
How High School Organization Influences the Equitable Distribution of Learning in Mathematics and Science

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Using a sample of 9,631 students in 789 U.S. high schools with three waves of data from the National Education Longitudinal Study of 1988, the study presented here was an extension of an earlier study that found positive effects for practices that are consistent with the restructuring movement on learning in the first two years of high school and on the equitable distribution of learning by social class. The current study identified the characteristics of high school organization that are positively related to learning in mathematics and science and to equity during the first and last two years of high school and investigated whether such organizational factors explain the results of the earlier study. It found that although students learn somewhat less in the last two years than in the first two years, several features of the social and academic organization of high schools are strongly associated with learning in both periods.

This article describes the third in a series of studies that examined how the structure of middle-grade and secondary schools affects learning (see Lee and Smith 1993, 1995). The study's major purpose was to identify the organizational characteristics of high schools that make them better places for students to learn. Toward this end, we linked features of the academic and social organization of schools to structural practices that we had shown, in earlier work, were related to learning.

The study described here was a longitudinal follow-up to Lee and Smith (1995), which we refer to here as the Early Restructuring Study (ERS). The ERS examined how practices consistent with the restructuring movement influenced the learning and academic engagement of 10th-grade students in a large and nationally representative sample of schools. The results of the ERS were strong and consistent: Achieve-

ment and engagement were significantly higher and were distributed more equitably in schools that engaged in practices consistent with the goals of restructuring. Thus, the stratifying effects of socioeconomic status (SES) on learning and engagement were weaker.

In sum, the findings from the ERS indicated that school policies and practices can reduce or exacerbate differences in learning among students from different socioeconomic backgrounds. And, as both our studies showed, they can do so substantially.

Despite the strength of our results, we had lingering questions about how to interpret them. What exactly is it about these high schools that accounts for their effectiveness? Do the structural practices account for the positive outcomes we identified, or do the practices reflect broader organizational differences among high schools?

In the ERS we looked at 30 practices

that principals reported were or were not in place in their schools. Twelve of these practices were classified as being consistent with the restructuring movement; the other 18 were considered to be more representative of traditional or conventional educational experiences. Our classification, which was based on several years of work by the Center on the Organization and Restructuring of Schools (CORS) (Newmann 1991), emphasized the content or presumed intent of the practices, not whether they were newly implemented. It combined two ideas drawn from the restructuring movement: (1) organic, rather than bureaucratic, approaches to education and (2) educational practices that represent a substantial departure from conventional experiences.

We found no evidence, however, that schools adopted either type of practice along a single philosophical or pedagogical dimension. Indeed, all the high schools that reported three or more practices consistent with restructuring also reported a large number of traditional practices. Students' performance was higher in schools that reported three or more nonstructural practices than in those that did not, but which three did not seem to matter (Lee and Smith 1995). Therefore, individual practices did not explain the large effects found in the ERS study. Our interpretation, and that of others who commented on it (Bryk 1994; McLaughlin 1994), was that the practices we examined reflected more fundamental differences in the organization of high schools. Pursuing that line of inquiry in the current study, we reexamined the link between structural practices and student learning through an organizational lens.

BACKGROUND

Organizational Forms

Two findings from the ERS stand out: Students who were enrolled in schools that we classified as nontraditional learned more in the first two years of high school (these schools were more effective), and students' SES had a less

stratifying effect on gains in achievement (these schools also were more equitable). Similar results for effectiveness and equity have been demonstrated in several strands of research: studies of Catholic schools and communally organized schools (Bryk and Driscoll 1988; Bryk, Lee, and Holland 1993; Lee and Smith 1993, 1996), research on organically structured secondary schools (Firestone and Rosenblum 1988; Lee, Bryk and Smith 1993; Rowan 1990), and studies of constructivist or authentic teaching (Cole and Griffin 1987; Newmann, Marks, and Gamoran 1996). These studies demonstrate that specific organizational forms count. Three general dimensions of school organization stand out: social relations, the curriculum, and instruction.

School social organization. The bureaucratic structure of most high schools relies on affectively neutral social relationships to facilitate the administration of standardized rules and procedures. Yet, as Waller (1932) noted long ago, the emotional bond between teachers and students plays a crucial role in engaging and motivating students to learn. The quality of affective ties among staff members also directly influences teachers' commitment and indirectly affects students' achievement (Bryk et al. 1993; Lee and Smith 1996; Rosenholtz 1991). The alienating and disengaging qualities of the comprehensive high school have received much attention (see, for example, Firestone and Rosenblum 1988; LeCompte and Dworkin 1991). Many proposals have encouraged downsizing schools to create stronger bonds and more trusting relationships between students and adults (including Carnegie Council on Adolescent Development 1989; National Association of Secondary School Principals 1996;Sizer 1984).

