightly below that of students who persist (but also higher than those who leave), and the new entrants are more likely to come from the non-academic (i.e. general or vocational) tracks. This could be interpreted as a pattern of "declining quality" for newcomers to science. Students who leave a particular field of science are considerably more likely to move out of science completely than to move to another scientific field.

Focus of Report 2. All of the analyses for the first report were descriptive in nature, which meant that they took into account only one or two variables at a time. Consequently, the analyses made no adjustment for the fact that many of the independent variables which relate to science majoring have previously found to be highly related to one another (for example, social class and race, or academic track and coursetaking). Neither did those analyses incorporate tests of statistical significance for the observed differences between groups. In this series of analyses, such multivariate relationships become the focus. More specifically, the analyses in this report build on several interesting findings from Report 1. In particular, there are six specific questions which comprise the focus of this report.

- Persistence in science. This set of analyses builds on the information supplied in Table IV-D, which investigated the science-oriented behaviors of those students who were in college and who indicated they planned to major in science. Specifically, how many of these students had been in science in previous years? If so, did they persist in the same fields the started in, or did they change from one science field to another? How different are the two groups of "persisters" (field persisters and science persisters) from a third group, those students who came into science from non-science fields at either transition point (science migrants)? Since the sample sizes for these groups of students are relatively small, it is unfortunately impossible to examine these patterns separately by science fields, as in Table IV-D. Instead, a causal model containing background, school, and behavioral characteristics which best differentiate the groups is constructed, after investigating the statistically significant mean differences between the groups on a large number of independent variables.

- Predictors of choice of science major. Among students who plan or attend college and who have selected a major, what characterizes and differentiates those who choose science from those who choose non-science fields? Since we know that many in-school behaviors and outcomes are related to student background characteristics, here we evaluate the strength of these relationships net of the effect of student and family background. The analyses investigate choice of science major for two slightly different (but overlapping) samples at two time points. First, student behavior at senior year of high school is examined for those students who have not eliminated the possibility of attending college. These analyses include statistical controls for background, ability, characteristics of the high schools the students attend, their curriculum track, and their behaviors and outcomes (coursetaking, test scores, aspirations, and high school grades). In such an analysis, we address such questions as, "What is the effect of enrollment in the academic track on the probability of choosing a science major, once ability and course enrollment are held constant?", or "Are black students less likely than whites to choose science, once we adjust for their social class and type of high school attended?"

  Using essentially the same model, the analysis is extended to the college time point, for those students who attended college and selected a major. In addition to the same statistical controls mentioned above, the college-level analyses include adjustments for science choice in high school (i.e. the dependent measure in the first analysis), type of college attended, and behaviors (grades, grade-level status) in college. As before, the analyses focus on the probability of choosing a major in the sciences. Thus, a typical question which may be explored in this analysis is, "How strongly does previous coursework in science affect college choice of science, once ability, test scores, and grades are taken into account?"

- Migrants into science. We found in Report #1 that there is considerable movement into and out of science in the high school and early college years. These analyses investigate the characteristics of students, their high schools, and their academically-related behaviors which differentiate students who migrate into science from a non-science field between their sophomore and senior years of high school, compared to their counterparts who remain committed to non-science fields. In particular, we seek to identify particular math and science courses (and their performance in math and science) which increase the likelihood for such movement into the sciences. We seek answers to such questions as, "Is student experience in biology, chemistry, or trigonometry more likely to encourage a change of opinion in favor of science?"

- Stifled in science? This set of analyses investigates a small but important group of high school students. This group of students (a) expressed interest in pursuing a major or career in the sciences at their sophomore year of high school; and (b) scored above average on a test of general achievement, indicating that they had the ability to realize their goal. However, these students also (c) were enrolled in one of the non-academic curriculum tracks (either the general or vocational programs) at sophomore year, which could limit their access to the coursework and possibly the motivational framework which would allow them to actually achieve their goals. In the first set of analyses, this group of students is compared to two groups: (i) their high-achieving science-oriented counterparts in the academic track; and (ii) their high-achieving non-academic track counterparts who were not interested in science. Those comparisons allow us to see if these students differ more, in their subsequent high school and college behaviors and outcomes, because of their track placement or because of their science interests. If their subsequent behaviors appear to result from track placement, it would hint that an inappropriate track placement may have stifled these otherwise qualified future scientists. In a subsequent analysis which compares these students to their high-achieving, science-oriented counterparts in the academic track, we may evaluate the net effect of track placement on coursetaking in math and science for these otherwise rather homogeneous groups.

- Quantitative vs. non-quantitative science fields. One finding in the first report concerned several differences in the types of students.

within those who indicated an orientation to the sciences, who choose the four science fields. Specifically, based on information from Report #1, we contrast those students in the life and health sciences (which we call "non-quantitative" science fields) with those in engineering, computer science, physical science, or mathematics ("quantitative" fields). The major differences between these two groups focused on gender (with females much more likely to be in the former group) and ability (with more able students more likely to be in the latter group). The analyses in this section investigate these differences further within the group of college science majors, attempting to draw a causal structure of who chooses the quantitative or non-quantitative fields, and why.

- SAT scores and science. It is taken as an article of faith in the educational community that student performance on the Scholastic Aptitude Test, particularly the math section of that test (the SAT-M), is a strong predictor of performance in college. Certainly, performance on that test controls access to selective colleges. In this analysis, we use a sample of students who have taken either the SAT-M or the ACT-M (combining the scores in order to increase the size of the sample). Since a group of about 400 students in the sample took both tests, it is possible to equate the two tests in order to compute an "SATM-comparable" score for those students who took only the ACT-M. This makes the assumption that both tests measure essentially the same thing. The fact that the two tests are highly correlated (.83) for students who took both tests supports that assumption. In this investigation, as a validation/sub-question, we examine the structural relationships between student background and performance separately for science and non-science students who have taken either of these tests. Essentially, we are comparing the structural parameters for the two groups of students. We examine such questions as, "Are gender effects on SAT-M equally strong for students in science and non-science fields, once their ability, background, and high school experiences are taken into account?"; or "Do race effects on the SAT-M disappear, once model variables are considered, and are they equivalent for science and non-science students?"

Data. The source of data for these investigations is exactly the same as that for Report 1 -- the 10,739 students in the High School and Beyond (HS&B)

study who neither transferred high schools nor dropped out of high school prior to graduation. Since many of the analyses in this report focus on subsamples of this random sample of high school graduates, sample sizes are included for each analysis. Statistical tests are based on subgroup sample sizes, of course. There are three sources of data in the HS&B study: (1) self-report data, which includes all items on background, aspirations, and behaviors; (2) test-score data, from tests administered by HS&B at both sophomore and senior year; and (3) data from students' high school transcripts. Course enrollment and grade-point average data come from student transcripts, as do SAT and ACT scores. It may be assumed that data from either transcripts or test scores is considerably more reliable than data from self-reports. Therefore, whenever self-report data could be avoided (e.g. course enrollment or grades), transcript data are used. Test scores are used for ability and achievement in high school. A caveat must be added. That is, it is certainly true that the relationships reported in these analyses represent lower bounds for the actual structual relationships that exist among these variables, since the correlations upon which parametric relationships are based are attenuated by the less than perfect reliabilities which result from the measurement error introduced by self-reports. However, this limitation applies to any analyses which use survey data. The details of construction of all variables used in these analyses are presented in the Appendix at the end of this report.

Results

I. Persistence in Science

The sample for these analyses is limited to those students who were in college at the second followup of HS&B (February 1984) and who indicated a field of study in the sciences for their major. This sample of 1579 students represents 14.7% of the overall sample, as stated in Report 1. Those college-level science majors have been divided into three groups, based on their past preferences for fields of study at the sophomore and senior years of high school. Three groups representing forms of "survival" in the college pipeline were created:

(1) "Field Persisters:" those students who indicated the same science field at all three time points. This is 299 students, or less than 19% of the sample of science majors.

(ii) "Science Persisters:" those students who indicated at all three time points that they were interested in science, but not necessarily the same field in which they have declared their majors. This is 277 students, or about 18% of the sample of science majors.

(iii) "Science Migrants:" those students who came into science from non-science fields (and stuck with it) at either of the two transition points investigated here. This is the largest group of students (1004), comprising about 64% of the sample.

The mean group differences between these three groups on a wide array of variables are shown in Table V-A. Testing for statistical significance among the three groups on each variable has been accomplished by using analysis of variance (ANOVA) methods. The significance levels for each variable are given at the right of the variable name. Since the grouping variable has three levels, the specific contrasts which contribute to statistical significance are not indicated. However, the means for groups should give an indication of the direction of differences. There are four difference patterns evidenced in these comparisons: (1) a steady progression downward, from field persisters to science persisters to science migrants; (2) a comparion of the two persistence groups (field and science persisters) to the science migrants; (3) field persisters compared to science persisters and migrants; and (4) those variables on which no clear patterns is evidenced. There are several variables in this analysis for which no significant relationships among groups exists, all of which fall in group (4). While only statistically significant differences are discussed here, the entire pattern of differences is presented in the Table.

Insert Table V-A about here

Three sets of variables show a steady deterioration across the groups of field persisters, science persisters, and science migrants. The first set relates to social class. Both student's own social class and the social class levels of the schools they attend follow this pattern, with the highest-SES students the field persisters and the lowest the migrants. Although these group mean differences are statistically significant, their magnitudes are less than .2 standard deviations. Notice that the students in science in all three groups are of considerably higher SES levels than the average of the high schools they attended. This same pattern is reflected by (and certainly related to) the minority concentration of the high schools. Another set of variables following this pattern is the proportion of students in the academic track. Although all three groups have over 70% of their students coming from the academic track in high school, the proportion is highest in the "field persister" group -- 85%. Enrollment in academic courses is related to track membership, and thus the same pattern is seen for the number of academic math and science courses these students have taken in high school.

Perhaps a more expected pattern is the contrast of the persisters in science (either in the same field or within science) compared to the science migrants. This pattern is most noticeable in achievement. Either as sophomores in a test of general ability, as seniors in math achievement, or in the average achievement levels of the high schools they attended, the persister/non-persister pattern is observed, with scores uniformly lower for the migrants than the persisters. We also see this pattern for the proportions of the groups which are black: the persister groups are 7% and 9% black, compared to the migrant group, which is 15% black. The pattern is also in evidence for the type of college attended. Although science students generally are less likely to attend junior (2-year) colleges than their non-science college-going counterparts, persisters are considerably less likely (22% and 24%) to be in junior college than the migrants (36%). A related comparison shows that persisters are also more likely (94% and 92%) than migrants (87%) to attend college full time. Since we know that students in junior college are less likely to be full-time students than their 4-year college counterparts, this is probably related to the 2-year college attendance pattern.

A third comparison shows field persisters contrasted against either science persisters or migrants. Although less logical than the previous pattern, certain variables follow this pattern. The proportion of students in these groups who are Hispanic is 5% for the field persisters, compared to 9% and 10% for the other two groups. Educational aspirations at either 10th or 12th grades, although measured on different scales, both follow this pattern. Another variable where the pattern is evident is in the proportion of students who are sophomores at the end of their second year in college. Although quite high for all science majors, the field persisters are considerably higher than the other two groups (90% vs. 76% and 75%). These comparisons, as well as those in the "steady progression" description, indicate that field persisters as a group are somewhat more selective than the other groups.

The final pattern -- really a non-pattern -- is shared by all the non-significant variables in the analysis. The type of high school or college attended (i.e. public vs. private) shows no pattern, nor do grades (either in high school or college), nor does the proportion of students who work (uniformly close to 50% of the students), although almost all report being full-time students as well. The noteworthy difference in this category is for the proportions of the groups which are female. The "science persister" group shows females considerably underrepresented (30%), whereas the other two groups are much closer to gender parity (46% and 48% female). This is a strong pattern, the logic of which is not apparent.

