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ABSTRACT

This study focused on the relationship between high school students' course-taking patterns and their achievement of higher-order thinking skills. PLAN scores (in grade 10) and ACT Assessment scores (in grades 11 or 12) were collected for 73,818 students in 1,174 high schools. The findings show that, in a typical high school, eleventh- and twelfth-grade students who took upper-level mathematics or science courses had higher ACT Mathematics, Science Reasoning, and Composite scores than those who did not take these courses, regardless of their previous PLAN scores, gender, family income level, and ethnicity. Further, average score differences between males and females, and between Caucasian-Americans and ethnic minorities were reduced when these variables were considered. The effects of taking mathematics and science courses were relatively small for students attending schools in districts where per-pupil expenditures were low and the percentage of ethnic minority students was high. Two appendixes contain tables of correlation coefficients and descriptive statistics for scores and independent variables. (Contains 1 figure, 9 tables, 2 appendix tables, and 10 references.) (Author/SLD)

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Abstract

This study focused on the relationship between high school students' course-taking patterns and their achievement of higher-order thinking skills. PLAN scores (in grade 10) and ACT Assessment scores (in grade 11 or 12) were collected for 73,818 students in 1,174 high schools. The findings showed that, in a typical high school, 11th- and 12th-grade students who took upper-level mathematics or science courses had higher ACT Mathematics, Science Reasoning, and Composite scores than those who did not take these courses, regardless of their previous PLAN scores, gender, family income level, and ethnicity. Further, average score differences between males and females, and between Caucasian-Americans and ethnic minorities were reduced when these variables were considered. The effects of taking mathematics and science courses were relatively small for students attending schools in districts where per-pupil expenditures were low and the percentage of ethnic minority students was high.

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Factors Associated with Longitudinal Educational Achievement, As Measured by PLAN and ACT Assessment Scores

The courses that students take in high school, the quality of the instruction and counseling they receive, their motivation, and their backgrounds all affect their educational achievement. Examining the relationships among test scores, high school course-taking experiences, and student and high school characteristics can help provide supportive evidence for the use of test scores as tools for monitoring educational development. Moreover, such research improves our understanding of the effects of different schools on student achievement.

The ACT Assessment and PLAN tests (ACT, 1989, 1992, 1995a) are intended to measure higher-order thinking skills in four content areas (English, Mathematics, Reading, and Science Reasoning). The PLAN tests are used in educational and career planning of high school sophomores. The ACT Assessment tests are used in college admissions and course placement. Both assessments include course work information and student information sections.

Related research (e.g., ACT, 1994) consistently highlights discrepancies in educational achievement favoring students who have completed a college preparatory "core" of courses, compared to those who have not. This core of courses, as defined by ACT, includes four years of English, and three years each of mathematics, social studies, and natural sciences. Large differences in average achievement scores have been found favoring PLAN/ACT-tested students who indicated that they intended to complete, or had completed, college preparatory core course work, compared to those who did not (ACT, 1993).

Other studies have investigated student performance on either PLAN or the ACT Assessment and its relationship to course work taken or planned in high school (Noble & Powell, 1995; Noble, Crouse, Sawyer, & Gillespie, 1992; Noble, 1990; Noble & McNabb, 1989). The results supported the claim that students who have taken, are currently taking, or are planning to take college-preparatory course work not only have higher test scores but are better prepared academically for college. However, other than the 1993 ACT research noted above, all the research conducted to date concerning differential course-taking patterns and subsequent achievement, as measured by PLAN and ACT scores, has been based on data from students who had taken one test or the other, but not both. This study focused on cohort achievement and specific course-taking patterns using longitudinal student data (i.e., students had taken both PLAN and the ACT Assessment).

Because high school course requirements for graduation vary from state to state and across school districts, not all students who aspire to attend a postsecondary institution take three or four years of college preparatory courses in a subject area. Although these students may accumulate required credits for graduation in these subject areas, grouping their PLAN and/or ACT scores with those of students who have taken a college preparatory sequence of courses distorts overall achievement results. Consequently, achievement trends were investigated in terms of specific courses and patterns of course work taken, in order to understand the course-taking patterns within and across subject areas that contribute most to student achievement. Two specific questions were investigated:

- What are the relationships among courses taken, grades received, high school attended, ethnicity, gender, family income, and educational achievement, as measured by PLAN and ACT Assessment scores?
- How useful are courses taken, grades received, ethnicity, gender, and family income in modeling academic achievement, as measured by ACT scores, while statistically controlling for preexisting differences in academic achievement, as measured by PLAN scores?

The answers to these questions provide evidence for using PLAN and ACT Assessment scores as measures of student achievement and as tools for monitoring educational effectiveness.

Data

The PLAN/ACT cohort file for the graduating class of 1994 contained matched records of students who completed PLAN during their sophomore year (fall, 1991) and the ACT Assessment during their junior or senior year, prior to graduating in 1994.[1] If students took the ACT Assessment on more than one occasion, only the most recent ACT Assessment record was used. Each student record consisted of PLAN and ACT Assessment scores (i.e., English, Mathematics, Reading, Science Reasoning, and Composite scores), student background information (gender, family income, majority/minority ethnic group membership), and self-reported course work information (course work taken, course grades [ACT Assessment only]). Dummy-coded variables

[1]Virtually every student in the total matched file attended the same high school at the time of ACT testing that he or she had attended at the time of PLAN testing. There were some students (slightly less than 1%), however, who transferred to different schools prior to taking the ACT Assessment.

were created for gender (males = 0; females = 1), majority/minority ethnic group membership (Caucasian-American/White = 1; African-American/Black or Hispanic = 0), and course work taken (taken or currently taking = 1; not taken = 0). An ordered categorical variable was created for family income (less than $11,999 = 1; $12,000-$23,999 = 2; $24,000-35,999 = 3; $36,000-$49,999 = 4; $50,000 or more = 5).