Rather than having formal and affectively neutral relationships, members of communally organized schools are typically committed to a common mission. The staff and students interact informally outside the classroom, and adults consider themselves responsible for students' total development, not just their

mastery of specific subjects or lessons. Teachers share responsibility for students' academic success, exchange information, and coordinate efforts among classrooms and across grades. In such schools, outcomes are more positive for both teachers (for example, satisfaction, morale, and absenteeism) and students (for instance, class cutting, absenteeism, and dropping out). Disadvantaged students especially benefit from attending such schools (Bryk and Driscoll 1988; Bryk et al. 1993; Lee et al. 1993; Lee and Smith 1996).

Organization of the curriculum. Students' academic experiences are compartmentalized, differentiated, and socially stratified in most high schools, since the curriculum is divided into discrete subjects grouped by departments. These units organize subject matter into course sequences (tracks), access to which is determined by students' aspirations and interests, prior performance, or evidence of ability. The typical high school offers students a wide range of courses in each department. Although this type of curriculum provides opportunities to explore numerous interests, the courses vary considerably in their academic content and expectations for performance (Powell, Farrar, and Cohen 1985). Expansion of the curriculum, both vertically (tracks) and horizontally (multiple offerings within tracks), creates substantial differences in what students in the same school study and learn (Lee et al. 1993).

Disadvantaged students are especially harmed by a highly differentiated curriculum. More of their courses are low-track offerings that require less academic effort, expectations for their achievement are lower, and the academic content is less challenging (Oakes 1985; Sedlak, Wheeler, Pullin, and Cusick 1986). A growing body of research has been finding that low-income and minority students are especially advantaged in schools with a narrow curriculum and a strong academic focus (Lee et al. 1993). Because the courses are similar in academic content and expectations, students in different classrooms have similar academic expe-

riences. This form of academic organization is typical in Catholic schools. Nonetheless, Bryk et al. (1993) suggested that public schools with similar forms are also more successful, since students learn more and academic success is more equitably distributed.

Organization of instruction. A bureaucratic conception of how knowledge is acquired emphasizes the standardization of teaching practices and learning tasks. This conception organizes learning into routines that shape the daily interactions of teachers and students. However, evidence is accumulating that this conception fails to provide students with opportunities to develop more advanced thinking skills, a greater proficiency in academic subjects, and a sense of themselves as active learners (McCaslin and Good 1992; Newmann 1993; Newmann et al. 1996). Moreover, the performance of disadvantaged students is especially limited by instruction that is rigid and incapable of responding to individual needs (Cole and Griffin 1987; Quality Education for Minorities Project 1990).

A different approach to instruction requires students to be involved in constructing (rather than reproducing) knowledge through disciplined and sustained involvement in tasks resembling real-life problems (Newmann et al. 1996). Although all students benefit from this type of instruction (also called authentic pedagogy), disadvantaged students (who are frequently low achieving) may benefit the most. Low-achieving students are often found in classrooms that emphasize lower-order skills, basic knowledge, drill and practice, recitation, and desk work. However, when such students are placed in classrooms that provide more intense, varied, and authentic instructional experiences, they usually demonstrate the ability to master more complex and demanding tasks. These richer learning environments can dramatically improve the performance of both high- and low-achieving students (Knapp and Shields 1990; Kozma and Croninger 1992; Levine 1988).

RESEARCH QUESTIONS

In the study described here, we focused on the social and academic organization of high schools. Our interest was in how these elements of high school organization affect learning and its distribution and whether organizational differences explain the educational advantages that we found in our previous studies that focused on structural practices in secondary schools. More specifically, we organized our study around three questions:

1. What are the differences in the social and academic organization of high schools that report different types of structural practices?
2. Do the benefits of attending the high schools that reported several non-traditional structural practices persist in later grades?
3. Do differences in the social and academic organization of high schools help explain the positive effects of structural practices on learning and its equitable distribution that we reported in our previous work?

The third question is the most important because it centers on important organizational characteristics of high schools that make them better places for all students to learn. If the schools that reported restructuring-like practices are different in their social and academic organization (Question 1), and if these organizational forms explain away or substantially reduce the effects of the classification by practices (Question 3), we would have evidence that broader, organizational differences—specifically, those that focus on variations in social relations, curriculum, and instruction—promote the desirable educational outcomes we described in earlier studies.

METHOD

Sample and Data

We drew our sample from the first three waves of the National Education Longitudinal Study of 1988 (NELS), a multiwave study of the educational status and progress of U.S. students and

schools that was sponsored by the National Center for Education Statistics (NCES). In 1988, NCES drew random samples of about 25 eighth graders in each of about 1,000 middle schools. Students were traced to high schools in 1990, with reasonably high response rates.

The sample included NELS 12th graders who fit these data filters: (1) there had to be full cognitive test-score data on the students for the three waves; (2) there had to be data from their high schools and their teachers; (3) students had to be in public, Catholic, or elite private high schools; (4) they must have been attending high schools with at least five NELS-sampled students in Grade 10; and (5) they had to be in the same high schools in Grades 10 and 12 (Ingels et al. 1994a, 1994b). Filters 1–4 were used for the ERS.

Our sample included 9,631 seniors in 789 high schools (all included in the ERS), most of which were public. The nested sample averaged 12.2 students per school. Because the original NELS oversampled certain types of students and schools, we constructed a school-level weight to allow us to generalize to the population of U.S. high schools. NELS did not include high school-level design weights in its data files. The procedure for constructing the weights is described in Lee and Smith (1995).