However, many of these independent variables are likely to be related to one another. It is therefore possible that some of these relationships would disappear if other variables were simultaneously taken into account. The next analysis attempts to determine a causal pattern of variables which best discriminate between these three groups. I say "attempts", because the results of the discriminant function analysis which was run to determine this causal structure show that there are fewer variables that discriminate the groups from one another than would discriminate these three groups from the non-science college-going population. The results of the discriminant analysis are shown in Table V-B.

Insert Table V-B about here

Although the final analysis included 14 independent variables, only three -- gender, a general measure of ability, and the number of high school science courses -- were sufficiently "discriminating" to be used to form the discriminant function. Moreover, in order to "force" more variables into the discriminant function, a rather non-stringent probability entrance criterion was used (.10), rather than the more general .05 probability level. Since there were three levels to the grouping variable, two discriminant functions were formed. The first function accounted for 75% of the variance explained by the discriminant analysis, and is generally interpretable. The second function (independent, or orthogonal, to the first) is considerably less important and is generally uninterpretable, so it will not be discussed. Function 1 loads heavily on gender (female), with a negative loading on both ability and the number of science courses students take. Thus we have a function which particularly contrasts gender and the more expected characteristics of science students. The three groups of science students load on this function rather predictably, given the comparison in Table V-A. That is, the group of science persisters loads highest on the function which is high on ability and low on female characteris- tics, where the science migrants load lowest on the function. This confirms the findings from Table-V, but also shows that once these three variables are taken into account (gender, ability, science courses), other variables are rather unimportant in discriminating among types of persisters among the science majors. Clearly, these groups are more similar than they are different. This also alters the unusual "female" pattern found in group means above.

II. Predictors of Science Major Choice

The analyses in this section of the report are meant to construct a causal model to determine the characteristics of the students who select a science major. That is, we seek to determine the direct and indirect effects of student background, the types of schools students attend, their curriculum track placement, and their behaviors and performance in high school, on the probability of their selecting a probable major in science when they get to college. Following these students into college, we wish to investigate further how these variables affect their college performance and subsequent choice of major, again in science or not. The investigations are separated into two -- determining a causal structure for choice of science in high school, and using that information about high school science interest to investigate science major choice in college. Although these two investigations are highly related, we treat each separately. The samples are overlapping in large degree, but not completely equivalent.

A. High school science choice. The students in this sample are those who have not eliminated the possibility of going to college (losing 1926 of the original 10,739 cases, or 17.9% of the sample). The sample is further restricted to only those who actually indicated an intended major in college (eliminating a further 2332, or 21.7% of the original sample). These two data filters have reduced the sample to 6,481 cases. Thirty six percent of the sample (2432 cases) indicated a major in one of the four science fields. The data analysis for this investigation has used two methods. First, the two groups are compared on the several variables which comprise the analytic model. For this first analysis, which is primarily descriptive, t-tests have been run on the difference between the means. Although the variables in the model are intercorrelated (i.e. non-independent), no adjustment has been made to the nominal significance levels of each t-test to adjust for this, since no substantive inferences are to be drawn from these tests. The second part of the data analysis uses ordinary least squares regression to investigate causal relationships between variables. A path analytic framework guides the data analysis, in order to investigate both the direct and indirect effects of predictor variables on the probability of majoring in science. Standardized, or beta, regression coefficients are reported, in order that results are consistent across dependent variables measured in different metrics. Since the final dependent variable is dichotomous (whether or not the student majors in science), log-linear or logistic methods were considered for this analysis. However, it is appropriate to use least squares in place of logistic regression for an analysis with dichotomous outcome variables if the distribution of the variable is not extreme (Goodman, 1978; Markus, 1979). Since 37.5% of the students in this sample plan to major in science, this falls within the 20-80% non-extreme distributions considered "safe" for substituting least squares methods. The path model on which these regressions models were based is shown in Figure I.

Insert Figure I about here

The variables in the model are grouped into constructs. First, we investigate the effect of student and family background on the types of high schools students attend, characterized in part by the compositional nature of the student population (e.g., minority enrollment, average SES). This set of relationships is shown in Path A of the model. Second, the effect of both student background and school characteristics are simultaneously regressed on the probability of being enrolled in the academic curriculum track (Paths B and C). Third, background, high school characteristics, and track status are simultaneously regressed on students' academically-related behaviors (Paths D, E, and F). In this case, these behaviors are course enrollments in math and science. Fourth, the relationships between all previous constructs and high school outcomes (grades and achievement in math, as well as educational aspirations) are assessed (Paths G, H, I, and J). Finally, the cumulative direct effects of all constructs on the probability of majoring in science are measured (Paths K, L, M, N, and O). Using such a model allows us to determine whether the effects of, say, background on science major choice are direct (i.e. Path L), or indirect (passing through, say, Paths B and M). The location of the variable constructs in the model is intended to reflect temporal sequencing to some extent. That is, background is seen as prior to sophomore year, and thus is considered outside, or exogenous, to the model. High school characteristics and track placement are early in students' high school careers, and are thus measured at sophomore year. The remaining constructs in the model are measured at senior year. The use of arrows assumes a directionality and non-recursiveness to the causal structure, a common assumption to path analysis.

Group mean differences between model variables for the science and non-science students are presented in Table VI-A. For most of the variables in the model, there are statistically significant differences between the groups. Science students are of higher social class, less likely to be minority or female, and of higher ability levels. The differences in the schools they attend are not significant. Science majors are more likely to have come from the academic track, and considerably more likely to have taken more math and science courses. They have significantly higher educational aspirations, higher grade point averages in math, and much higher math achievement scores. Most of these differences are large, particularly those in coursetaking, and achievement. However, since we know that student background and track placement is related to course enrollment and school performance, will these differences in student background "explain away" the large differences in academic behaviors and performance between science and non-science students?

Insert Table VI-A about here

The regression models which examine the path model shown in Figure I are displayed in Table VI-B. The regressions which represent Path A are those where background variables (SES, race/ethnicity, gender, and ability) are regressed on three variables which characterize the schools students attend. Social class and race/ethnicity relate strongly to larger schools, but the predictive power of the model is low. Not surprisingly, all background variables (except gender) relate to compositional features of schools -- the minority concentration and the academic achievement level of the student body. The second set of regressions relate background and school characteristics to the probability of academic track membership (Paths B and C in Figure I). Social class, ability, and compositional characteristics relate strongly to academic track membership, with more advantaged and higher ability students more likely to be so placed. Interestingly, once SES, ability, and the type of school attended is controlled for, black students are more likely to be in the academic track.

Insert Table VI-B about here

High school behaviors are here typified by the number of math and science courses students take, and the sets of background, school, and track variables are regressed on these measures (Paths D, E, and F). SES relates strongly to taking more math courses, even after controlling for ability. Females are significantly less likely to take these courses, especially science courses. Interestingly, school characteristics predict coursetaking in math and science, with students in larger schools, especially those with higher minority concentrations, likely to take more courses. Unsurprisingly, students in the academic track are much more likely to take such courses, since that is what the academic track is all about. Next, the effects of background, school, track, and coursetaking are evaluated on several outcomes of high school -- aspirations for higher education, grades in math, and math achievement (Paths G, H, I, and J). Coursetaking is a very strong predictor of all three outcomes, as is ability. Gender is very strongly related to all three outcomes, as well. Whereas females are more educationally ambitious and have higher grades (even in math), they show a lower level of math achievement on the HS&B test. Note that these gender differences take into account a general measure of ability. After adjusting for ability and SES, blacks are also more educationally ambitious, but score lower in math achieve- ment (as do Hispanics). Students in high-minority schools are more educationally ambitious, which probably results from the higher aspirations of black students, whom we know to be largely grouped in high minority schools. Course enrollment in math and science strongly predict all three outcomes, with math courses being more important than science courses. The explanatory power of the models for high school outcomes is considerable, particularly for math achievement.

Finally, we investigate how these sets of variables predict the probability of choosing a science major. The answer: not too well, since the model explains only 8% of the variance. However, there are several interesting relationships in this analysis. For example, even with the considerable number of statistical adjustments in this model (including ability, SES, course enrollment, and math achievement), girls are significantly less likely to choose a science major. However, blacks are significantly more likely to so choose, after we take all the model adjustments into account. Course enrollment in math and particularly in science very strongly predicts choice of science, which is no surprise. Neither is it surprising that high grades and achievement in math are significantly related to choice of a science major. The small but negative effects of SES, ability, and school-level achievement are not interpretable, however, and probably reflect the collinearity of these variables with the control measures.

What does this tell us about how student and school characteristics and behaviors combine to influence choice of science as a major? First, we can see that although many of these model variables are related to gender, the direct and negative effect of being female on science choice is sustained. Second, we see that other background variables, particularly ability and social class, have an indirect, rather than a direct, effect on science choice. That is, these variables are strong predictors of students' enrollment in the academic curriculum track. In turn, being in that track strongly predicts what courses students take. Taking the right courses is strongly related to outcomes of schooling like achievement and grades, which in turn are strong predictors of science choice. Thus, most background variables (with the exception of gender) more indirectly than directly affect this choice, through the treatment students receive in school. It is these academically- related behaviors (track placement and subsequent course choices) which mediate performance. And students decide to go into or avoid science on the basis of their performance in the subject areas which are science. However, it hard to avoid noticing that the structure of schooling -- tracking and courses -- are the central elements in this picture. Although background characteristics are largely immutable, and society as a whole finds it difficult to directly influence the composition of the schools students attend (i.e. bright students attend strongly academic schools, minority students are more likely to attend relatively segregated schools), course enrollment and tracking are things that schools and school people can do something about. This regression model hints that perhaps we should focus our efforts in this area, if we wish to influence directly the choice of a science career or indirectly, through the outcomes of schooling which have a strong influence on that choice.

B. College science choice. Although somewhat more complex, the model of science choice at the college level shares a similar structure for the same choice at the high school level. That path model is presented in Figure II. The left-hand part of the diagram is identical to Figure I, which models background, school, track, high school behaviors, and high school outcomes on science major choice as students graduate from high school. The college-level model adds two additional constructs to the predictive model: college characteristics and college behaviors. We have background, school, track, behaviors, outcomes, and high school science choice predicting college characteristics (Paths P, Q, R, S, T, and U). Next, we have the entire set of dependent constructs predicting behaviors in college (Paths V, W, X, Y, Z, and AA). Finally, the effects of all constructs in the model on the choice of a major in science at the college level are evaluated in Paths, BB, CC, DD, EE, FF, GG, HH, and JJ. Although the model at first glance looks quite complicated, I hope the logic of the analysis is clear. This sample of students is somewhat different from the earlier sample, including the students who are actually in college two years out of high school, almost all of whom indicated a major.

Insert Figure II about here

Due to the relatively more select nature of this sample compared to that at the senior year of high school, many of the mean differences between science and non-science majors have become stronger (comparing Table VI-C with Table VI-A). Although race and gender differences remain about the same, the relatively more select SES levels of both groups, and of the science compared to the non-science group, is noteworthy. School characteristic differences remain rather weak. Although the proportion of students from the academic track in high school has increased for both groups in the college sample, it is also noteworthy that the difference between the science and non-science majors in academic track enrollment has increased. Whereas there was an 8% difference at senior year of high school, at the college level there is a 14% difference. Difference in high school math course enrollment has increased as well, as have differences in all three high school outcomes. On every measure of selectivity of background or high school, students who plan science majors are higher. Correspondly, science majors are less likely to have attended a community college within their first two years of college, and are significantly more likely to have achieved sophomore standing by the second year after high school graduation.