The total matched file contained 191,025 student records from 3,088 high schools across the nation, with a minimum of 25 records per school. Of these, 73,818 student records from 1,174 high schools had valid values for all relevant independent and dependent variables. These student records were used in the analyses.

School and district demographic information from the Market Data Retrieval (MDR) data file was appended to each student record and included school location (urban/suburban/rural), district total per pupil expenditure, and district percentage of students below poverty level. The primary purpose for including these variables was to describe schools.

From information provided in the PLAN and ACT data files, variables that reflected students' course-taking patterns and grade averages were created. These variables were based on previous research (Noble, et al., 1992; Noble, 1990), and were used to address the chief issues in this investigation: the relationships among student course-taking patterns, course grades, and PLAN and ACT Assessment scores.

Method

Means and standard deviations were computed for PLAN scores, ACT scores, course work and grade information, and student and high school characteristics. These statistics were computed for each high school; the statistics were then summarized across schools using minimum, median, and maximum values. For comparative purposes, means and standard deviations based on data pooled over institutions were also computed for all relevant variables.

Correlation coefficients between ACT Assessment scores and relevant independent variables were calculated based on data pooled across all schools. Correlations between pairs of PLAN scores and ACT scores were fairly large, ranging from .69 (Science Reasoning) to .88 (Composite). These statistics are reported in Appendix A. Partial correlation coefficients were also computed between ACT scores and other independent variables after the effect of PLAN scores was removed. Those predictors with the strongest, statistically significant ($p < .001$) correlations with ACT Assessment scores were included in regression models for predicting ACT Assessment scores.

PLAN/ACT Regression Models

Preliminary regression models were developed for PLAN and ACT scores, using data pooled across all schools. In these models, ACT scores were regressed on logically-related PLAN scores (e.g., ACT Mathematics score was regressed on PLAN Mathematics, Science Reasoning, and Composite scores, but not on PLAN English score). The models were evaluated in terms of model statistical significance ($p < .001$), multiple R, standard error of estimate (SEE), and the statistical significance ($p < .001$) of the regression coefficient associated with each independent variable. In addition, for models that contained two or more PLAN scores as independent variables, only statistically significant, noncollinear PLAN scores were considered. Because of the large sample size, most regression coefficients were statistically significant for all of the models tested.

Models containing more than one PLAN score showed minimal increases in accuracy over the single independent variable models, as measured by multiple R and SEE. Models containing either the PLAN Composite score or Mathematics score as the independent variable were determined to be optimal for modeling all five ACT scores. These models are described below:

Test Score Models (N = 191,025)

Dependent variable	Independent variable	r	SEE
ACT Composite	PLAN Composite	.88	2.15
ACT English	PLAN Composite	.82	2.91
ACT Reading	PLAN Composite	.79	3.68
ACT Mathematics	PLAN Mathematics	.82	2.82
ACT Science Reasoning	PLAN Composite	.77	2.95

Curvilinear relationships between ACT and PLAN scores were investigated for the test score models by including second- and third-order polynomial terms. Although these terms were statistically significant ($p < .001$) for all of the models tested, multiple R was only slightly larger than that of models containing only a first-order polynomial term. The one-variable models were therefore used in subsequent analyses.

Additional Independent Variables

Although students' PLAN scores were the principal independent variables for modeling ACT Assessment scores, other potential independent variables were also investigated. This was done using stepwise selection. Additional independent variables were retained in the models only if (1) they were statistically significant ($p < .001$), over and above PLAN scores, (2) they resulted in a practical (i.e., 5%) increase in multiple R or decrease in SEE, and (3) they were not collinear with other independent variables. Because of the likelihood of misspecified models, the results of the stepwise selection method were confirmed by examining the simple correlations among the independent variables and ACT scores, and by determining whether the relationships were reasonable. For example, English course work taken may be positively associated with ACT Mathematics score, but such an association may not be as meaningful for explaining student achievement as is the association between mathematics course work and Mathematics score.

The selection of additional independent variables proceeded in the following manner: Blocks of independent variables were entered in models containing PLAN score (either Mathematics or Composite) as the only independent variable. Stepwise selection was then performed within blocks, where applicable. The order of entry (see A, B, & C in table below) of the blocks was varied to ensure that their contribution to explaining ACT Assessment performance was clearly understood, as shown below:

Blocks of Predictors and Their Order of Entry

Block	Description	Order of entry for block		
		A	B	C
Grade level/time variables	Educational level at the time of ACT Assessment testing, length of time between taking PLAN and the ACT Assessment	1	3	2
Student background variables	Gender, family income, ethnicity	2	1	4
Aspiration variables	Change over time in college-bound status, expressed need for help	3	4	3
Course work/grade variables	Courses taken and grades earned in those courses	4	2	1

Note: PLAN Mathematics or Composite scores were included in all models.

When stepwise regression analyses were performed on each separate block, no meaningful improvement in multiple R (5% increase) or SEE (5% decrease) was found as a result of including course work and grade variables, grade level and time variables, student background variables, or aspiration variables in the test score models. For example, when ACT Mathematics was regressed on PLAN Mathematics, the simple correlation between these variables was .81 (n = 73,818). When course grades for algebra II, geometry, and trigonometry, and variables indicating whether biology, chemistry, and physics were taken were added to this model, the increase in multiple R was only .03 (R = .84). Similar findings occurred for ACT English, Reading, Science Reasoning, and Composite models when selected course work variables (e.g., grade averages, number of courses taken, weighted grades in highest level courses taken) were added.