Analysis

Hierarchical approach. Since our research questions focused on estimating how students' learning in mathematics and science is influenced by the organization of the schools they attend, we used a method designed for such situations—hierarchical linear modeling (HLM) (Bryk and Raudenbush 1992)—as we did in previous studies in this series (Lee and Smith 1993, 1995). The method, now common in studies of school effects, was described in Lee and Bryk (1989). Our HLM models have a three-level nested structure: multiple test scores nested in students, who are, in turn, nested in schools.

Within-person (Level 1) HLM model of achievement growth. The three-level

HLM approach to modeling change over time was described by Bryk and Raudenbush (1992). How that technique applies to this study is somewhat restrictive, since there were only three points in time to model change. The NELS test scores allowed us to estimate change in a repeated-observations model because each score positions a student on an absolute scale of science or mathematics performance. Differences in scores at different points in time are framed as growth or gains in performance. We explored two parameters of growth: (1) 8th–10th grade (early) and (2) 10th–12th grade (late). Of course, the parameters are not independent, nor is either independent of the initial status (8th grade).¹

Classifying schools by their structural practices. In the ERS study, we classified high schools on the basis of several practices. The logic of our categorization was based on the degree to which the schools reported practices consistent with the restructuring movement. In a two-step process, we categorized (1) practices by their consistency with restructuring and (2) schools by the practices they had in place. Using a set of 30 structural practices for which data on NELS high schools were available, principals indicated whether their schools had each practice in place in 1990, when the NELS first follow-up data were collected. We grouped the NELS high schools according to the number and type of structural practices that the principals reported were then in place. For a practice to be consistent with restructuring, it had to promote activities advocated by the proponents of the restructuring movement (see Newmann 1993) and represent a departure from conventional practice.

Our colleagues at CORS helped us fulfill the first requirement; we examined the likelihood of each practice to satisfy the second. None of the practices that we identified as being consistent with restructuring was reported by more than 30 percent of the principals, and most such practices were reported by substantially fewer. Thus, we did not include the notion of restructuring as a

change in policies or practices in our definition. Appendix A lists the 30 practices considered in this study and the probability of their occurrence, as well as some details about the process used to classify schools. The classification of schools by practices was described more completely in Lee and Smith (1995).

Measures

Outcomes. Our extended analysis focused on estimating school effects on the growth in achievement in mathematics and science. Three rationales guided our choice of outcomes: (1) we restricted the subject areas to limit the complexity of results; (2) we selected mathematics and science because useful data on classroom instruction collected by NELS was limited to these subjects; and (3) information on the courses students took in mathematics and science was more precise than for other subjects, from both self-reports and transcripts. Using growth-curve analysis, we investigated four outcomes for each subject: early and late gains in achievement and the social distribution of these gains according to the students' SES.

Figure 1 provides a picture of Outcomes 1 and 2: early (8th–10th grade) and late (10th–12th grade) growth in achievement in mathematics and science in standard deviation (*SD*) units. We considered Outcomes 1 and 2 as *parameters of effectiveness*. Three trends are relevant: (1) Students learned more earlier than later in both subjects, (2) students did not learn much in either time span,² and (3) learning rates were not constant across subjects.

Figure 2 displays graphically the *parameters of equity* (the relationship between SES and gains in achievement in mathematics (Panel A) and science (Panel B), early (Outcome 3) and late (Outcome 4) in high school. Although the relationship between SES and gains in both subjects is consistently positive, the slopes vary over time and SES level. Although it decreases over time, the slope is somewhat steeper for higher-SES students. In other words, SES has a

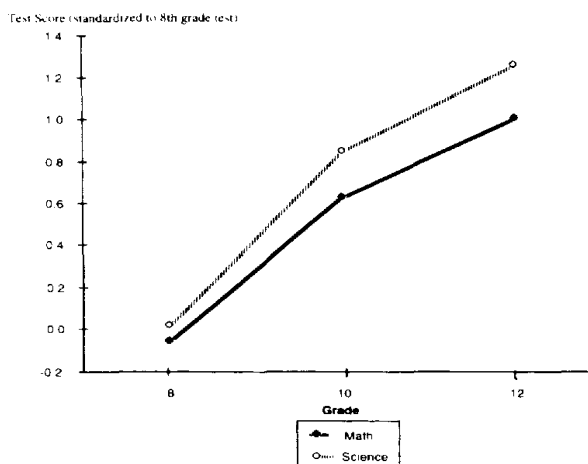


Figure 1. Gains in Mathematics and Science: Grades 8–12. The numbers in this figure are estimated after social class, gender, ethnicity, individual course taking, and 8th-grade ability are taken into account. These scores are then converted to a standard metric based on the 8th-grade test, showing how much students gain in the 10th and 12th grades relative to their initial performance in the 8th grade.

larger effect on learning among more advantaged students.