Insert Table VI-C about here

Again, it is appropriate to ask whether these relationships will be sustained in a multivariate regression model. The path coefficients measured regression models shown in Table VI-D are very similar to those from the model on high school science major choice are very similar (although the populations are somewhat different), and thus are not be discussed in detail. Reflecting the slightly more select sample in these analyses, the regression on academic track in the high school model is better explained (i.e. R^2 figures decreased from 23% to 19%). Correspondly, in the college sample the model predicts the high school outcomes (aspirations, grades, achievement) better. Importantly, the regression model for high school science choice is better predicted in the college-level sample (12%) than the high school sample (8%). However, the patterns of variable predictors are very similar -- background and school predicting track and courses, which in turn predict outcomes, which predict science choice at the end of high school.

Insert Table VI-D about here

Unfortunately, the HS&B study contains only limited descriptions of the colleges students attend. The major college characteristic examined in this study is whether the college attended is a 2-year (junior) or a 4-year institution. Our model shows that high school characteristics are rather strong predictors of whether a student attends a junior college, with students from larger high schools, with higher minority concentrations and lower average achievement levels, more likely to go to 2-year colleges. In fact, high school characteristics are a stronger predictor of this than any other outcome in the model. College behaviors are typified by students' self-reported grades and whether or not the student had achieved sophomore status by the end of two years. The strongest set of predictors for both college behavioral outcomes are students' high school outcomes, with high school GPA (unsurprisingly) strongly predicting college grades, and educational aspirations the strongest predictor of whether or not a student has gotten two full years of credit in college (i.e. is a sophomore).

The final model, on choice of college science or non-science major, is better predicted than at the high school level (with 25% of the variance explained). However, the major difference in these two models is the addition of the choice of a science major in high school, a very strong predictor of the same choice two years later. Otherwise, high school outcomes and the number of science courses still show residual direct effects on choice of science major. Females are still significantly less likely to choose science, even after taking their high school preferences into account. Likewise, blacks are equally strongly likely to choose science, taking all other considerations into account. This contrasts with the analyses in the first report, which showed blacks to be less likely to choose majors in the sciences. The structural pattern within high school is identical in the same model. The fact that high school outcomes and gender have a strong residual on college major choice, after taking prior choice into consideration, may be interpreted to mean that what happens to students in high school is quite important in college, despite persistence or lack of persistence in science. These models show that it is not lower course enrollments in high school math and science which inhibit these young women's choice of science, for the most part. In fact, it appears that explanatory models which include only the factors of family background, high school, and college experiences (but omit other socialization experiences and attitudes) do not allow a full exposition of this important issue. In fact, data on the entire life experiences of students is seldom available.

III. Migrating Into Science

Why do students who initially indicated they planned to major in a field other than science move into science? More specifically, what it is about their experience in high school which encourages such students to change their minds? This investigation looks at a particular group of 3'36 students: those who were not interested in science at their sophomore year of high school. These students must also have had plans to go to college and have indicated their potential field of study. Of that group, 799 students (25.5%) had changed their proposed major to a science field by their senior year of high school. The analysis has eliminated those students who were consistently interested in science while in high school. The background and high school experiences of these two groups of students are documented in Table VII-A, and the differences between the means on each variable tested for statistical significance with t-tests.

Insert Table VII-A about here

In terms of background (i.e. conditions which we assume to be operative before the experiences of the last two years of high school), the two groups differ on neither sophomore-year achievement nor academic track placement. Although those who "migrate" into science while in high school are of somewhat lower SES, 12% less likely to be female (53 vs. 65%), and somewhat more likely (11 vs 8%) to be black. Those who migrate into science are more likely to be in high schools with somewhat higher achievement and slightly more minority students. However, their coursetaking patterns in math and science, as well as their grades in those courses, are considerably different. While there are no significant differences between the groups in the proportions who take early math or sciences courses (Algebra I, Geometry, or Biology I), there are large differences in the proportions who take more advanced math and science courses. There are especially large differences in Calculus (13 vs. 4%), Chemistry I (39 vs. 27%), and Physics I (26 vs. 11%). Again, since we know that this course-taking and performance pattern is related to background, we must statistically adjust for these potentially confounding factors.

Again, we use ordinary least squares to examine the pattern of explanatory factors which predict migration into science by the end of high school. Use of non-logistic methods is again justified by the non-extreme distribution of science migrators (25.5% of the sample). The results of these regressions are shown in Table VII-B. Using the identical outcome variable (migrating into science or not) in all models, the regressions were run hierarchically, examining the cumulative effects of (1) background; (2) high school characteristics; (3) curriculum track; and (4) high school courses in math and science, as well as performance in math and science courses. Each of these courses is coded dichotomously, with those who has less that one year of credit (i.e. one Carnegie unit) coded "0" and those with a year or more of credit coded "1". It should be noted that the coursetaking and grade performance data are taken from student transcripts, which makes it highly reliable. Models 1, 2, and 3 have low explanatory power (2%), and should thus be be considered as only preliminary to the major analysis -- Model 4 -- where the explanatory power is higher (10%) than for previous models, but still moderately low.

Insert Table VII-8 about here

In all models, females are very significantly less likely to migrate into science, even after adjusting for coursetaking and performance. Social class is a consistent significant predictor, with students of lower SES more likely to move into science. Ability is unrelated to movement into science (except in the final model, where its negative coefficient is likely to be a statistical artifact of the inclusion of multiple course. Blacks are somewhat more likely to be among the migrants, although in the final model this difference is not statistically significant. In examining the pattern of which courses seem to "make a difference" in terms of migrating into science, we see that the earlier courses in the academic math sequence (Algebra I and II, Geometry, and Trigonometry) are not important, nor are courses in Biology (I and advanced) or Computer Programming. However, enrolling in courses in the physical sciences -- Chemistry and Physics (at both the beginning and advanced levels) and in Calculus make a big difference. The culumative grade point average in math appears to be more important to a chance into science than that for science. We interpret these findings as indicating that students initially not interested in science fields must persist in math to the most advanced level in high school (i.e. Calculus) to really change their minds. However, positive experiences in the physical sciences, especially in physics, appears to change students' minds in favor of science. Since grades in math and science are sure to be highly related to one another (i.e. they are correlated .64), one variable (math GPA) has simply subsumed the other. However, performance in this area is very strongly related to a "change of heart" in favor of science as a planned major.

IV. Stifled in Science?

These analyses focus on a relatively small group of high school students. At their sophomore year of high school, this group had indicated that they were interested in science as a possible college major. Moreover, they scored above the average for American students on general achievement test, which indicates that they have the ability to pursue their interest in science. However, these students were not enrolled in the traditional college-preparatory (i.e. academic) curriculum track. The purpose of these investigations is to see whether this "improper" track placement acted in some structural manner to stifle their interest in science. We have selected two separate comparison groups against which we measure student progress for the target group. First, the high- achievement low-track science students are compared to their high-achieving counterparts, also interested in science, but in the academic track. If the progress of the potentially stifled group shows few differences with this group, we may conclude that our target group is not stifled. The second comparison group are those high-achieving non-academic track counterparts who expressed interest in field other than science. If the target group more closely resembles this group than the first, it suggests that they had been stifled.

Table VIII-A, presents these comparisons, with group means on a wide array of variables for our target group found in column 3 of that table. Means for the first comparison group, academic track students in science, are found in column 4. Those for the second group on which we wish to make comparisons are located in column 5. The data in columns 1 and 2 describe students in the below-average achievement groups interested in science, for the non-academic (column 1) and academic tracks (column 2). In general, our target group more closely resembles their low-track non-science counterparts than their high-track science counter- parts. This is the case for SES, race, the proportion taking college-placement exams (SAT or ACT), educational aspirations at 8th, 10th, and 12th grades, grades in math, SAT math scores (for those who took the test), the proportion working four years after graduation, the proportion of the groups attending college, and (for those in college), those attaining sophomore status. On other measures, the low-track science students fall midway between their low-track non-science counterparts and their high-track science counterparts. This is the case for the number of math courses taken in high school and achievement in math in the 12th grade. Only on a single measure -- the proportions of the groups which are female -- does "science" affiliation appear to make more difference than track affiliation. However, again we know that these factors on which the groups differ are interrelated. Therefore, we must use multivariate methods to untangle these relationships.

Insert Table VIII-A about here

To determine the net effect of these independent variables on membership in these groups, a three-level variable which categorizes these groups was formed, and discriminant function analysis employed. The analysis employed the several variables on which the three groups varied most markedly, from the data in Table VIII-A. The results of that discriminant analysis are presented in Table VIII-B. The method is the same one used earlier (in Table V-B) to examine science persistance patterns. Although two functions were formed, the first explained the large majority of variance in the combined analysis (95%). Therefore, only the first discriminant function is discussed. Several variables have entered the function, showing that there are important differences between the groups. High school course enrollments in math and science loaded highest on the function, as did ability (despite the fact that our groups are from the top half of the ability distribution), achievement in mathematics, and educational aspirations at 8th grade. Grades and gender (female) loaded negatively. Several other variables did not enter the function, despite the rather unstringent .10 probability level entry criterion used.

Insert Table VIII-B about here

The function is typified primarily by larger numbers of math and science courses, and by higher achievement. The three groups loaded (rather predictably) on this function as follows: the two non-academic track groups loaded negatively, and the academic track students load positively. This indicates that track enrollment is more important in discriminating students who take a lot of science and math courses (and do well in math) than is interest in science. However, within the two low-track groups (1 and 3), the science-oriented groups was relatively more highly loaded on the function. However, interest in science appears to be secondary to track enrollment. These results may be interpreted as indicating that incorrect track placement has in fact stifled the students who expressed interest in science from taking the courses (and experiencing the resulting higher achievement levels in math) that make the eventual college major in science possible or probable.

We pursue this question further with regression methods. In this analysis, the sample of 1575 high school sophomores of above-average ability interested in science (Groups 3 and 4 on Table VIII-A) is employed. Specifically, we investigate whether the non-academic track placement of our "stifled" group is a limiting factor on the number of academic math courses these students take in high school. The analysis, presented in Table VIII-C, is done in three steps. The first model (column 1) includes only background variables (social class, race/ethnicity, and gender). Social class is a strong predictor of math course-taking -- much stronger than either race or gender. The second model (column 2) includes the same background factor, but includes ability. Even for these above-average science-oriented students, ability (as well as SES) is strongly associated with coursetaking. The final model (column 3) includes background, ability, and track placement. It is clear that track placement is strongly related to the number of math courses taken by these students, even after their ability, social class, race/ethnicity, and gender are taken into account. In fact, academic track placement is the strongest predictor of coursetaking -- stronger than ability and much stronger than SES. Thus, it may be concluded that academic track placement is vital for the pursuit of the coursework in mathematics which has been shown to be so important for pursuing a major in the sciences. We would conclude that students interested in science, with the demonstrated ability to pursue these interests, are structurally stifled in that pursuit if they are not enrolled in the academic track. The fact that over one-quarter of all science-oriented high ability students are thus limited by this placement is troubling.

Insert Table VIII-C about here

V. Quantitative vs. Non-Quantitative Science

In the first report, we found that the group of college science majors is a rather heterogeneous group. However, the groups of students majoring in each particular science field in college are too small to support separate analyses. However, it is possible to group science majors into quantitative and non-quantitatve fields. Specifically, among science majors in college we investigate here the causal factors which indicate which students choose non-quantiative (life and health sciences) or quantitative (physical science, math, engineering, and computer science) fields of study, as well as identifying some reasons for this choice. The model for this analysis resembles the path model used to investigate the choice of a science major in college (Figure II). However, the model for this analysis (see Figure III) differs in one fundamental characte-ristic -- the final construct of whether the 1581 students in this sample choose quantitative or non-quantitative fields. We know from previous analyses that 36.3% of this group (574 cases) choose the biological or health sciences. However, except for the outcome variable and the sample, the analyses for Figure II and III are similar.