Final Model Development

Because multiple-independent variable models yielding meaningful increases in multiple R and/or decreases in SEE over the test score models could not be identified, an alternative, explanatory approach to model development was chosen. This approach capitalized on the fact that regression coefficients associated with course work variables could be used to describe the unit change in ACT score resulting from taking a particular course, while holding PLAN scores and other relevant variables constant. Because the course work variables were dichotomous, they could be interpreted as reflecting the difference in average ACT score associated with taking a particular course, while statistically controlling for differences in PLAN score, gender, family income, majority/minority ethnic group membership, and the other course work taken. For example, a regression coefficient of 1.5 for the independent variable trigonometry in the ACT Mathematics model indicates that when other differences were statistically controlled, the average ACT Mathematics score for students who took trigonometry was 1.5 scale score units higher than the average ACT Mathematics score for students who did not take trigonometry.

Course Work Taken

For the ACT Mathematics, Science Reasoning, and Composite score models, we focused on courses taken in mathematics and science. The relationships between these courses and ACT Mathematics and Science Reasoning scores were logical and easily interpreted. In addition, mathematics and science courses taken were more strongly correlated with these ACT scores than were other courses taken. English and social studies course work taken contributed only minimally, if at all, to multiple R for ACT English and Reading models, over and above PLAN Composite score. We therefore included only PLAN Composite score and student demographic characteristics as independent variables in these models.

High School Attended

Because PLAN scores were to be included as covariates (to control for preexisting differences in the academic achievement of sophomores), including high school as an effect-coded dummy variable in the models was contingent upon satisfying the (ANCOVA) assumption of homogeneous slopes and residual variances across high schools. If heterogeneous slopes were found, then this would require fitting a separate regression equation for each school.

To test the assumption of homogeneity of slopes, high school attended by PLAN score interactions were included in an ANCOVA model containing PLAN score and high school main effects. Three random samples of 20 high schools each, and two random samples of 480 high schools each were drawn for the ANCOVA analysis[2]. Effect sizes for the interactions were computed as the range (maximum - minimum) of the regression coefficients divided by their average standard error. The effect sizes were sufficiently large to conclude that the slopes differed across high schools.

Because the assumption of homogeneous slopes was not met, within-school regression equations were developed. These equations utilized a common set of independent variables, and relevant within-school regression statistics (e.g., multiple R,

[2]Random samples of high schools were drawn because including all 3,088 high schools in the analysis exceeded computing resources.

SEE, regression coefficients) were summarized across schools using minimum, median, and maximum values. Variability in regression statistics across schools would help illustrate the effect of high school attended on educational achievement. The final models were:

ACT English	=	*f* (PLAN Composite; gender; family income; majority/minority ethnic group membership)
ACT Mathematics	=	*f* (PLAN Mathematics; trigonometry, calculus, chemistry, and physics course work taken; gender; family income; majority/minority ethnic group membership)
ACT Reading	=	*f* (PLAN Composite; gender; family income; majority/minority ethnic group membership)
ACT Sci. Reas.	=	*f*(PLAN Composite; trigonometry, calculus, chemistry, and physics course work taken; gender; family income; majority/minority ethnic group membership)
ACT Composite	=	*f*(PLAN Composite; trigonometry, calculus, chemistry, and physics course work taken; gender; family income; majority/minority ethnic group membership)

To further assess the effect of high school attended on students' ACT Assessment performance, given their PLAN scores and demographic variables, each high school was classified into one of five categories of expected ACT Assessment performance. High schools with predicted mean ACT Composite scores that differed by ± 2 score units from the pooled predicted mean ACT Composite score across all students and schools were categorized as performing above expectation (+ 2 or more score units) or below expectation (-2 or fewer score units). To be classified as performing above or below expectation, predicted school means were also required to be statistically significantly different ($p < .001$) from the pooled predicted mean ACT Composite score. A description of this method is provided in ACT (1995b). Additional performance categories were also identified: performance slightly above expectation (+1 or more score units, but less than +2 score units), performance slightly below expectation (-1 or fewer score units, but no fewer than -2 score units), and performance as expected (between -1 and +1 score units). Schools with predicted means that were not statistically significantly different from the pooled predicted mean ACT Composite score were placed in the category of performance as expected, regardless of the difference in score units. Regression statistics and school characteristics were summarized across high schools within school performance category.

Results

Descriptive statistics, summarized across schools, for PLAN scores, ACT Assessment scores, course work taken, and student background variables are shown in Table 1. Minimum, median, and maximum values summarize the distribution of statistics (mean or percentage) across the 1,174 high schools that had at least 25 students with valid values on the relevant variables (n = 73,818). The median value represents the mean observed in the typical high school.

Mean PLAN scores typically ranged from 19.2 (Reading) to 20.0 (English) across schools; for the ACT Assessment, typical means ranged from 21.6 (Mathematics) to 23.0 (Reading). In general, the ACT Assessment and PLAN score means summarized across high schools were very similar to the corresponding means based on pooled data, which are shown in Appendix B.

TABLE 1

Distribution, Across Schools, of Descriptive Statistics for PLAN Scores, ACT Assessment Scores, and Independent Variables (Number of schools = 1174)

Statistic	Variable		Med.	Min.	Max.
Mean	PLAN				
		English	19.9	13.2	24.2
		Mathematics	19.3	14.3	22.9
		Reading	19.2	12.3	23.3
		Science Reasoning	19.3	15.1	22.2
		Composite	19.5	13.8	23.1
	ACT Assessment				
		English	22.3	15.5	27.3
		Mathematics	21.6	15.8	27.1
		Reading	23.0	15.3	29.3
		Science Reasoning	22.4	16.3	27.0
		Composite	22.5	16.1	27.7
Percent	Course work taken				
		Trigonometry	48	3	98
		Calculus	12	1	59
		Chemistry	86	23	100
		Physics	29	2	96
	Gender				
		Female	59	1	99
		Male	41	1	99
	Family income				
		Less than $11,999	5	0	62
		12,000 - 23,999	11	1	44
		24,000 - 35,999	19	2	58
		36,000 - 49,999	21	2	50
		50,000 or more	40	2	89
	Majority/minority				
		Majority	94	2	100
		Minority	6	1	98

Median percentages of course work taken ranged from 12% (calculus) to 86% (chemistry). Across schools, the typical percentage of females (59%) was larger than the percentage of males, the median percentage of students reporting a family income of $50,000 was 40%, and the median percentage of students indicating that they were ethnic minorities was 6%. These percentages were similar to those based on pooled data (see Appendix B).