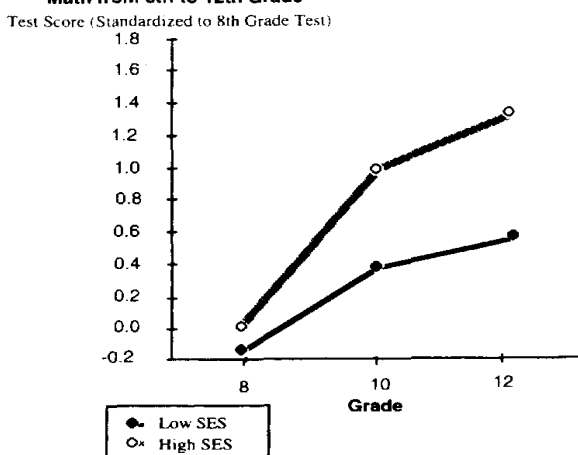
Independent variables. Our independent variables were of three types: two sets of controls describing both students and schools and a set of measures of high school organization (our major

focus) Details of the construction of variables and the NELS variables from which they were drawn are presented in Appendix B.

Controls for students. The within-school controls were of three types: *demographic characteristics, academic status on entry into high school, and course taking.* The demographic controls included SES (a z-score with a mean of 0 and an *SD* of 1), a dummy-coded measure of minority status (Hispanic or Black = 1, nonminority = 0), and gender (female = 1, male = 0). We used two measures to control for academic status at the beginning of high school: achievement (in mathematics or science, depending on the outcome) and engagement in academic activities. We also included controls for students' course-taking patterns in mathematics (self-reports of courses in the first two years of high school for Outcome 1 and a measure of high school courses in mathematics and science taken in the last two years of high school from students' transcripts for modeling Outcome 2). The controls (except course taking) were used in the ERS.

Controls for schools. There were two types of between-school controls. The first type—*composition*—includes average SES, minority concentration (a

A. High vs. Low SES Students' Gains in Math from 8th to 12th Grade



B. High vs. Low SES Students' Gains in Science from 8th to 12th Grade

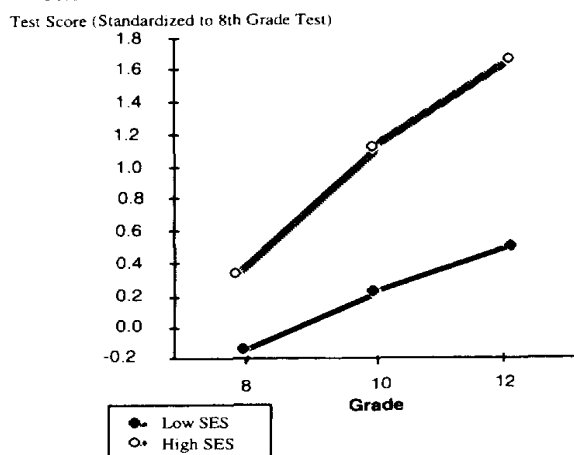


Figure 2. Gains in Achievement and Mathematics for Low- and High-SES Students. The numbers in this figure correspond to the average test scores, shown in Figure 1, for low-SES students (1 *SD* below the population mean) and high-SES students (1 *SD* above the population mean). SES is a z-score variable ($M = 0$, $SD = 1$).

dummy-coded measure, with 40 percent or more minority enrollment coded 1, otherwise 0), school sector (two dummy variables for Catholic and elite private schools, each compared to public schools), and school size. The second type—the *structural-practice categories*—captured the effects of school structure reported in the ERS. On the basis of categorizations described in Appendix A, we included two dummy-coded contrasts: (1) schools that reported practices characteristic of restructuring compared to schools with traditional practices and (2) schools without any of the structural practices compared to schools with traditional practices. The school-composition measures were used mainly as statistical controls. The structural-practice categories were used to address Questions 1 and 2.

Measures of high school organization. The variables capturing the organizational properties of schools were of two types. One tapped *school social organization*. Although we investigated several such measures, our final HLM models include a single variable: collective responsibility for learning. This composite incorporates measures of teachers' attitudes about their ability and willingness to take personal responsibility for the academic success of their students. It was shown elsewhere (Lee and Smith 1996) to have a strong influence on learning.³

A second (and extensive) set of variables taps *academic organization*. One variable, the school average of courses taken in academic mathematics and science courses over the four years of high school, is a proxy measure of the common curriculum. The *SD* of course taking indicates the variability in students' intellectual experiences. Another variable, academic press, is a composite of principals' reports of the importance the school places on academic pursuits and the morale of teachers and students. Although morale could be high for other than academic reasons, the strong reliability of this composite suggests a consensus among school members on an academic mission for the school.

Also capturing elements of schools' academic organization are two measures of instruction. One, authentic instruction in science and mathematics, is the mean of four school-level aggregates of students' and teachers' reports of the frequency of various instructional activities in those two subjects.⁴ We used the school average of this composite as an indicator of schools with instructionally rich classrooms that use multiple techniques, including those associated with authentic pedagogy or active learning. The *SD* of the composite of student items taps variability in authentic instruction in a school.⁵

RESULTS

School Characteristics by Structural Practices

School characteristics. We began our investigation of how high school organization influences learning and its equitable distribution by exploring how school compositional and organizational characteristics are related to the structural practices of the 789 schools (Question 1). The schools in the sample were broken down into the three groups described earlier (see Table 1): those that reported neither atypical structural nor traditional practices (Column 1), those with traditional practices (Column 2), and those with three or more atypical structural practices (Column 3).