Insert Figure III about here

Mean differences between these two groups of science students are displayed in Table IX-A, again with the statistical significance between the groups determined by t-tests. As seen previously, females in science are much more likely to choose non-quantitative majors (69 vs. 32%). Several other differences show the quantitative science majors more select: higher ability, more likely to be from the academic track in high school, taking more math (but fewer science) courses in high school, with higher grades and achievement in math, and 9% more likely to have also planned a science major in high school. Quantitative science majors are slightly less likely to be in 2-year than 4-year colleges and to have achieved sophomore standing two years out of high school. These latter differences are not statistically significant, however. On only two measures are the non-quantitative science majors more advantaged: they have taken a year more of science in high school (3.3 vs. 2.1 years) and they are slightly more educationally ambitious. As before, we need multivariate methods to untangle this set of highly interrelated group differences. We again employ OLS regression with this dichotomous outcome variable, because of its non- extreme distribution (i.e. 63.7% of the sample chose quantitative majors. The explanatory power of these analyses is moderate to strong, with the final analysis explaining a credible 21% of the variance.

Insert Table IX-A about here

Discussion of these path analysis results will focus on the final model (right hand column), which examines the probability of choosing a quantitative science major. As in the previous analysis which examined choice of a science major in college (Table VI-D), we see females less likely, and blacks more likely, to select a quantitative science major. However, these differences are much stronger in this analysis. That is, females are much less likely and blacks considerably more likely to choose quantitative fields. Recall that there were no significant race/ethnicity differences between group means in

Table IX-A, but these have emerged in this multivariate analysis for blacks (but not Hispanics). The number of high-school science courses is a negative predictor of choosing a quantitative major, also reflecting the group mean differences seen above. Other strong predictors of quantitative major choice are educational aspirations (negative) and achievement and grades in math in high school (positive). College-level predictors in this analysis are not statistically significant. The somewhat anomolous results seen in these analyses is likely to be explained by the fact that a large proportion of students choosing the quantitative science major are in engineering (406 out of 1007 students, or 40.3%). In particular, few females choose engineering, future engineers probably take more math and less science in high school than other science majors, and since the majority of engineering jobs do not require advanced degrees, these students probably account for the negative coefficient for educational aspirations. Because these quantitative "science" majors are mostly mathematical majors (engineering, computer science, and math), students' coursetaking and performance in mathematics rather than science is likely to drive these path analyses.

Insert Table IX-B about here

VI. SAT Scores and Science

One of the major advantages of this sample of HS&B students is access to their transcripts. On this file, we have standardized test scores for those students who took the national college entrance exams. Of our sample of 10,739 high school graduates, 2,964 has scores on the mathematics section of either the SAT or the ACT, and 393 has scores on both. For those 393 students, it was possible to equate the scores on the two tests, by regressing ACT-M score on SAT-M score. We computed a "virtual" SAT-M scores, which we have called "SAT-M (X). The details of this computation are found in the Appendix. The question which is addressed in these analyses focuses on the causal factors for SAT-M performance. Specifically, we compare the causal relationships for two groups of students of special focus in this study -- those who have expressed the intention to major in science, compared to those who plan majors in non-science areas. Since the SAT test is taken in students' senior year of high school, their plans for college majors are also taken from senior year. The results of these analyses are displayed in Table X-A.

Insert Table X-A about here

The regression models shown in Table X-A are somewhat different from those shown previously. Instead of a path analytic scheme, these regressions are hierarchical. That is, sets of variables which represent the constructs described earlier -- background, high school characteristics, track, high school behaviors, and high school outcomes -- are entered into the regresson models in groups. In this way, one can evaluate two things: (1) the addition to the proportion of variance explained by each set of variables, or the gain in the R^2 figure when each variable set is added to the model; and the change in the relationship between certain background variables and the outcome when additional sets of variables are controlled for.

Several relationships are consistently strong in these models. The strongest (and least surprising) effect on SAT-M score is the 10th grade achievement/abiity test. Although that relationship is attenuated slightly by additions to the model, it remains by far the strongest effect. Therefore, one should realize that all other relationships are net of measured ability. A second consistently significant relationship is that of social class. However, the most noteworthy and most troubling observation in these analyses is the enormous sex difference in SAT-M scores favoring males, a difference which is sustained in all 5 models. The standardized (beta) coefficients for females range from -.10 in model 4 for girls not in science to -.17 for girls in science in model 5. These standardized coefficients are equivalent to score deficits in the range of 20 to 37 points. In these models, which adjust for background, ability, and -- most important -- for the coursetaking differences for women in math and science, women are still at a serious disadvantage on this important test. Even more striking, the females who have expressed an interest in the sciences show a slightly larger disadvantage vis-a-vis their male science colleagues than the non-science girls. This finding is very disturbing!

In general, the predictive models for students in science are slightly better than those for non-science students. That is, the proportion of variance explained by the models is consistently higher for the students in science than those in non-science. Since the variables in the predictive model are not science-specific (expect, perhaps, for math and science coursetaking), I can venture no evident explanation for this consistent pattern except, perhaps, that the variables for science students are somehow more reliably measured. We have already noted that sex differences are stronger for science students. Ability relationships are also stronger. However, the coursetaking variables exert a slightly weaker effect on SAT-M scores for the science group, presumably because there is somewhat less variability in coursetaking for science students. It should also be noted that race differences, although small and negative throughout, are quite small once students' social class and ability levels are taken into account.

The prediction pattern for SAT-M scores is quite similar across the science and non-science students. However, the fact that the models predict better for science students, the fact that the male advantage is stronger for science students but the coursetaking differences weaker is noteworthy. As we have seen previously in regression models, the variables which are temporally closer to the SAT test -- grades and courses -- show stronger effects than many other model variables. However, the gender difference and the ability relationship are both very strong and very consistent. Other than the consistently stronger prediction pattern for science students, there is not a markedly different causal structure for science and non-science students in predicting SAT math scores. That is, the results of this test have important implications for all college-going students, regardless of their intended field of study.

Discussion

Summary of results. The findings from this second series of analyses for the project on the high school-college transition for potential scientists and engineers are less straightforward than those from the first report. We first attempted to define differences in the pre-college behaviors among three groups of students who indicated they planned to major in science -- those who had shown a consistent pattern of interest in a specific science field, those who had consistently indicated interest in science (field persisters), but had changed fields within the sciences (science persisters), and students who had changed into science from non-science fields (science migrants). In general, the two groups of persisters were somewhat more select than the "migrants", in terms of ability or achievement, social class, and educational aspirations. Minority students were less likely to be among the two science persistence groups, as well. The general ranking of the three groups was progressively less select on other measures, especially the number of math and science courses taken in high school and (relatedly) the proportion of students in the academic track. One striking example of an anomoly for these groups is that females were less likely to be among the the science persisters than the other two groups. However, a multivariate discriminant function analysis showed a weak differentiation pattern between the three groups, with more females, lower ability, and less high school coursework in science differentiating the migrants from the science persisters. It seems that these three groups are reasonably similar when compared to the rest of the college-going population on science-related behaviors.

In causal analyses predicting science major choice at the high school and college levels, an understandable and unsurprising pattern of relationships emerged. Social class is related to science majoring, but indirectly, through both the types of schools students attend and their probability of being enrolled in the academic curricular track in high school. Ability is also an indirect predictor, passing through academic track placement, course enrollment in science and math, and (of course) math achievement. Gender is strongly and directly related to science major choice, even after taking ability, achievement, track placement, coursetaking, and grades into account, with females significantly less likely to choose science. Once the social class and ability of black students is controlled for, they are more likely than whites to choose a science major in high school. Of course, society does not make these adjustments, however. The strongest direct effects on science major choice, in addition to gender, are coursetaking in science and math, and high performance in these areas.

When students get to college and choose a major, the prediction pattern for background and high school behaviors is very similar. Once the major choice of science/non-science in high school is held constant, however, the major predictors of science major (in addition to persistence in science) are performance in high school, high school coursetaking in science, being black, and being male. That is, even after considering the strong relationship for persistence in science from high school to college, black students are still more likely, and female students less likely, to choose science. Although we know that fewer blacks actually choose science, compared to thier proportions in the college-going population, it seems that their disadvantage in terms of background, achievement levels, and high school and college experiences explain that under-representation. This is not the case for females.

Taking certain courses in high school -- particularly advanced math and physical science courses -- and doing well in them appears to be a major facilitating factor for students who "migrate" into science during the last two years of high school. Although all academic math and science courses are positively related to a newly expressed interest in science, it is taking (and succeeding in) calculus, physics, and/or chemistry which appears to be particularly encouraging for movement into science for college-bound students who earlier had stated plans to major in a non-scientific area. Reflecting earlier analyses, females are less likely, and black students more likely, to migrate into science.

The relatively small but important group of high-achieving students interested in science but misplaced in the non-academic tracks at their sophomore year of high school appear to be discouraged from persuing the requisite coursework in high school math and science that would lead them to realizing their aspirations in the sciences. When comparing this "misplaced" group of students to both counterparts interested in science but in the academic track, and to students who are high achieving, not in the academic track, and interested in non-science fields, our target group looks more similar to the latter than the former group. This is especially true in regard to college going -- SAT scores (for those who took that test), the proportion of all three groups who end up in college two years out of high school, the higher proportion in community colleges for those who make it to college, and the likelihood of achieving sophomore status by their second year. Moreover, it was demonstrated that academic track placement is a strong predictor of coursetaking in math, even after taking differences in students' ability and background into account. We may therefore conclude that non-academic track placement acts as a serious structural limitation for certain students who are interested in science and demonstrate the ability to focus their studies on science. Strikingly, 27% of all high-achieving high school sophomores who express an interest in science are in this group; that is, over one-quarter of all bright science-interested 10th graders are not enrolled in the academic track. That represents a serious potential loss of students to the sciences, in my opinion.

The first report demonstrated substantial differences between students majoring in different science fields in college, primarily between those choosing biology and health science fields and those in physical science, computer science, engineering, and mathematics. Multivariate analyses indicate very strong sex and moderate races differences, favoring males and blacks into the quantitiative fields. Ability is not a factor in these science field distinctions, but educational aspirations and science coursetaking are, favoring the choice of life sciences. Students with higher achievement levels and higher grades in math are much more likely to enter the quantitative fields. Many of these differences are likely to result primarily from the fact that over 40% of the quantitative science majors are planning a career in engineering, a field which attracts very few females, somewhat more blacks, and students typified by strong skills and interest in mathematics, rather than science. Many engineers do not pursue graduate degrees, explaining the lower educational aspirations for the quantitatively-orientated science majors.

Our final set of analyses produced even more distressing results in terms of female passage through an important "gateway" on the path to a career in the sciences -- the math section of the SAT test. Our analyses have shown that females experience a very substantial score deficit on this test, even after adjusting for their ability, their coursetaking patterns, and their grades in high school. Moreover, the "female SAT-M score disadvantage" is even greater for those girls who indicated plans to major in science than for the non-scientists: 37 vs. 29 points. This difference is close to being statistically significant. That is, in the somewhat more selective group of future scientists, gender makes even more difference in math test performance.

Conclusions. The causal patterns for predicting science major choice are quite understandable and not surprising. That is, it is obvious that students interested in a college major in the sciences take more courses in math and science, are more likely to be in the academic curricular track, are of higher social class, and do better in math tests. However, the fact that minority students are more likely to choose science -- especially the quantitative sciences -- once these things are held constant is surprising and rather gratifying. While that relationship for blacks is statistically signifiicant, there is also a positive but smaller relationship for Hispanics. These analyses add some insight to those from the first report. Clearly, black students are interested in science. From these analyses we conclude that the major barriers to their choosing science are the structural barriers in the social and educational process -- lower social class, less probability of being placed in the academic track (and the resulting lower academic emphasis of their courses of study in high school, lower achievement levels, and lower probabilities of getting to college). Black students' lower achievement scores seem to result primarily from these structural barriers.