Student and School Performance Differences

Regression Statistics Summarized across All Schools

Distributions of student sample sizes, multiple Rs, standard errors of estimate (SEEs), and (unstandardized) regression coefficients are shown, by ACT Assessment test score model, in Tables 2a and 2b. Table 2a includes results for ACT Mathematics, Science Reasoning, and Composite scores. Table 2b includes results for ACT English and Reading. The English and Reading models are presented separately because they did not include course work taken variables.

Table 2a shows, for example, that ACT Mathematics score was modeled as a function of PLAN Mathematics score, gender, family income, majority/minority ethnic group membership, and whether or not trigonometry, calculus, chemistry, and physics were taken. Student sample sizes, across schools, ranged from 25 to 380 for the ACT Mathematics model (see the first row of numbers in Table 2a). The median multiple R, across schools, for the ACT Mathematics model was .87, with a median SEE of 2.44. Median regression coefficients for this model ranged from -.64 (gender) to 1.37 (trigonometry). Median multiple Rs for all models were fairly large, ranging from .79 (Reading, see Table 2b) to .91 (Composite). Median SEEs ranged from 1.94 (Composite) to 3.59 (Reading).

TABLE 2a

Distributions, Across Schools, of Regression Statistics for Modeling ACT Mathematics, Science Reasoning, and Composite Scores (Number of schools = 1174)

	ACT Assessment score								
	Mathematics			Science Reasoning			Composite		
Statistic	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.
N[1]	49	25	380	49	25	380	49	25	380
R	.87	.55	.98	.82	.42	.95	.91	.63	.97
SEE	2.44	1.11	3.64	2.70	1.16	4.15	1.94	1.15	3.25
Intercept	4.10	-11.02	18.70	3.46	-8.62	24.21	.71	-10.21	14.19
Regression coefficients									
PLAN Mathematics /Composite[2]	.80	.12	1.53	.92	.21	1.68	1.04	.57	1.45
Trigonometry	1.37	-4.41	7.80	.43	-6.59	5.39	.62	-3.26	4.85
Calculus	1.27	-7.34	10.50	.19	-8.91	7.52	.50	-5.53	5.07
Chemistry	.87	-8.07	8.05	.66	-8.15	8.17	.61	-5.03	5.84
Physics	.97	-5.57	6.87	.56	-8.45	8.60	.49	-3.06	7.23
Gender	-.64	-4.91	3.17	-1.51	-4.86	2.45	-.60	-3.55	2.10
Family income	.03	-.69	.90	.02	-.72	.68	.04	-.65	1.02
Majority/minority	.42	-8.24	8.72	.67	-8.01	11.93	.48	-5.72	7.14

[1]N = number of students.
[2]PLAN Mathematics score was used to model ACT Mathematics score. PLAN Composite score was used to model ACT Science Reasoning and Composite scores.

TABLE 2b

Distributions, Across Schools, of Regression Statistics for Modeling ACT English and Reading Scores (Number of schools = 1174)

	ACT Assessment score					
	English			Reading		
Statistic	Med.	Min.	Max.	Med.	Min.	Max.
N[1]	49	25	380	49	25	380
R	.83	.50	.94	.79	.44	.94
SEE	2.76	1.73	4.28	3.59	2.15	5.47
Intercept	-2.24	-17.30	10.60	-3.92	-19.54	11.26
Regression coefficients						
PLAN Composite	1.18	.64	1.74	1.36	.67	2.01
Gender	.53	-2.52	3.84	-.11	-5.25	4.47
Family income	.08	-.78	1.00	.03	-1.03	1.16
Majority/minority	.48	-7.06	8.46	.36	-10.55	10.46

[1]N = number of students.

The course work regression coefficients reflect the average difference in ACT score associated with taking or not taking a particular course. When differences in PLAN score, gender, majority/minority ethnic group membership, and family income were statistically controlled, students who took trigonometry, calculus, chemistry, or physics typically showed higher average ACT scores than students who did not take the courses. The typical (median) difference in mean ACT score between students taking and not taking a particular course ranged from .19 scale score units (on ACT Science Reasoning for calculus) to 1.37 scale score units (on ACT Mathematics for trigonometry). Mean score differences were largest for ACT Mathematics[3].

Negative course work regression coefficients that exceeded the respective standard errors of measurement for the ACT Assessment tests were found for about six percent of the schools, indicating a higher mean ACT score for students not taking a particular course[4]. In many instances, these coefficients were associated with relatively small within-school sample sizes. Negative coefficients were also found for some schools in which very small percentages (e.g., 2%) of students had taken a particular mathematics or science course. One possible explanation for this finding is that a school's more academically able students (i.e., those who earn high ACT scores) might elect not to take a particular course, for whatever reason. For example, a large percentage of students who took trigonometry at a particular school might, because of a teacher's reputation, choose not to take calculus. In spite of this, these students might earn high ACT Mathematics scores, resulting in an inverse relationship between calculus course taking and test score. Of course, it is possible that the negative regression coefficients accurately reflect the relationship between ACT scores and course taking at some schools. Regardless of the reasons for negative regression coefficients occurring for some

[3]When examining course work regression coefficients, it is important to consider that the scale score units for each test are not equivalent. The scales were not constructed to ensure that a particular scale score on one test is comparable to the same scale score on another test (e.g., a 21 on the Mathematics test is not comparable to a 21 on the Science Reasoning test). Although mean score differences were largest for ACT Mathematics, this does not necessarily mean that the effect of course taking was greatest for this test, relative to effects for the other tests.

[4]The standard errors of measurement for ACT Mathematics, Science Reasoning, and the Composite are approximately 1.5, 2, and 1 scale score units, respectively.

schools, their effect on the findings is likely minimal, given the large number of schools in this study.