Group means on many school characteristics were tested using one-way analysis of variance (ANOVA) with two contrasts: (1) schools without practices compared to traditional schools and (2) schools with structural practices compared to traditional schools. Almost half (46 percent) the schools had three or more atypical structural practices, 43 percent had only traditional practices, and 11 percent reported neither atypical nor traditional practices. Although nearly half the high school principals reported three or more atypical practices, far fewer reported individual practices (see Appendix A).

Composition. The schools' organizational characteristics were distinctive in

Table 1. Organizational Characteristics of High Schools with No Structural Practices, with Traditional Practices, and with Three or More Atypical Structural Practices ($N = 789$ schools)

Variable ^a	Schools with No Structural Practices ($n = 88$)	Schools with Traditional Practices ($n = 338$)	Schools with Three or More Atypical Structural Practices ($n = 363$) ^b
<i>School Composition</i>			
Average SES ^c	-.43~	-.19	.33***
% Minority enrollment	34.14***	10.73	13.78
% Public	98.80	96.01	83.02***
% Catholic	0.85~	3.50	9.73***
% NAIS	0.35	0.48	7.25***
Average Achievement, 8th grade	-.52*	-.16	.30***
School size	1,091***	632	769**
<i>Social Organization</i>			
Collective responsibility for learning ^c	-.74***	-.14	.31***
<i>Academic Organization</i>			
Average number of mathematics and science courses, grades 9-12	4.52	4.73	5.14***
Variability in mathematics, science course taking (<i>SD</i>)	2.05	2.00	1.83***
Authentic instructional practices, science and mathematics ^{c,d}	-1.63***	-.58	1.04***
Variability in authentic instructional practices (<i>SD</i>) ^c	.56**	.13	-.26***
Academic press ^c	-.25	-.21	.31***

~ $p \leq .10$, * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$ ^aGroup mean differences tested with one-way ANOVA and contrasts. Both no-practices and atypical-practices schools were contrasted (separately) with traditional-practice schools.^bThe sample sizes reported in this table are unweighted. The group means are weighted, using the NELS-constructed school weights.^cThese variables are z-scored, with $M = 0$, $SD = 1$.^dCreated with Rasch-model scaling and then z-scored.

several ways. Schools with no structural practices were significantly disadvantaged compared to schools with only traditional practices on several social demographic factors (more minority students and students of lower ability). More striking is the advantage that schools with several atypical practices had over those with no structural practices in average SES and average eighth-grade achievement. Distribution by sector is important here. Although only 14 percent of the sample was private

schools, the majority of them used atypical practices. However, the overwhelming majority of schools in all groups were public. Finally, traditional-practice schools had smaller enrollments than did either comparison group.

Social organization. Our measure of school social organization focused on reports from teachers about how much responsibility they took for their students' learning. The pattern, favoring atypical-practice schools, suggests that social organization may be intertwined

with school practices, although the causal direction is unclear.

Academic organization. We found a similar pattern among measures of academic organization. The schools with atypical practices were significantly advantaged in this area: Students took more mathematics and science courses and there was less variability in course taking, instruction was more authentic, authentic instruction was more homogeneous across classes, and these schools had higher levels of academic press. Although again the causal direction is unclear, the pattern is not: Schools with atypical structural practices have stronger academic organizations.

It is evident that schools that reported specific educational practices are advantaged in terms of the organizational factors we considered. Besides these differences, however, the patterns from Table 1 suggest that atypical-practice schools are also advantaged in the types of students who attend them, including (and not independent of) the larger proportion of private schools in their ranks. Therefore, their social composition and sector should be taken into account in any analyses that estimate organizational effects on learning for schools in these three groups.

Organizational Effects on Gains in Achievement

Learning trajectories. Because we know that learning builds on prior learning, we needed an analytic model that takes early gains in science and mathematics into account, one that considers a student's learning trajectory, rather than the simple changes in status discussed so far. We were interested in knowing whether the effects of attending schools classified by their structural practices are sustained on learning later in high school (see Question 2), and we wanted to understand the implications of the effects of the organizational characteristics of high schools on effectiveness and equity.

Within-school (Level 2) HLM models. NELs measured students' achievement at three important time points: near the

end of the 8th grade (entry into high school), in the 10th grade (midway through high school), and at the end of the 12th grade (just before graduation). We used the Level-1 modeling structure described in the Methods section on the four outcomes displayed in Figures 1 and 2: Outcome 1 (8th to 10th grade) and Outcome 2 (10th to 12th grade). Outcomes 3 and 4 focus on the relationship between SES and those gains. Important statistical properties of Outcomes 1 and 2 are described in the top panel of Table 2.