The gender question is more complicated. That is, even though we know that girls still take somewhat fewer courses in high school mathematics (Lee & Ware, 1986) and perform less well on tests of math achievement (most notably, the SAT-M), and we have included these adjustments in our analyses, females are still less likely to choose science. We have confirmed findings from the first report that this pattern of females avoiding science is very strongly related to particular fields -- specifically, the physical sciences, engineering, computer science, and math. It is troubling that these regression models, which include a wide array of statistical controls, are unable to "adjust away" the female disadvantage in the sciences with controls for background, high school and college experiences, and math achievement. Moreover, even after adjusting for the gender difference in science choice at the senior year of high school, there is still a residual female disadvantage in science majoring in college (again, in the quantitative fields only). These are serious findings. Although the female disadvantage in the sciences has been longstanding and well documented, it is very distressing that very large residual SAT-M score differentials between males and females exist, and that they are even stronger for those (few) females who have actually stated their plans for majoring in sciences, compared to their science-oriented male counterparts. We suggest that the sex differences in representation in the sciences are very strongly (even primarily) related to the well-documented sex differences in mathematics achievement.

We can only speculate on the explanation for these differences. There are at least four possibilities. First, there could be a sex-related genetic difference. This was discussed in the literature several years ago (most notably by Benbow & Stanley, 1980), and was documented to be strongest for the most able students. However, these findings were heavily criticized (e.g., Pallas & Alexander, 1983). Second, there may be attitudinal differences in how the genders view science, math, and quantitative studies in general. If young women consider these fields to be either unimportant or unrelated to their lives, or not useful to their futures, girls may shy away from these fields for those reasons (although the science-inclined young women seem to know better). Third, the sex-related socialization differences which are pervasive in children's lives may act as subtle messages to discourage girls from pursuing careers in the science. Although the second and third explanations are reasonably likely to occur (and to be related to one another), such factors are unmeasured by HS&B and are thus unavailable in these analyses. Fourth, it is possible that tests like the SAT-M (and even the HS&B math test) are systematically biased against females. The fact that the adjusted score differentials due to race/ethnicity are lower than those due to gender would indicate that, if the tests are biased, such bias is more serious for females than for racial minorities. Since none of these possible alternative explanations may be explored directly with these data, we unfortunately must add these analyses to the body of literature which documents sex differences in science and math which favor males without being able to explain them.

The considerable change into and out of the science for students at the end of high school and the first years of college was an important finding of the first report, suggesting an effort to identify school-related factors which encourage student movement into science majors. It was found that exposure to certain types of courses, and performing well in them, was strongly and positively related to "migration" into the sciences during high school. However, these are not introductory-level, but rather advanced courses -- calculus, physics, chemistry, and the advanced levels of those physical sciences. Of course, students who take calculus must have taken all of the lower-level math courses. This suggests that all able students -- and not just those who believe they "need" these courses for their future -- be encouraged to persist in mathematics in order to experience calculus while in high school. It also suggests that many more students than currently elect chemistry and physics in high school be encouraged to take these courses. The fact that advanced mathematics and more demanding courses in the physical sciences are electives (resulting in low enrollments in these courses nationally) allows students who might be recruited into the sciences to miss the very academic experiences which might "turn them on" to science.

This suggests a more positive effort on the part of schools to encourage (or even require) such courses for able students, regardless of students' perceived need or interest in them. That is, we suggest a stronger academic press toward advanced courses for all students who can handle them. This is certainly in line with the current reform movement taking place in America's public high schools. However, we wish to add a strong caution to these recommendations. By identifying "able" students, we would suggest broading the base considerably. Exposure to such courses should be available to a wide range of students, not just those high performers in the academic track. Encouraging enrollment in advanced mathematics means that many more students need to have taken the beginning and intermediate levels of math. The fact that over a quarter of the sample of students initially planning non-science majors do not have Algebra I on their records, almost half have not taken geometry, about three-fifths have never taken Algebra II, and three- quarters have not taken trigonometry suggests that "access" to calculus is currently being denied to very large numbers of students, because of lack of mathematical preparation. Although there are not specific requirements for chemistry and physics, it is likely that students with weak backgrounds in mathematics shun such courses. We believe that strong preparation in mathematics for a much broader range of students is imperative to encouraging potential scientists into the fields as they enter college. This is also related to tracking, which is discussed below. Large-scale student choice, without sufficient guidance from school staff, has resulted in a general weakening of student preparation (Cusick, 1983; Powell, Farrar, & Cohen, 1985.)

In some sense, the analyses for this report have focused on equity issues. That means that I have particularly emphasized questions of race/ethnicity and gender as they influence orientation and behaviors which relate to the sciences. Another equity issue I have explored is curriculum tracking, which has been documented elsewhere to be related to social class and race. The finding that over a quarter of all students who indicate an interest in a possible major and/or career in the sciences at the sophomore year of high school and who are above the national average in achievement are impeded in their pursuit of this interest by the tracking process is troubling. Our evidence suggests that placement in the non-academic tracks causes these students to take fewer academic math and science courses in the last two years of high school. That means that the academic progress of these students seems to have been impeded by their track placement, with their stated interest in science unable to transcend a curriculum placement which restricts their exposure to the necessary coursework. We conclude that tracking is acting as a structural barrier to their progress. Although this group of students is not large (only 4% of all high school graduates), it is a not inconsequential segment of those interested in the sciences. Although social policy can act only indirectly on questions of race/ethnicity and gender, it is easier to imagine policy changes in the academic organization of schools. If all students who (a) expressed a desire to pursue higher education, (b) demonstrated moderate or higher levels of ability, and (c) were willing to invest the effort to pursue more difficult courses in these topics had access to the academic "treatments" in schools (i.e. those academic courses) which led to the actualization of their desires, our schools would not present barriers to students. Tracking is the major school structure that erects such barriers, and tracking practices are changeable.

References

Benbow, C.P. & Stanley, J.C. (1980). "Sex Differences in Mathematical Ability: Fact or Artifact?" Science. 210, 1262-1264.

Cusick, P. A. (1983). The Egalitarian Ideal and the American High School. New York: Longman, Inc.

Goodman, L.A. (1978). Analyzing Qualitative/Categorical Data. Lanham, MD: University Press of America.

Kahle, J. (Ed.) (1985). Women in Science. A Report from the Field. Philadelphia: Falmer Press.

Hilton, T.L. and Lee, V.E. (in press). "Student Interest and Persistence in Science: Changes in the Educational Pipeline in the Last Decade." Journal of Higher Education.

Lee, V.E. (1986). "When and Why Girls 'Leak' Out of High School Mathematics: A Closer Look." Paper presented at the American Educational Research Association Annual Meeting, San Francisco, California, April 1986. Available from ERIC.

Lee, V.E. and Ware, N. C. (1986). "When and Why Girls 'Leak'Out of High School Mathematics: A Closer Look." Presentation at the Annual Meeting of the American Educational Research Association, San Francisco, CA, April 1986.

Markus, G.B. (1979). Analyzing Panel Data. Sage University Papers Series: Quantitative Applications in the Social Sciences, Number 18. Beverly Hills, CA: Sage Publications.

Powell, A.G., Farrar, E. & Cohen, D.K. (1985). The Shopping Mall High School: Winners and Losers in the Educational Marketplace. Boston: Houghton Mifflin.

Pallas, A.M. & Alexander, K.A. (1983). "Sex Differences in Quantitative SAT Performance: New Evidence on the Differential Coursework Hypothesis." American Educational Research Journal, 20(2), 165-182.

Ware, N.C. and Lee, V.E. (1987). "Sex Differences in Choice of College Science Majors." Submitted for publication. Cambridge, MA: Radcliffe College.

White, K. R. (1982). "The Relationship Between Socioeconomic Status and Academic Achievement." Psychological Bulletin, 91, 461-481.

TABLE V-A 1

Persistence in Science: Means on Model Variables For Three Science Persistence Groups Among College Science Majors (N=1579)

	Persist in Same Science Field N=298	Persist in Science, Not in Same Field N=277	Entered Science Field From a Non-Science Field N=1004
Descriptive Variables (2):			
Personal and Family Background:			
Social Class ** (3)	.359	.240	.193
% Black ***	.070	.088	.147
% Hispanic *	.052	.085	.100
% Female ***	.467	.297	.484
% Planning College, Gr.8	.800	.739	.759
% Planning College, Gr.10 ***	.835	.686	.701
General Ability ***	58.46	58.31	54.96
High School Characteristics:			
School Size	1321	1212	1293
% Catholic HS	.099	.108	.096
% Private HS	.033	.035	.041
Average SES *	.099	.063	.030
% Minority Enrollment ***	.157	.186	.244
Average Achievement ***	53.56	53.01	52.17
Av.# Math Courses	2.09	2.08	1.98
Curriculum Track:			
% in Academic Track ***	.847	.734	.711
High School Behaviors:			
Homework, Hrs./Week	2.32	2.25	2.24
# Math Courses ***	3.11	2.98	2.68
# Science Courses ***	3.54	3.25	2.97
High School Outcomes:			
Math GPA	2.72	2.76	2.66
Educ. Aspirations, 12th **	7.32	6.88	6.99
Math Achievement, 12th ***	26.06	25.82	21.62
SATM-X ***	516.3	540.5	499.9
College Characteristics:			
% in Junior College ***	.222	.238	.356
% in Private College	.328	.277	.336
College Behaviors:			
% in College Full Time ***	.935	.919	.873
% Working, Feb. 1984	.427	.458	.497
College GPA	2.80	2.84	2.79
% Sophomores in College ***	.895	.763	.747

---

[1] Students in this sample are all high school graduates who have indicated that they plan to major in a science field (health or biological science, engineering, computer science, physical sciences, or mathematics). Sample represents 14.8% of 1982 high school graduates.

[2] Precise descriptions of these variables may be found in Figure III.

[3] Asterisks indicate nominal significance level from an analysis of variance on each variable. Significance levels: *=p<.05; **=p<.01; ***+p<.001.

TABLE V-2

Persistence in Science: Discriminant Analysis of Background, High School, and College Characteristics and Behaviors Which Relate to Group Membership

Sample: Students Who Indicated A College Major in Science (N=1579)

Groups: (1) Field Persisters (18.9%). These students were in the same science field at the three time points measured. N = 298.

(2) Science Persisters (17.5%). These students were in science at all three time points, but not in the field of science in which they are found in college. N = 277.

(3) Science Migrants (63.6%). These students were in science at the college time point, but migrated in from having expressed interest in a non-science field at either their sophomore or senior year. N = 1004.

Discriminant Function Coefficients[1]

	Function 1	Function 2
Independent Variables:		
Female	.77	.53
Ability	-.41	.19
# HS Science Courses	-.17	.85
Percent of Variance	75.5%	24.5%

Group Loadings on Discriminant Functions

	Function 1	Function 2
Groups:		
Field Persisters	-.09	.24
Science Persisters	-.44	-.12
Science Migrants	.16	-.05

---

[1] The following variables were attempted, but did not enter either discriminant function: college expectations in Grade 8, social class, black racial status, high school characteristics (% minority enrollment, average achievement), academic track, number of math courses, math achievement in Grade 12, senior-year educational aspirations, whether student attended a 2-yr or 4-yr college, and whether or not student had attained sophomore status in college.