Gender. The regression coefficients associated with gender reflect the typical adjusted mean difference in ACT scores between males and females, when all other variables were statistically controlled. Note that the sign (-) of the regression coefficient for gender simply reflects its arbitrary coding (females = 1, males = 0). Males, on average, had higher mean ACT Mathematics, Science Reasoning, and Composite scores than did females when PLAN score, course work, family income, and majority/minority ethnic group membership were statistically controlled. The Reading scores of males were also higher than those of females when PLAN score, family income, and majority/minority ethnic group membership were statistically controlled. Median average score differences ranged from .60 (Composite) to 1.51 scale score units (Science Reasoning). Females, however, typically had higher average ACT English scores than did males when PLAN score, family income, and majority/minority ethnic group membership were statistically controlled (median average score difference = .53).

Although average score differences for males and females might seem fairly large, gender differences in performance were, in fact, reduced considerably when other background and course work variables were statistically controlled. As shown in Table 3, when gender was included as the only independent variable in the ACT Mathematics model (i.e., PLAN score, background variables, and course work variables were *not* statistically controlled), the median regression coefficient associated with this variable was relatively large (1.58 vs. .64). In other words, the typical ACT Mathematics mean for males was 1.58 scale score units higher than that for females, when PLAN score, background variables, and course work variables were not statistically controlled. When these variables were statistically controlled, this difference decreased to .64 score units.

Findings for the ACT Science Reasoning and Composite models, summarized in Table 3, indicated that gender differences in performance were similarly reduced by statistically controlling for PLAN score, background, and course work variables. The same is true for ACT English when statistically controlling for PLAN score and background. However, the reductions for these three models were much smaller than those for the Mathematics model. Findings for the Reading model, on the other hand, indicated a slight increase in average score differences by gender when PLAN score and background variables were statistically controlled.

TABLE 3

Median Regression Coefficients for Gender and Majority/Minority Ethnic Group Membership

	Median regression coefficients			
ACT Assessment score	Gender only	Gender, given course work taken[1], majority/minority membership, family income, & PLAN score	Majority/minority membership only	Majority/minority membership, given course work taken[1], family income, & PLAN score
English	.57	.53	2.52	.48
Mathematics	-1.58	-.64	2.14	.42
Reading	-.07	-.11	2.81	.36
Science Reasoning	-1.56	-1.51	2.48	.67
Composite	-.67	-.60	2.42	.48

[1]Course work variables were not included in ACT English and Reading models.

Ethnicity and income. Caucasian-American students typically had higher mean ACT scores than did ethnic minority students when PLAN score, course work (ACT Mathematics, Science Reasoning, and Composite models only), gender, and family income were statistically controlled. The median differences in average score ranged from .36 (Reading) to .67 (Science Reasoning) scale score units. When majority/minority ethnic group membership was used singly to model ACT Assessment scores, typical average ACT score differences were considerably larger, ranging from 2.14 (Mathematics; see Table 3) to 2.81 (Reading) scale score units. This suggests that the other variables included in the models played a significant role in diminishing the effects of differential ACT Assessment performance between majority and minority ethnic groups.

Family income level contributed very little to average ACT performance differences when PLAN score, course work, gender, and majority/minority ethnic group membership differences were statistically controlled. Typical average ACT score differences between family income levels did not exceed .08 scale score units in any of the models.

Regression Statistics by School Performance Category

Tables 4a-4c show distributions, across schools, of regression statistics by school performance category. Each table corresponds to a different ACT test score model (Mathematics, Science Reasoning, Composite). Regression statistics by school performance category were not developed for the English and Reading models because course work variables (the only variables directly relevant to school attended) were not included in these models. There were 125, 664, and 90 schools, respectively, in the categories of performance below expectation, performance as expected, and performance above expectation.

TABLE 4a

Distributions, Across Schools, of Regression Statistics, for ACT Mathematics, by School Performance Category

	School performance category								
	Below expectation (k=125)			As expected (k=664)			Above expectation (k=90)		
Statistic	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.
N[1]	43	25	182	46	25	380	58	27	228
R	.84	.55	.95	.87	.69	.98	.88	.78	.95
SEE	2.33	1.11	3.46	2.45	1.18	3.58	2.47	1.65	3.58
Intercept	5.91	-4.16	13.38	3.56	-7.61	17.27	5.07	-9.37	18.70
Regression coefficients									
PLAN Mathematics	.67	.12	1.09	.82	.16	1.53	.80	.15	1.11
Trigonometry	1.24	-1.97	5.50	1.33	-4.41	7.42	1.50	-3.36	4.98
Calculus	1.26	-5.10	5.75	1.36	-7.34	10.50	.96	-4.74	4.07
Chemistry	.72	-3.31	5.21	.88	-5.21	7.92	1.17	-8.07	7.12
Physics	1.19	-1.92	4.83	.92	-5.57	6.87	1.03	-2.89	5.43
Gender	-.70	-3.71	1.53	-.65	-4.91	2.91	-.67	-2.62	1.82
Family income	.02	-.48	.56	.03	-.69	.90	.05	-.34	.89
Majority/minority	.36	-3.34	4.60	.47	-8.24	8.72	.29	-8.02	5.84

[1]N = number of students, k = number of schools.