As Figure 1 suggests, the average gain on the 25-item science test is larger earlier (2.86 points) than later (1.60), as is the average gain on the 40-item mathematics test (earlier: 8.47, later: 4.66). This finding indicates that students do not learn much in science over the course of high school, at least as measured by the NELs test items, but they learn somewhat more mathematics.⁶ Although the *SDs* of the two science gains are similar (and large), late mathematics gain is less variable. It is not surprising that the HLM estimates of the variance of within-school gains in both subjects, pooled across schools (τ -pi), are much larger than the estimates of the variance of between-school gains (τ -beta). In a three-level HLM model, most of the variation in the outcome is captured by the measurement (Level-1) model. The gains themselves, however, are reliable (.85-.95), despite modest between-school variances. The results for the Level-2 (within-school) HLM model are in the bottom panel of Table 2. The HLM growth model includes controls for early gain on late gain and for initial status on both outcomes. The beta coefficients for students' characteristics on Outcomes 1 and 2, estimated simultaneously for each subject, are displayed in effect size (ES) units, computed by dividing the estimated beta coefficients by the *SD* of each outcome estimated with an unconditional HLM growth model.⁷

Although engagement is only weakly related to learning in the multivariate Level-2 models, prior achievement (the eighth-grade score in each subject) is. In

Table 2. HLM Within-school Model of Early and Late Achievement Gains in Science (N = 9,631 students in 789 schools)

	Dependent Variables			
	Outcome 1: Early Gain (Grades 8–10)		Outcome 2: Late Gain (Grades 10–12)	
	Science	Mathematics	Science	Mathematics
<i>A. Descriptive Information</i>				
Mean between-school gain	2.86	8.47	1.60	4.66
SD of gain	3.79	6.33	3.72	4.66
Between-student variability (tau-pi)	18.89	40.13	11.54	21.71
Between-school variability (tau-beta)	.19	3.90	.02	1.00
HLM reliability	.904	.953	.852	.916
<i>B. HLM Within-school Model Results</i>				
<i>Fixed Effect^a</i>				
Estimated intercept (base)	4.002***	8.903***	1.981***	4.816***
<i>Independent Variables^b</i>				
8th-grade engagement	-.138	-.352*	.061	-.099
8th-grade achievement ^c	2.402***	2.326***	-.202	.936**
Academic course taking in mathematics and science, Grades 8–10	.083	.509**		
High school academic course taking in mathematics and science, Grades 10–12			.301	.169
Social class ^d	.607***	.745	.736***	1.213***
Minority status	-1.312*	-.561	.632	1.588**
Gender (female)	-1.378***	-.189	-1.411*	-.797*

* $p \leq .05$, ** $p \leq .001$, *** $p < .001$

^aIn these HLM models, the fixed effects of 8th-grade achievement scores are science, 19.799*** and mathematics, 37.538***.

^bAll effects are presented in a standardized ES metric, computed by dividing the HLM gamma coefficient for each outcome by the adjusted HLM school-level SD of that outcome.

^cThe 8th-grade ability control was constructed as a composite test score at that grade in the three curricular areas not measured by that gain score.

^dIn these HLM models, SES is allowed to vary randomly among schools, while the other controls are used as fixed parameters. SES is centered on the sample mean, while the other controls are centered on their respective school means.

both subjects, effects are large and positive on early gains. The effects for other characteristics of students are quite different for the two subjects. For example, the number of academic courses taken in mathematics and science early in high school has no effect on early science gain, but it is an important predictor of early mathematics learning. A surprising finding is that courses taken in these subjects in the last half of high school exert no residual effect on late

gain, once other variables are taken into account.

SES has stronger effects on late gains than on early gains in both subjects. Gender effects are large and favor males, especially in science, but also in mathematics, particularly later gains. The residual effects of minority status are unusual. For early gains in both mathematics and science, minority status is negatively related. Once early gains are controlled for, minority effects on late gains become positive. Many of these

effects are important and interesting; however, because they do not relate directly to the research questions in this study, we do not discuss them further. Their magnitudes suggest the importance of including them as statistical controls. The SES effects in Table 2 represent Outcomes 3 and 4 in subsequent analyses (see Figure 2).

Do Structural-Practice Effects Endure?

Between-school (Level 3) HLM structural-practice model. Retaining the within-school HLM models shown in Table 2, our subsequent analyses pursued school effects. Preliminary to the school organization model, we explored a three-level HLM analysis of Outcomes 1 to 4 in both subjects with a growth-model format exploring the demographic effects of schools and those of the structural-practice contrasts described earlier. The analyses differed from the ERS in two respects: (1) They used a three-level growth-trajectory design, whereas the ERS used a simpler two-level HLM design with differences in test scores as outcomes, and (2) they explored whether the effects of structural-practice contrasts are sustained later in high school. Besides the statistical controls on students from Table 2, the models also include school controls for average school SES, minority concentration, school sector, and school size. The results, shown in Table 3, are presented in school-level ES units.