TABLE VI-A

Means on All Variables in Regression Analyses for Students Reporting Interest in Possible Science and Non-Science College Majors At Their Senior Year in High School (N=6481)[1]

	Non-Science Major (N=4049)	Science Major[2] (N=2432)	T-Statistic of Difference[3]
Background[4] :			
Social Class	.105	.089	0.91
% Black	.087	.109	-2.90**
% Hispanic	.101	.097	0.56
% Female	.593	.467	8.81***
General Ability	52.62	54.03	-6.61***
HS Characteristics:			
Average School Size	1284	1286	-0.12
% Minority Enrollment	.213	.217	-0.65
School Average Ach.	52.13	51.98	1.16
Curriculum Track:			
% Academic Track	.564	.639	-5.97***
HS Behaviors:			
# Math Courses (Yrs.)	1.99	2.43	-10.57***
# Science Courses (Yrs.)	2.20	2.80	-17.35***
HS Outcomes:			
Educ. Aspirations	6.20	6.40	-3.82***
GPA in Math	2.23	2.49	-8.46***
Math Achievement, 12th	17.38	20.35	-10.75***

[1] Students in this sample must have (a) not eliminated the possibility of attending college; and (b) indicated a probable major in college.

[2] "Science" includes (i) life and health science; (ii) engineering; (iii) computer or information sciences; and (iv) physical sciences and mathematics.

[3] Nominal significance levels are as follows: *=p<.05; **=p<.01; ***=p<.001. These values include no adjustment for the fact that multiple t-tests were conducted on the same sample.

[4] Exact definitions of variable construction are found in Figure III.

TABLE VI-B

Regression Results for Path Analysis Examining Science Major Choice at the Senior Year in High School (N=6181)[1]

Dependent Variables

	HS Size	% Minority Enrollment	Average Ach'ment	Academic Track	# Math Courses	# Science Courses	Educational Aspirations	Math GPA	Math Achievement	Choice of Science Major
Independent Variables:										
Background:										
Social Class	.09***	-.07***	.21***	.15***	.06***	.01	.24***	-.09***	.00	-.04*
Black	.13***	.51***	-.19***	.07**	-.03	.02	.11***	.00	-.05***	.07***
Hispanic	.09***	.34***	-.12***	.01	-.04**	-.02	.02	.02	-.04***	.03
Female	-.01	.02	-.03*	.03*	-.03*	-.07***	.05***	.12***	-.09***	-.10***
Ability	-.03	-.07***	.31***	.39***	.39***	.34***	.18***	.31***	.52***	-.07*
HS Characteristics:										
School Size				.00	-.06***	-.05***	.02	-.04***	.02	.02
% Minority Enr.				.08***	.07***	.06***	.09***	-.07***	.01	-.06*
Average Ach.				.09***	.03	.01	.04*	-.10***	.10***	-.08***
Curriculum Track:										
Academic Track					.30***	.27***	.15***	-.07***	.01	-.02
HS Behaviors:										
# Math Courses							.19***	.39***	.26***	.05*
# Science Courses							.11***	.08***	.09***	.22***
HS Outcomes:										
Educ. Aspirations										-.05*
GPA in Math										.06**
Math Achievement										.09**
% Variance Explained:										
(R-squared)	.02	.42	.31	.23	.40	.27	.37	.34	.71	.08

1 Results are presented as beta, or standardized, regression coefficients. Nominal significance levels are as follows: * = p<.05; ** = p<.01; *** = p<.001. No adjustment has been made for the two-stage probability sampling design.

TABLE VI-C

Means on All Variables in Regression Analyses for Students Reporting Science and Non-Science Majors in College[1] (N=6200)

	Non-Science Major (N=4618)	Science Major (N=1582)	T-Statistic of Difference[2]
Background[4]:			
Social Class	.172	.232	-2.87**
% Black	.095	.122	-3.12**
% Hispanic	.089	.088	0.10
% Female	.577	.449	8.04***
General Ability	52.99	56.19	-12.68***
HS Characteristics:			
School Size	1277	1283	-0.26
% Minority Enr.	.211	.217	-0.90
Average Ach.	52.17	52.58	-2.97**
Curriculum Track:			
% Academic Track	.600	.741	-10.12***
HS Behaviors:			
# Math Courses (Yrs.)	2.11	2.81	-15.92***
# Science Courses (Yrs.)	2.29	3.12	-22.39***
HS Outcomes:			
Educ. Aspirations	6.35	7.04	-13.17***
GPA in Math	2.44	2.69	-14.12***
Math Achievement, 12th	17.95	23.20	-17.67***
Plans for Science Major?	.253	.724	-32.72***
College Characteristics:			
% Junior College	.426	.309	7.71***
College Behaviors:			
College GPA	2.82	2.81	0.79
% Sophomore Status	.749	.782	-2.37*

---

1 Students in this sample must have (a) attended college at least one semester during the first two years after high school; (b) indicated a probable major in one of the colleges they attended.

2 "Science" includes (i) life and health science; (ii) engineering; (iii) computer or information sciences; and (iv) physical sciences and mathematics.

3 Significance levels are as follows: *=p<.05; **=p<.01; ***=p<.001.

4 Exact definitions of variable construction are found in Figure III.

TABLE VI-D

Regression Results for Path Analysis Examining Science Major Choice at the Sophomore Year in College (N=6200) [1]

	Dependent Variables													
	HS Size	% Minority Enrollment	Average Achievement	Academic Track	# Math Courses	# Sci. Crses	Educ. Aspir.	Math GPA	Math Ach'nt	HS Sci. Major	Junior Coll.	Coll. GPA	Soph. Status	College Sci. Major
Independent Variables:														
Background:														
Soc'l Class	.09***	-.08***	.23***	.13***	.05***	.02	.19***	-.11***	.00	-.05*	-.06**	.01	.00	.00
Black	.12***	.53***	-.20***	.07***	-.04*	.00	.10***	-.02	-.03*	.10***	-.07***	-.02	.05**	.07***
Hispanic	.09***	.31***	-.09***	-.03*	.03*	-.03	.03	.01	-.03*	.06**	-.01	-.02	-.01	.03
Female	-.01	.03*	-.02	.03*	-.04***	-.08***	.03*	.12***	-.08*	-.10***	.00	.11***	.01	-.03*
Ability	-.01	-.08***	.30***	.37***	.36***	.31***	.14***	.29***	.53***	-.01	-.05**	.15***	.01	-.02
HS Characteristics:														
School Size				-.00	-.06***	-.05***	.05***	-.05***	.03**	.03	.10***	-.03	-.04*	.00
% Minority Enr.				.07***	-.06**	.06***	.08***	-.03	.01	-.10***	-.08**	.02	-.04	.02
Average Ach.				.08***	.05**	.02	.04*	-.06**	.11***	-.10***	-.05*	.00	.03	.00
Curriculum Track:														
Academic Track					.29***	.27***	.18***	-.06***	.01	-.03	-.03	.02	.05*	-.01
HS Behaviors:														
# Math Courses							.18***	.36***	.25***	.06*	.00	-.05*	.95	.02 [2]
# Science Courses							.14***	.09***	.10***	.26***	-.07***	.00	.07***	.13***
HS Outcomes:														
Educ. Aspirations										-.07***	-.27***	-.09***	.22***	.07***
GPA in Math										.05**	-.04*	.27***	.06**	.09***
Math Achievement										.08***	-.15***	.08**	.01	.08**
HS Major Plans:														
Planning Science Major?											.07***	-.07***	-.07***	.36***
College Characteristics:														
Junior College													-.13***	-.01
College Behaviors:														
College GPA														-.03*
Sophomore Status														-.05**
% Variance Explained:														
(R).	.02	.44	.32	.19	.36	.25	.33	.33	.68	.12	.24	.15	.19	.25

---

[1] Results are presented as beta, or standardized, regression coefficients. Nominal significance levels are given as follows: * = p<.05; ** = p<.01; *** = p<.001. No adjustment has been made for the two-stage probability sampling design.

[2] Science and math courses are strongly collinear. Therefore, the variance in one (here math courses) takes up a substantial amount of the variance in the other. Interpreting the contribution of one vs. the other, therefore, is not justified.

TABLE VII-A

Migrating Into Science: Means on All Variables in Regression Analyses for Students Coming Into Science At Their Senior Year in High School Compared to Those Choosing Non-Science Majors (N=3136)

	Non-Science Major (N=2337)	Migrating[2] Into Science (N=799)	T-Statistic[3] of Difference
Background[4]:			
General Ability	53.81	54.03	-0.59
% Female	.65	.53	5.32***
Social Class	.17	.09	2.72***
% Black	.08	.11	-3.15**
% Hispanic	.09	.10	-0.90
HS Characteristics:			
Average School Size	1281	1254	0.80
School Average Ach.	52.41	51.83	2.91**
% Minority Enrollment	.21	.23	-2.29*
Curriculum Track:			
% Academic Track	.61	.63	-1.00
HS Courses in Math and Science (% Taking a year or more):			
Algebra 1	.71	.70	0.40
Geometry	.55	.59	-1.95
Algebra 2	.35	.44	-3.75***
Trigonometry	.21	.25	-2.07*
Calculus	.04	.13	-7.93***
Computer Programming	.04	.05	-2.01*
Biology 1	.54	.56	-0.91
Adv. Biology	.15	.21	-3.36***
Chemistry 1	.27	.39	-5.63***
Adv. Chemistry	.03	.07	-4.23***
Physics 1	.11	.26	-9.47***
Adv. Physics	.01	.03	-4.21***
HS Performance in Math.Science Courses:			
GPA in Math	2.26	2.54	-5.94***
GPA in Science	2.50	2.60	-2.44*

---

[1] Students in this sample must have (a) indicated a major at both sophomore and senior year of high school; (b) not eliminated the possibility of attending college; and (b) indicated a non-science major at sophomore year.

[2] "Science" includes (i) life and health science; (ii) engineering; (iii) computer or information sciences; and (iv) physical sciences and

mathematics.

TABLE VII-B

Migrating Into Science: Regression Results For Various Models Predicting the Probability of Coming Into Science (N=3136) [1]

	Model 1	Model 2	Model 3	Model 4
Independent Variables:				
Background:				
General Ability	.04	.06*	.05	-.10**
Female	-.11***	-.10***	-.11***	-.10***
Social Class	-.06*	-.05*	-.05*	-.06*
Black	.06*	.07*	.06*	.05
Hispanic	.02	.02	.02	.01
HS Characteristics:				
Av.School Size		-.02	-.02	-.02
Average Ach.		-.06*	-.06*	-.07*
% Minority Enr.		-.03	-.03	-.04
Curriculum Track:				
% Academic Track			.02	-.03
HS Courses in Math and Science:				
Algebra 1				.01
Geometry				.04
Algebra 2				.02
Trigonometry				-.03
Calculus				.11***
Computer Programming				.02
Biology 1				.00
Adv. Biology				.04
Chemistry 1				.06**
Adv. Chemistry				.05*
Physics 1				.14***
Adv. Physics				.06**
HS Performance in Math.Science Courses:				
GPA in Math				.13***
GPA in Science				-.05
% Variance Explained (R^2)	.02	.02	.02	.10

---

[1] Results are presented as beta, or standardized, regression coefficients. Nominal significance levels are as follows: * = p<.05; ** = p<.01; *** = p<.001. No adjustment has been made for the two-stage probability sampling design.