TABLE 4b

Distributions, Across Schools, of Regression Statistics, for ACT Science Reasoning, by School Performance Category

	School performance category								
	Below expectation (k=125)			As expected (k=664)			Above expectation (k=90)		
Statistic	**Med.**	**Min.**	**Max.**	**Med.**	**Min.**	**Max.**	**Med.**	**Min.**	**Max.**
N[1]	43	25	182	46	25	380	58	27	228
R	.80	.42	.93	.82	.57	.95	.82	.68	.92
SEE	2.59	1.16	3.70	2.71	1.61	3.83	2.78	2.11	4.15
Intercept	4.06	-4.52	14.91	3.25	-8.62	16.47	3.07	-8.55	13.91
Regression coefficients									
PLAN Composite	.81	.21	1.54	.94	.28	1.68	.92	.57	1.36
Trigonometry	.43	-5.36	4.59	.38	-6.59	4.68	.52	-3.85	4.33
Calculus	.03	-6.12	6.50	.16	-8.91	7.52	.47	-5.51	4.99
Chemistry	.45	-3.63	4.87	.69	-8.15	8.17	.75	-5.69	5.74
Physics	.41	-3.85	5.23	.58	-8.45	8.60	.62	-2.96	5.20
Gender	-1.15	-4.69	2.06	-1.53	-4.86	2.45	-1.62	-4.20	2.42
Family income	.03	-.58	.64	.01	-.72	.59	.04	-.45	.63
Majority/minority	.77	-4.99	10.17	.64	-6.77	10.42	.92	-4.28	11.93

[1]N = number of students, k = number of schools.

TABLE 4c

Distributions, Across Schools, of Regression Statistics, for ACT Composite, by School Performance Category

Statistic	School performance category								
	Below expectation (k=125)			As expected (k=664)			Above expectation (k=90)		
	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.
N[1]	43	25	182	46	25	380	58	27	228
R	.89	.70	.97	.91	.63	.97	.91	.75	.96
SEE	1.90	1.18	3.25	1.96	1.15	3.12	1.92	1.47	2.57
Intercept	.79	-6.79	6.08	.50	-9.69	10.89	1.84	-10.21	10.48
Regression coefficients									
PLAN Composite	1.02	.57	1.36	1.06	.57	1.45	1.01	.64	1.34
Trigonometry	.43	-2.82	4.24	.62	-3.26	3.73	.69	-2.56	3.18
Calculus	.46	-4.03	4.92	.51	-5.53	5.07	.56	-3.96	3.77
Chemistry	.38	-3.57	3.98	.65	-5.03	5.84	.56	-2.71	4.54
Physics	.66	-2.50	4.51	.51	-3.06	7.23	.38	-2.39	3.73
Gender	-.53	-2.47	2.10	-.61	-3.55	2.06	-.64	-2.70	1.45
Family income	.06	-.47	.51	.03	-.65	.54	.05	-.31	1.02
Majority/minority	.56	-4.21	5.90	.49	-5.72	6.35	.40	-4.09	7.14

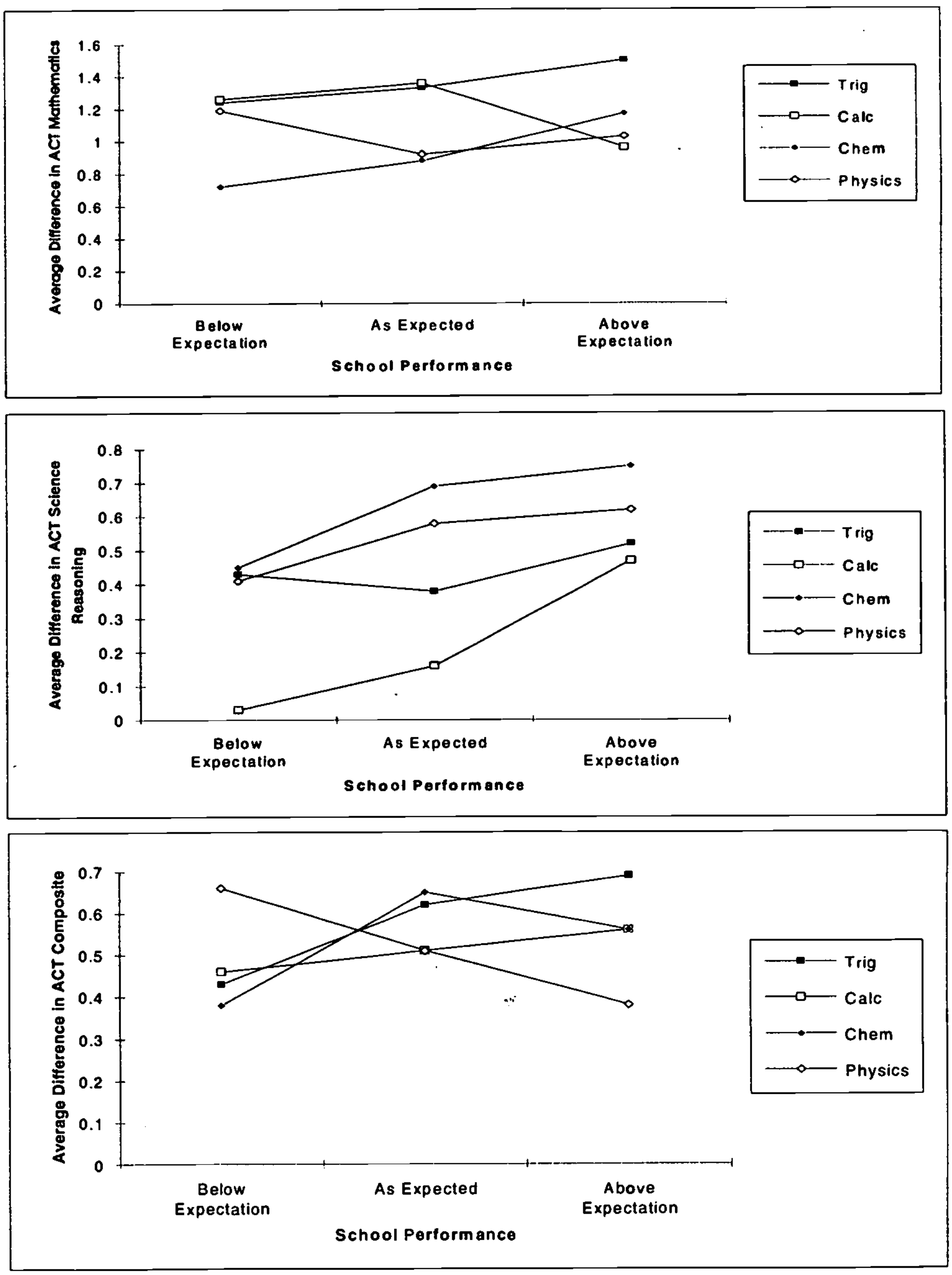
[1]N = number of students, k = number of schools.