In general, the results confirm the stability of effects for the structural-practice contrasts, over time and over subject matter (Question 2). For Outcomes 1 and 2 (the parameters of effectiveness), the learning of students attending schools with atypical practices was higher in both subjects, and these effects endured over the four years of high school. Students in schools without atypical or traditional structural practices were disadvantaged in learning in both subjects. For Outcomes 3 and 4 (the parameters of equity), learning in science and mathematics was more equitable among students in the atypical-practice schools.

The effects of attending schools with-

out these practices suggest that learning in both subjects was both lower and more socially inequitable. The results in Table 3 confirm and extend the positive findings from the ERS, providing a positive answer to our second research question. Students who attended schools with practices that are consistent with the restructuring reform movement seemed to learn more in science and mathematics, and that learning was distributed more equitably. Except for school size, where the effects on both effectiveness and equity favor smaller schools, the contextual effects of school composition are nonsignificant (over and above the effects of individual student characteristics) on either equity or effectiveness.

Effects of High School Organization on Learning and Equity

Our HLM models that address the third research question are organized around four sets of school-level variables: (1) the controls for school composition and structure (average SES, minority concentration, school sector, and size), (2) the two contrasts that focus on schools' structural practices, (3) school social organization, and (4) the several measures of school academic organization. The focus of these models, the results of which are displayed in Table 4, is on the organizational factors in sets 3 and 4.⁸ Organizational effects on the four outcomes (early and late achievement gains in science and mathematics and the SES slopes on gains in both subjects) are large, consistent, and logical. Our discussion here is organized around the constructs that the independent variables represent, rather than around the outcomes.

Compositional effects. Both social composition and school sector have generally nonsignificant effects. However, even after several related organizational characteristics of schools are taken into account, the effects of school size on both learning and its equitable distribution are substantial. Learning in science and mathematics is greater in smaller schools, both early and late in high school. There are also

Table 3. HLM Between-school Model for Structural Practice Effects on Achievement Gains in Science and Mathematics ($N = 9,631$ students in 789 schools)

	Dependent Variables ^a							
	Outcome 1: Early Gain, Grades 8–10		Outcome 3: SES Slope on Gain, Grades 8–10		Outcome 2: Late Gain, Grades 10–12		Outcome 4: SES Slope on Gain, Grades 10–12	
	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics
Base estimate ^b	3.86***	9.12***	.67***	1.14**	1.90***	4.62***	.27	1.51***
<i>A. Demographic Characteristics^c</i>								
Average SES	.49	.97–	.86	.12	.67	1.28*	.56	1.26
High minority enrollment	.48	–.39	.90	–1.34	1.06	–1.87*	1.03	–2.47
Catholic school	.31	.79	–1.13	–.46	.16	.80	–.34	–1.10
NAIS school	–.27	–1.29	.89	–3.38~	–.41	–.23	–.52	4.39
School size	–.56**	–.95**	1.75***	1.30**	–1.33***	–.96*	2.02*	2.33*
<i>B. Effects of Structural Practices^c</i>								
Atypical-practice vs. traditional schools	.69*	.69*	–2.75**	–1.45**	1.53*	1.11**	–3.26***	–2.97*
No practice schools vs. traditional schools	–.70*	–.95**	2.18*	1.03*	–1.30~	–.89*	2.23~	2.71*
HLM-computed <i>SD</i>	.927	1.774	.315	.942	.443	1.087	.181	.477

~ $p \leq .10$, * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

^aThe numbering of these outcomes refers to designations in Figure 1.

^bHLM results computed with within-school adjustments from Table 4: students' course taking in academic courses in mathematics and science in high school, minority status, gender, SES, 8th-grade ability, and 8th-grade engagement.

^cAll effects are presented in a standardized ES metric. Effects were computed by dividing the HLM gamma coefficient for each outcome by the school-level *SD* that outcome. These *SD*s are shown in the bottom panel of this table.

large effects of size on the equity parameters: Smaller schools are equitable as well as more effective.

Effects of structural practices. In the full HLM models, the effects of schools' structural practices that were statistically significant in Table 3 generally dropped to nonsignificance. However, the pattern of effects is in the same direction: Attending schools with atypical structural practices has a positive influence on the parameters of effectiveness and a negative effect on the parameters of equity. These results allow us to respond positively to the third research question. That is, the organizational characteristics of schools we considered explained away the effects of

structural practices demonstrated in Table 3 that were also reported in the ERS. Of course, this finding provides only a literal (albeit positive) answer to the question. More important is knowing *which* organizational effects matter, in terms of effectiveness and equity.