TABLE VIII-A

Stifled in Science: Group Mean Differences on Background; High School Characteristics, Behaviors, and Outcomes; and College Behaviors for High-Achieving Science-Oriented Students Not in the Academic Track

	Group 1 Lo-Ach. Non-Acad Science	2 Lo-Ach Acd.Trk Science	3 Hi-Ach Non-Acad Science	4 Hi-Ach Acd.Trk Science	5 Hi-Ach Non-Acad Non-Science
	N=528	N=309	N=428	N=1147	N=826
Background:[1]					
Soc'l Class	-.337	-.145	.060	.317	-.031
% Black	.216	.224	.033	.050	.039
% Hispanic	.210	.176	.057	.052	.058
% Female	.412	.544	.401	.410	.577
Gen'l Ach.,10th	42.54	44.12	55.88	59.25	54.97
Academic Orientation:					
% Taking SAT-M	.034	.220	.105	.355	.113
% Taking ACT-M	.072	.133	.206	.181	.186
HS Behaviors:					
# Math Courses	0.82	1.85	2.01	3.13	1.58
% Plan Coll.,Gr.8	.405	.622	.537	.803	.524
% Plan Coll.,Gr.10	.234	.475	.413	.790	.340
HS Outcomes:					
Educ. Asp.,12th	4.22	5.74	5.44	7.06	5.27
Overall GPA	2.20	2.44	2.76	3.02	2.69
GPA in Math	1.73	1.87	2.35	2.67	2.09
Gen'l Ach.,12th	43.73	46.55	55.52	59.47	54.05
Math Ach. (2)	6.38	9.06	15.13	18.64	12.89
SAT-M (X)	371.6	371.3	456.7	524.9	442.3
College Characteristics and Behaviors:					
% Working, 2-84	.588	.562	.676	.510	.643
% In College	.435	.629	.669	.890	.632
If in College:					
% Junior Coll.	.649	.513	.472	.241	.514
% Private Coll.	.260	.337	.279	.332	.320
% in Coll, F-T	.788	.811	.829	.913	.830
College GPA	2.61	2.56	2.81	2.88	2.89
Soph. Status	.497	.639	.707	.845	.637

[1] Full description of variables is found in Figure III.

[2] This math achievement score is on a slightly different scale than that described in Figure III, but comparisons are comparable.

TABLE VIII-B

Stifled in Science? Discriminant Analysis of Background, High School, and College Characteristics and Behaviors Which Relate to Group Membership

Sample: Students Scoring Above Average on Sophomore Achievement Test (N=2401)

Groups: (1) Low-Track Science. High-achieving students not in the academic track, but who expressed interest in science at their sophomore year (Group 3 above). N=428.

(2) Hi-Track Science. High-achieving students in the academic track, but who expressed interest in science at their sophomore year (Group 4 above). N = 1147.

(3) Low-Track Non-Science. High achieving student not in the academic track, but who expressed interest in a non-science field at their sophomore year (Group 5 above). N=826.

Discriminant Function Coefficients[1]

	Function 1	Function 2
Independent Variables:		
Black	.09	-.33
Female	-.07	.52
Ability	.15	.53
# Math Courses	.41	.11
# Science Courses	.57	.00
College Plans, Gr.8	.16	.54
Math GPA	-.14	-.26
Math Achievement,Gr.12	.19	-.16
Attended Jr. College	-.19	-.04
College GPA	-.20	.26
Percent of Variance	95.1%	4.9%

Group Loadings on Discriminant Functions

	Function 1	Function 2
Groups:		
Low-Track Science	-.42	-.42
Hi-Track Science	.54	.04
Low-Track Non-Sci.	-1.27	.13

---

1 The following variables were attempted, but did not enter either discriminant function: social class, Hispanic racial status, whether student was working two years after high school, whether student attended college, whether student was in collegr and a sophomore two years after high school.

TABLE VIII-C

Stifled in Science: Regression Analysis of the Effects of Background, Ability, and Curriculum Track on High School Coursetaking in Science and Math for High-Ability Students Expressing Interest in Science[1]
(N=1575)

Dependent Variable: Number of High School Courses in Science and Math[2]

	Model 1	Model 2	Model 3
Social Class	.21***	.13***	.09***
Black	.00	.02	.00
Hispanic	-.07*	-.04	-.05*
Female	-.04	.01	-.01
Ability		.39***	.31***
Academic Track			.33***
% Variance Explained (R^2)	.06	.20	.30

[1] Sample combines students in Groups 3 and 4 of Table VIII-A. All are of above average ability and all expressed interest in majoring in science at the sophomore year of high school.

[2] Numbers of math and science courses are summed. They are measured in years. Math includes academic math courses (Algebra, Geometry, Algebra 2, Trigonometry, Analysis, and Calculus). Science includes all high school science courses taken.

TABLE IX-A

Quantitative vs. Non-Quantitative Science: Means on All Variables in Regression Analyses for College Science Students (N=1582)[1]

	Biological or Health Sciences (N=574)	Engineering, Computer Sci., Phys.Sci.or Math (N=1007)	T-Statistic of Difference[2]
Background[3]:			
Social Class	.23	.23	-0.05
% Black	.12	.12	-0.13
% Hispanic	.10	.08	0.81
% Female	.69	.32	13.71***
General Ability	54.95	56.87	-4.14***
HS Characteristics:			
Average School Size	1238	1308	-1.72
% Minority Enrollment	.22	.21	0.64
School Average Ach.	52.50	52.62	-0.51
Curriculum Track:			
% Academic Track	.71	.76	-2.06*
HS Behaviors:			
# Math Courses (Yrs.)	2.60	2.93	-4.05***
# Science Courses (Yrs.)	3.26	2.06	2.69**
HS Outcomes:			
Educ. Aspirations	7.26	6.92	4.07***
GPA in Math	2.56	2.75	-3.53***
Math Achievement, 12th	20.86	24.49	-6.60***
Plans for Science Major?	.67	.76	-3.50***
College Characteristics:			
% Junior College	.29	.32	-1.14
College Behaviors:			
College GPA	2.82	2.80	0.76
% Sophomore Status	.81	.76	1.87

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[1] Students in this sample must (a) be in college; and (b) indicated a probable or actual major in the sciences.

[2] Nominal significance levels are as follows: *=p<.05; **=p<.01; ***=p<.001. These values include no adjustment for the fact that multiple t-tests were conducted on the same sample.

[3] Exact definitions of variable construction are found in Figure III.

TABLE IX-B

Quantitative vs. Non-Quantitative Science: Regression Results for Path Analysis Examining Type of Science Major[1]

Dependent Variables

	HS Size	Average Achievement	% Minority Enrollment	Academic Track	# Math Courses	# Sci. Crses	Educ. Aspir.	Math GPA	Math Ach'mt	HS Sci. Major	Junior Coll.	Coll. GPA	Soph. Status	Quant. Sci. Major
Independent Variables:														
Background:[1]														
Ability	-.02	.28***	-.11***	.37***	.29***	.26***	.08*	.37***	.56***	-.01	-.12*	.11*	-.06	-.04
Female	-.04	.00	.02	-.02	-.09***	-.03	.03	.14***	-.07***	-.01	-.02	.16***	.09*	-.33***
Soc'l Class	.05	.23***	-.09***	.11***	-.08**	.03	.21***	-.10***	-.01	-.06	-.04	.03	-.02	.01
Black	.08*	-.22***	.53***	.02	-.07**	-.06	.13***	-.01	-.04*	.06	-.07	.00	.03	.09*
Hispanic	.06	-.09***	.28***	.08**	-.03	-.09**	.03	.01	-.03	.00	-.02	-.02	-.04	-.01
HS Characteristics:														
School Size				.06*	-.07**	-.03	.04	-.04	.01	-.04	.10***	-.04	.01	.04
Average Ach.				-.02	.05	.02	-.01	-.01	.11***	-.08	-.11***	.00	-.01	-.05
% Minority Enrollment				-.02	.09*	.08*	.04	.06	.01	-.04	-.07	-.03	-.11*	-.01
Curriculum Track:														
Academic Track					.34***	.30***	.24***	-.04	.03	.01	.01	.03	.07*	.07*
HS Behaviors:														
# Math Courses							.13***	.32***	.19***	.07	.07	-.03	.04	.05
# Science Courses							.10***	08*	.09***	.06	-.07*	-.04	.06	-.19***
HS Outcomes:														
Educ. Aspirations										-.06	-.25***	.01	.21***	-.19***
GPA in Math										-.09*	-.06	.30***	.09*	.13***
Math Achievement										22***	-.14*	.10	.06	.21***
HS Major Plans:														
Planning Science Major?											-.04	-.04	.03	.06*
College Characteristics:														
Junior College												.10*	-.10**	.04
College Behaviors:														
College GPA														-.03
Sophomore Status														-.02
% Variance Explained														
(R-squared)	.02	.34	.45	.17	.35	.25	.30	.31	.71	.05	.23	.19	.19	.21

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1 Results are presented as beta, or standardized, regression coefficients. Nominal significance levels are given as follows: * = p<.05; ** = p<.01; *** = p<.001. No adjustment has been made for the two-stage probability sampling design.

TABLE X-A

SAT-M: Regression Results of Prediction Model for Science vs. Non-Science Students

Dependent Variable: SAT-M (X)[1]

	Model 1[2]		Model 2		Model 3		Model 4		Model 5	
	Science	Non-Science	Science	Non-Science	Science	Non-Science	Science	Non-Science	Science	Non-Science
Independent Variables[3]:										
Background:										
Soc'l Class	.07**	.06**	.06*	.04*	.06*	.04*	.05*	.04*	.06**	.05*
Black	-.06*	-.05*	-.04	-.02	-.04	-.02	-.03	.00	-.03	.01
Hispanic	-.03	-.04*	-.02	-.03	-.02	-.03	-.01	-.02	-.01	-.02
Female	-.15***	-.11***	-.14***	-.11***	-.14***	-.11***	-.13***	-.10***	-.17***	-.14***
Coll.Plans,Gr.8	.06**	.05**	.06*	.05*	.05*	.04*	.02	.01	.01	-.01
Ability	.65***	.62***	.64***	.61***	.62***	.60***	.56***	.52***	.48***	.44***
HS Characteristics:										
School Size			.04	.01	.03	.01	.03	.01	.06**	.03
Catholic HS			.00	-.02	-.01	-.02	-.02	-.04*	.00	-.03
Private HS			.00	.04	-.01	.04	-.01	.03	.01	.05*
% Minority Enr.			-.04	-.06*	-.04	-.06*	.03	-.07**	.04	-.05
Average Ach.			.03	.01	.01	.01	.03	.01	.04	.04
Curriculum Track:										
Academic Track					.07**	.03	.01	-.03	.00	-.02
HS Behaviors:										
# Math Courses							.15***	.21***	.10***	.17***
# Science Courses							.09***	.10***	.08***	.09***
HS Outcomes:										
High School GPA									.21***	.19***
% Variance Explained (R-squared)	.56	.49	.56	.49	.57	.49	.60	.54	.64	.56

[1] SAT-M (X) combines equated scores for the SAT-M and ACT-M tests. See Figure III for the details of construction of this and all other variables in these regression models.

[2] The Science and Non-Science groups are those who indicated, at senior year of high school, their intended college major in either a scientific or non-scientific field. Only those students who have taken either the SAT-M or ACT-M tests are included in these analyses. Sample sizes are 978 for the "Science" group, 1593 for the "Non-Science" group.

[3] Results are presented as beta, or standardized, regression coefficients. Nominal significance levels are given as follows: * = p<.05; ** = p<.01; *** = p<.001. No adjustment has been made for the two-stage probability sampling design.

APPENDIX

Definition of HS&B Variables Used in Regression Analyses

Background:

Social Class: A standardized SES composite measured at students' sophomore year of high school. Includes measures of family income, parental educational level, parental occupation level, and a sum of educationally related possessions in the home. All are self-reports.

Black: A dummy variable, taken from sophomore year self-report of racial status. Hispanic blacks are coded "Hispanic."

Hispanic: A dummy variable, taken from sohomore year self-report of ethnicity status.

Female: A dummy variable, coded "1" if student is female, "0" for males.

College Plans at Grade 8: A dummy variable ("1" = planned 4-year college, "0"= everyone else) measured retrospectively at sophomore year of high school.

College Plans at Grade 10: A dummy variable coded as above, measured at students' sophomore year of high school.

Ability: A composite achievment test taken at students' sophomore year of high school. Contains test scores for reading, vocabulary, and mathematics. Test is standardized with a mean of 50, a standard deviation of 10, for the entire HS&B sample.

HS Characteristics:

School Size: Principal's report of total enrollment of high school.

Catholic High School: If high school student attended was a Catholic high school.

Private High School: If high school student attended was a non-Catholic private high school.

Average School SES: Social class level of the high school, measured as an aggregate of student sample in each high school.