Median average differences in ACT score for students taking and not taking the courses, represented by the median regression coefficients for the Mathematics, Science Reasoning, and Composite models, are plotted by school performance in Figure 1. The effect of taking trigonometry, calculus, chemistry, and physics differed across school performance categories for each model: In general, smaller average score differences between students taking and not taking a given course were associated with lower-performing schools, whereas larger average score differences were associated with higher-performing schools. Figure 1 illustrates, for example, that for schools categorized as performing below expectation, the median average ACT Mathematics score was 1.24 scale score units higher for students taking trigonometry than for students not taking trigonometry. For schools categorized as performing as expected and performing above expectation, median average Mathematics score differences were somewhat larger (1.33 and 1.50, respectively).

The effect of taking trigonometry, calculus, chemistry, and physics was greatest for ACT Mathematics score, relative to ACT Science Reasoning and Composite scores. The first plot in Figure 1 shows that across school performance categories, average score differences in ACT Mathematics score ranged from .72 (chemistry) to 1.50 (trigonometry) scale score units when PLAN score, gender, family income, and majority/minority ethnic group membership were statistically controlled. The second and third plots in Figure 1 show the results for Science Reasoning and Composite scores. On ACT Science Reasoning, average score differences typically ranged from .03 (calculus) to .75

(chemistry) scale score units. On the ACT Composite, average score differences ranged from .38 (chemistry and physics) to .69 (trigonometry) scale score units.

FIGURE 1. Median Increase in ACT Score for Courses Taken, by School Category.



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The effects of gender, ethnicity, and family income were also compared across school performance categories. In all cases, no differences were found across performance categories: Coefficients for these variables were comparable to those based on data summarized across schools (see Table 2a).

Characteristics of Schools

Table 5 contains distributions across schools of descriptive statistics, by school performance category. The results in this table show trends in student test performance and course taking across school performance categories. As might be expected, relatively low average PLAN and ACT Assessment performance was associated with students at lower-performing schools, whereas relatively high average test performance was associated with students at higher-performing schools. Similarly, relatively smaller median percentages of courses taken were associated with students at lower-performing schools; larger percentages occurred for students at higher-performing schools.

Table 6 summarizes school characteristics across school performance categories. Of the schools categorized as performing below expectation, 85% were located in districts where 12% or more of students were below the poverty level. For schools performing as expected and schools performing above expectation, only 35% and 9%, respectively, were located in districts where 12% or more of students were below the poverty level.

The district per-pupil expenditure of schools categorized as performing below expectation was lower than that of schools categorized as performing as expected. This expenditure, in turn, was lower than that of schools categorized as performing above

TABLE 5

Distributions, Across Schools, of Descriptive Statistics for PLAN Scores, ACT Assessment Scores, and Independent Variables, by School Performance Category

		School performance category								
		Below expectation (k[1]=125)			As expected (k=664)			Above expectation (k=90)		
Statistic	Variable	Med.	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.
Mean	PLAN									
	English	17.7	13.3	19.9	19.9	14.9	22.9	21.9	20.0	24.2
	Mathematics	17.1	14.4	19.2	19.3	16.2	21.6	21.4	19.7	22.8
	Reading	16.9	12.5	19.0	19.2	15.7	22.4	21.1	19.9	23.4
	Science Reasoning	17.5	15.1	19.2	19.3	16.5	21.9	20.8	19.8	22.2
	Composite	17.5	13.9	18.8	19.5	16.8	21.4	21.4	20.5	23.1
	ACT Assessment									
	English	19.6	15.5	21.3	22.3	17.6	24.7	24.8	23.6	27.3
	Mathematics	18.6	16.0	21.6	21.6	18.3	25.0	24.6	23.0	27.1
	Reading	19.9	15.4	21.7	23.0	16.8	26.2	26.0	24.3	29.3
	Science Reasoning	19.6	16.4	21.3	22.4	17.0	24.5	24.7	23.4	27.0
	Composite	19.6	16.1	20.5	22.5	17.5	24.6	25.0	24.5	27.7
Percent	Course work taken									
	Trigonometry	41	7	97	47	3	98	63	9	94
	Calculus	11	2	44	12	1	55	15	2	59
	Chemistry	85	26	98	86	23	99	91	28	99
	Physics	27	6	83	28	2	96	39	8	94
	Gender									
	Female	62	33	99	59	1	99	60	37	82
	Male	38	1	67	41	1	99	40	18	63
	Family income									
	Less than $11,999	12	3	61	4	1	48	3	1	13
	12,000 - 23,999	20	3	44	10	1	41	6	1	19
	24,000 - 35,999	24	7	46	19	3	48	12	2	39
	36,000 - 49,999	20	2	42	23	3	48	19	3	41
	50,000 or more	21	2	64	40	3	89	60	18	88
	Majority/minority									
	Majority	73	2	98	95	4	99	97	56	99
	Minority	27	2	98	5	1	96	3	1	44

[1]k = number of schools.

TABLE 6

Percentages for Selected Background Variables, by School Performance Category

		School performance category		
Level	Variable	Below expectation (k[1]=125)	As expected (k=664)	Above expectation (k=90)
School district	Percent below poverty level			
	0 - 4.9%	1	30	52
	5 - 11.9%	15	35	39
	12 - 24.9%	54	31	8
	25% or more	31	4	1
	Per-pupil expenditure			
	$.00 - 3199.99	32	25	12
	3200 - 4199.99	41	40	29
	4200 - 5199.99	12	18	18
	5200 or more	15	17	42
	Location			
	Rural	47	30	15
	Suburban	26	43	50
	Urban	27	27	36
Student	Race/ethnicity			
	African-American	22	5	3
	Asian-American	0	0	0
	Caucasian-American	67	91	95
	Hispanic	11	5	3

[1]k = number of schools.

expectation. The majority of schools categorized as performing below expectation were identified as having rural locations (47%), rather than suburban (26%) or urban (27%) locations. In comparison, the majority of schools categorized as performing as expected or performing above expectation were identified as having suburban locations (43% and

50%, respectively). At schools categorized as performing below expectation, relatively large percentages of students indicated that they were members of ethnic minority groups (33%). At schools performing above expectation, relatively large percentages of students indicated that they were Caucasian-American (95%).

Discussion

The results of this study indicate that, in a typical high school, students who take upper-level mathematics or science courses (e.g., trigonometry, calculus, chemistry, or physics) can expect, on average, to earn meaningfully higher ACT Mathematics, Science Reasoning, and Composite scores than students who do not take these courses. This is true regardless of students' gender, family income, majority/minority ethnic group membership and PLAN scores. Taking English and social studies courses has little, if any, effect on ACT English and Reading scores, while controlling for PLAN score. This does not imply that students receive no benefit from taking these courses, however; it merely suggests weaker content relationships for English and social studies courses, while controlling for PLAN score, relative to those observed for mathematics and science courses.

The effects of taking mathematics and science courses varied across school performance categories. Generally, smaller mean differences in ACT score were associated with schools performing below expectation. This indicates that taking mathematics and science courses will differentially affect the achievement of higher-order thinking skills of students, as measured by ACT scores, depending on the school they attend. Schools in poorer districts with higher percentages of ACT-tested ethnic minorities are more likely to show small mean differences than are other types of schools. These achievement differences are likely attributable to such factors as differences in instruction, course content, or instructional materials, although other factors could also account for them.

The models examined in this study provide some insight into differences in ACT Assessment performance for different population subgroups. The results show that ACT performance differences, particularly on the Mathematics test, are reduced for males and females when PLAN score, course work taken, majority/minority membership, and family income are considered. Similarly, ACT score differences between Caucasian-Americans and ethnic minorities are considerably reduced when PLAN score, course work taken, gender, and family income are considered. It is likely that other important (i.e., non-cognitive) variables could reduce these differences further.

Family income level contributed minimally to average ACT performance differences when controlling for PLAN score, course work taken, and background variables. This suggests that most of the sources of ACT performance differences among students with varying income backgrounds were identified in this study.

References

American College Testing (1989). Preliminary technical manual for the enhanced ACT Assessment. Iowa City, IA: Author.

American College Testing (1992). EPAS: ACT's educational planning and assessment system. Iowa City, IA: Author.

American College Testing (1993). Users' guide for AIM reports. Iowa City, IA: Author.

American College Testing (1994). ACT Assessment high school profile report. Iowa City, IA: Author.

American College Testing (1995a). PLAN technical manual. Iowa City, IA: Author.

American College Testing (1995b). Alternative methods of deriving an achievement index for AIM reports. Unpublished manuscript.

Noble, J. (1990). Using P-ACT+ in the Tennessee comprehensive assessment program. Unpublished manuscript.

Noble, J., Crouse, J., Sawyer, R. and Gillespie, M. (1992). Ethnic/Gender bias and the differential preparation hypothesis: Implications for performance on the ACT Assessment. A paper presented at the annual meeting of the American Educational Research Association.

Noble, J. and McNabb, T. (1989). Differential course work in high school: Implications for performance on the ACT Assessment. (ACT Research Report No. 89-5). Iowa City, IA: American College Testing.

Noble, J., & Powell, D. (1995). Factors influencing differential performance on higher-order thinking skills tests. A paper presented at the annual meeting of the American Educational Research Association in San Francisco, California.

Appendix A

TABLE A.1

Correlation Coefficients Among ACT Assessment Scores and PLAN Scores (Based on Data Pooled over High Schools, N = 73,818)

		PLAN scores					ACT Assessment scores			
		English	Mathematics	Reading	Science Reasoning	Composite	English	Mathematics	Reading	Science Reasoning
PLAN	Mathematics	.63								
	Reading	.68	.56							
	Science Reasoning	.65	.63	.67						
	Composite	.88	.81	.86	.84					
ACT	English	.80	.63	.68	.65	.82				
	Mathematics	.61	.82	.54	.62	.75	.67			
	Reading	.71	.58	.72	.67	.78	.78	.61		
	Science Reasoning	.64	.68	.64	.69	.77	.71	.73	.74	
	Composite	.78	.76	.73	.74	.88	.89	.84	.90	.89

Appendix B

TABLE B.1

Descriptive Statistics for PLAN Scores, ACT Scores, and Independent Variables (Based on Data Pooled over High Schools[1])

Variable	Statistic		
	Mean	SD	Percent
PLAN			
English	19.8	4.4	-
Mathematics	19.3	3.8	-
Reading	19.2	4.6	-
Science Reasoning	19.3	3.2	-
Composite	19.5	3.4	-
ACT Assessment			
English	22.3	5.0	-
Mathematics	21.8	4.9	-
Reading	23.0	5.9	-
Science Reasoning	22.4	4.6	-
Composite	22.5	4.5	-
Course work taken			
Trigonometry	-	-	49
Calculus	-	-	13
Chemistry	-	-	81
Physics	-	-	33
Gender			
Female	-	-	58
Male	-	-	42
Family income			
Less than $11,999	-	-	5
12,000 - 23,999	-	-	11
24,000 - 35,999	-	-	19
36,000 - 49,999	-	-	21
50,000 or more	-	-	45
Majority/minority			
Majority	-	-	89
Minority	-	-	11

[1]Total number of students = 73,818.

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