% Minority Enrollment: An estimate of the percent of the high school student body who are minority, either black or Hispanic. Taken as an aggregate of the student sample in each high school.

Average Math Course Enrollment: An estimate of the math coursetaking concentraiton in each high school, measured as an aggregate of the math course enrollment of the student sample in each high school.

Average Achievement: An aggregate measure of the average sophomore-year achievement test score for sampled students in each high school.

Curriculum Track:

Academic Track: A dummy variable for curriculum track followed in high school for each student. Coded "1" if student was in the college preparatory (academic) track, "0" if student is in either the general or vocational curriculum track.

HS Behaviors:

Homework: A self-report of the number of hours per week student spends on homework.

Number of Math Courses: A sum of the academic math courses (Algebra I, Geometry, Algebra II, Trigonometry, Math Analysis or Pre-Calculus, and Calculus. Taken from students' transcripts, rather than self-reports. All scores are in Carnegie units (i.e. one year). From high school transcripts.

Number of Science Courses: A sum of all science courses students have taken in high school, including general science. Taken from students' transcripts, rather than self-reports. Scores in Carnegie units. From high school transcripts.

Algebra 1, Geometry, Algebra 2, Trigonometry, Calculus, Computer Programming, Biology 1, Advanced Biology, Chemistry 1, Advanced Chemistry, Physics 1, Advanced Physics: Coded on this file as "0" or "1" according to whether student's transcript indicated he/she had taken at least one year of the course (i.e. one or more Carnegie units coded "1", otherwise "0"). From students' transcripts.

HS Outcomes:

Educational Aspirations: A 9-level self-report of educational aspirations measured at the senior year of high school. Score of "7" indicates plans to graduate from a 4-year college.

GPA in Math: Average grades in courses students took in math in high school, excluding non-academic math courses. Taken from students' high school transcripts.

GPA in Science Average grades in courses students took in science in high school, including general science. Taken from students' high school transcripts.

Math Achievement: A math achievement test administered by HS&B taken in the senior year of high school. Test measures basic abilities in mathematics, rather than mastery of content of higher-level math courses. Test has 38 items.

SAT-M (X): SAT mathematics scores for those who took the SAT test, otherwise ACT mathematics scores for ACT takers, equated to the SAT-M standard. Equating formula was derived using the scores of the 393 students on the file who took both tests. Equation for equating: SAT-M (X) = 250.283 +

12.27(ACT-M). The SAT-M and ACT-M scores correlated .83 with each other for the students who took both.

College Characteristics:

Junior College: A dummy variable typifying the first college student attended after high school. Coded "1" if college was a 2-year institution, "0" if a 4-year college.

Private College: A dummy variable typifying the first college student attended after high school. Coded "1" if college was a private institution, "0" if a public college.

College Behaviors:

Full-Time College: A dummy variable coding student's report of whether he or she attended college full time (coded "1") or part time (coded "0") in the first college attended after high school.

Working?: Whether or not student was working for pay in February 1984, the date of the second followup survey. Coded "1" for yes, "0" for no.

College GPA: Self-reported average grades in college (if student attended college), reported two years after high school graduation.

Sophomore Status: Dummy variable, coded "1" if student reported being in college full-time for four semesters after high school graduation.

Science Major Outcomes:

HS Senior-Year Intentions: Students who didn't exclude the possibility of attending college and who responded to the questionnaire item: "What is your intended field of study in college," were coded "1" if they intended a major in a science field (health and biological sciences, engineering, computer science, physical science, or mathematics) and "0" if they indicated another probable college major.

College Major: Students who attended college at least one semester during the first two years after high school and who indicated a declared or probable major were coded "1" if that field was in science (same categories as above) and "0" for all other fields.

Quantitive/Non-Quantitative Science Major Field: All those students coded "1" for intended college science major constitute the sample. Students indicating a proposed major in health or biological science were coded "0", those in engineering, computer science, physical science, or mathematics were coded "1".

FIGURE I: Path Diagram for Model Predicting Science Major Choice in High School

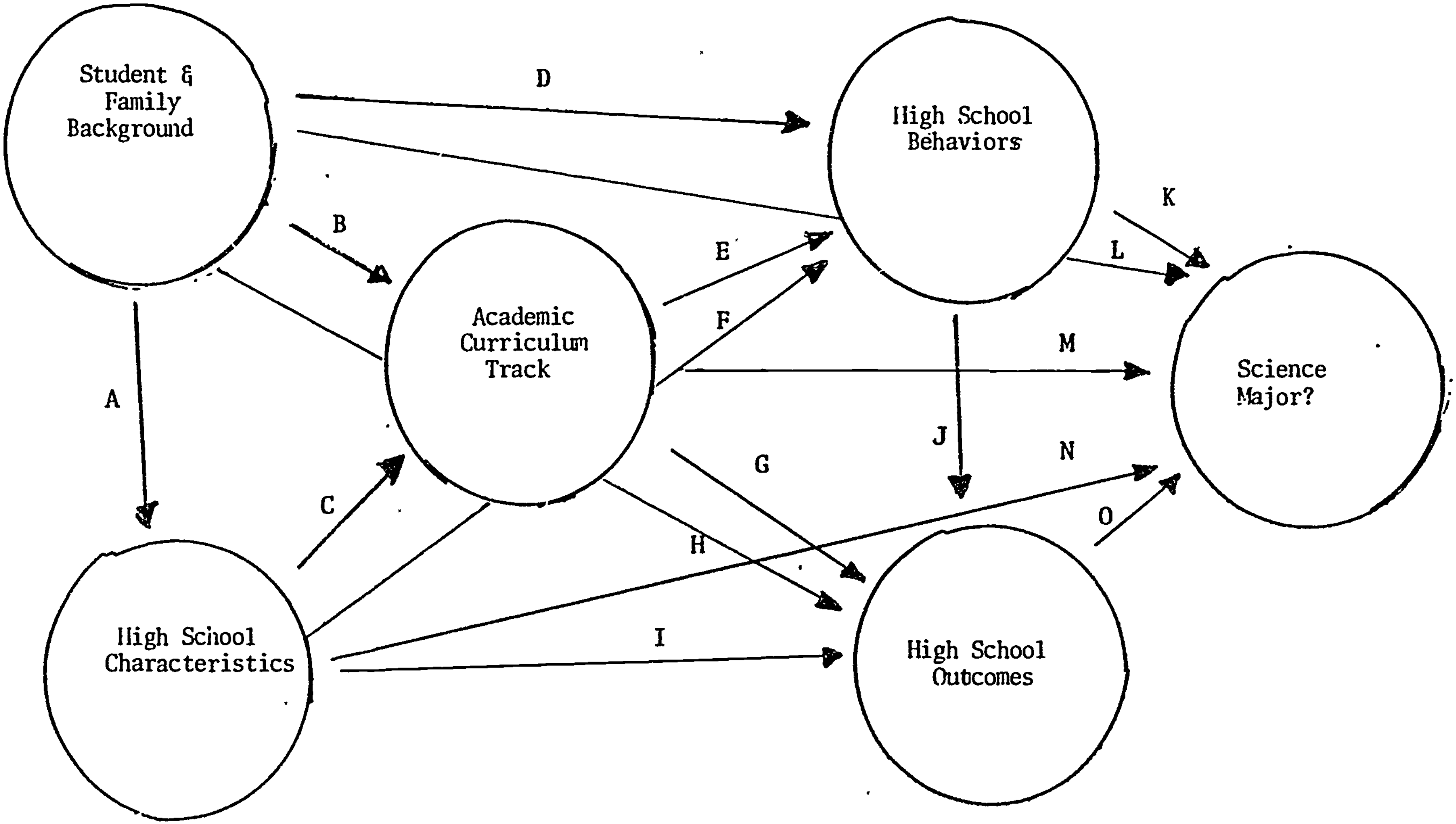

FIGURE 11: Path Diagram for Model Predicting Science Major Choice in College

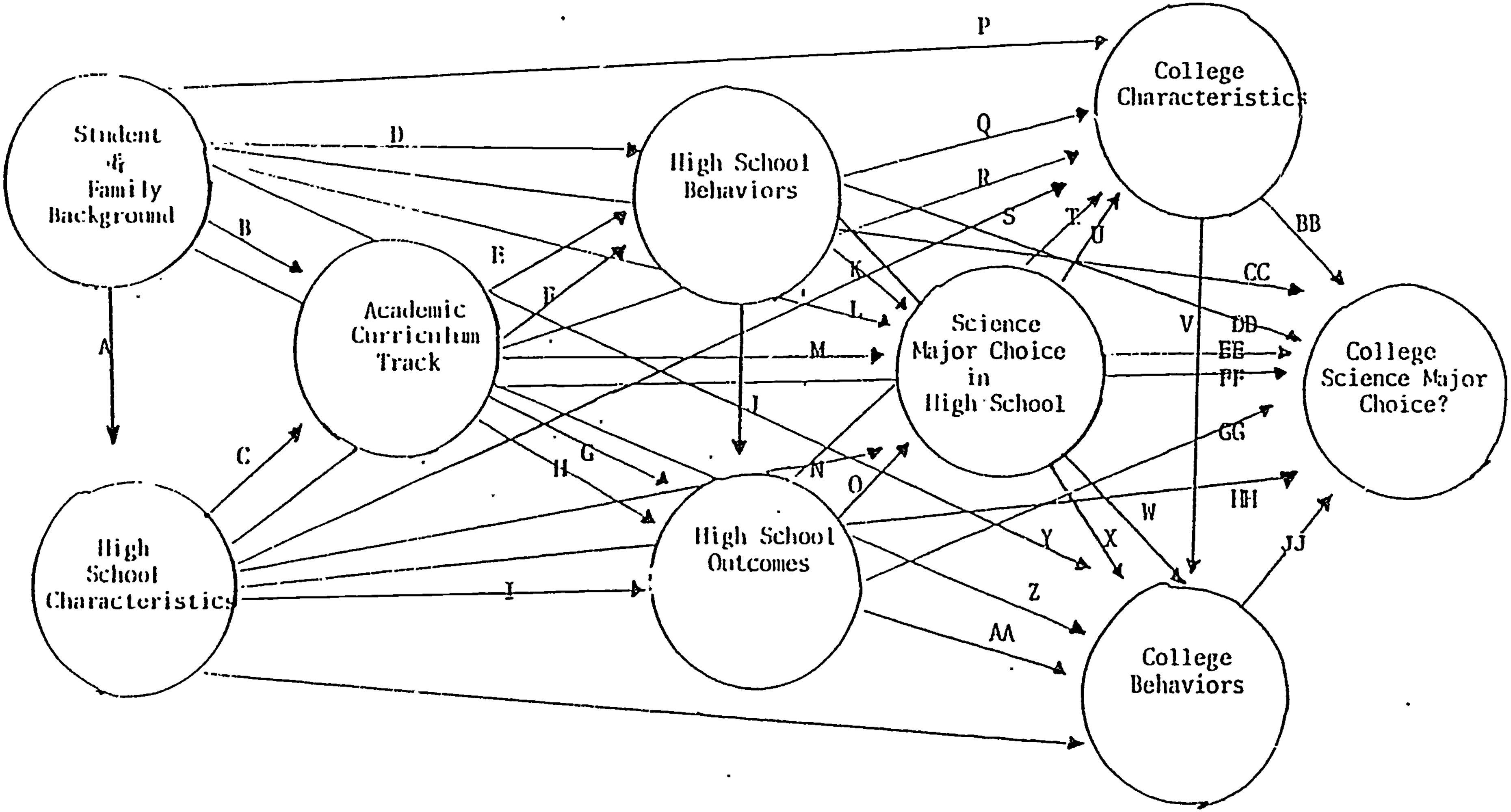

FIGURE III: Path Diagram for Model Predicting Quantitative or Non-Quantitative Field for College Science Majors