Social organization. Our single indicator of school social organization—collective responsibility for learning—is strongly and positively associated with both effectiveness and equity in learning in both mathematics and science.⁹ Its effects, although consistently positive, differ over time and subject. The effect of collective responsibility on science learning increases from the beginning to the end of high school, but

Table 4. HLM Between-school Model for Achievement Gains in Science and Mathematics: Effects of School Organizational Factors ($N = 9,631$ students in 789 schools)

	Dependent Variables ^a							
	Outcome 1: Early Gain, Grades 8–10		Outcome 3: SES Slope on Gain, Grades 8–10		Outcome 2: Late Gain, Grades 10–12		Outcome 4: SES Slope on Gain, Grades 10–12	
	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics
Base estimate ^{b,c}	3.50***	6.92***	2.66***	1.01**	4.36***	2.73*	1.63	2.35*
<i>A. Demographic Characteristics</i>								
Average SES	.26	.90	.99	.43	.95	.70	.74	.16
High Minority enrollment	.33	–1.54~	–.67	–.03	1.67	–1.81~	.38	–.73
Catholic school	.29	1.58~	–.45	–.72~	.45	.92	–.50	–1.97
NAIS school	–.15	–.29	1.82	–.20	.72	–.19	–2.55	1.36
School size	–.43*	–.56*	1.02*	.98*	–.77*	–.65*	1.60*	.78*
<i>B. Effects of Structural Practices</i>								
Atypical-practice vs. traditional schools	.24	.52	–1.56~	–1.21	2.01	.23	–3.69	–1.31
No-practice schools vs. traditional schools	–.31	–.24	1.40~	1.35	–1.82~	–.66	4.40~	.72
<i>C. Social Organization</i>								
Collective responsibility for learning	.39*	.89**	–1.01*	–.59*	1.00*	.40*	–1.48**	–1.37**
<i>D. Academic Organization</i>								
Average number of mathematics and science courses	.49*	.74*	–.76	–.95	1.04*	.37***	–2.04~	–1.34~
Variability in mathematics and science course taking	–.26	–.44	1.17*	.59*	–.45	–.12	2.30*	1.88*
Authentic Instructional Practices in science mathematics	.42*	.50***	–.69	–.50	1.66*	.36**	–3.27~	.43
Variability in authentic instruction	–.29~	–.49~	1.11**	1.34**	–.25	–.59~	3.08**	1.41**
Academic press	.35**	.67	–.83*	–.54	.56*	.21	–1.15*	–.71*

~ $p \leq .10$, * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

^aThe numbering of these outcomes refers to designations in Figure 1.

^bAll models also include within-school adjustments for all variables shown in Table 4: students' course taking in academic courses in mathematics and science in high school, minority status, gender, SES, 8th-grade ability, and 8th-grade engagement.

^cAll effects are presented in a standardized ES metric, computed by dividing the HLM gamma coefficient for each outcome by the HLM adjusted school-level *SD* of that outcome. These *SD*s are displayed in the bottom panel of Table 3.

declines somewhat for mathematics learning. Effects on equity are large and increase over time in both subjects.

Academic organization. It is not surprising that the largest organizational effects on learning and its equitable distribution in science and mathematics are associated with schools' academic organization. We considered the two measures of academic course taking in mathematics and science—level and variability—as a set and interpreted them as being related indicators of a school that offers a narrow curriculum that is academic in content and in which most students take the same courses of this type (variability in course taking is low). Our results indicate that students who attend such “core curriculum” schools learn more and that learning is more equitably distributed. Although the magnitude of effects varies somewhat over time and subject, the general pattern favors schools with this core-curriculum emphasis.

We also considered the two measures of instruction in a school—the level and distribution of authentic instruction—together. On average, students attending schools that are instructionally rich and incorporate active learning and in which this type of instruction is shared widely (the variability of authentic instruction is constrained) gain more in science and mathematics achievement, both early and late in high school. Less variability in authentic instruction is also associated with gains that are more equitably distributed. Thus, we see a similar pattern of effects over time and subject matter for both authentic instruction and curriculum structure.

School academic press, another measure of academic organization, follows the same general pattern: a positive association with both early and late learning and a negative association with the SES-gain slopes. However, these effects are subject specific (in terms of statistical significance). In schools with a higher academic press, students learn significantly more in science, and that learning is more equitably distributed.

Our outcomes are intended to incor-

porate the dual notions of effectiveness and equity. Although the general trends of effects for the measures of academic and social organization are favorable on both, there was also a more specific pattern we wish to highlight. For both the constructs of common curriculum and of authentic instruction, *levels* of course taking or authentic instruction in schools are associated with average learning, whereas the *pervasiveness* of each (less variability among school members) is associated more with social equity in learning. Small school size, although related to effectiveness and equity, is most strongly associated with the equitable distribution of learning. This pattern of association points to the importance of considering both levels and distributions as outcomes when evaluating organizational effects.

DISCUSSION

Effects Endure

Looking broadly at our series of three studies that used nationally representative and longitudinal data from NELS to study how the structural practices of U.S. schools influence the level and distribution of students' learning (Lee and Smith 1993, 1995; this study), we conclude that the structural practices that schools engage in *do* influence academic achievement. Nonetheless, this study also indicated that these effects may be due less to individual practices and more to broader organizational attributes that reflect the willingness of schools to adopt and stick to policies and practices that move them away from bureaucracies toward communities with a strong academic focus. As Table 3 indicated, the effects on learning persist into the later years of high school, rather than disappear after the early years, when one might expect students to be most influenced by schools that are relatively new to them.

Create Smaller Places

Our findings also support the need for smaller high schools. Without new bricks, mortar, bond issues, or property

tax increases, a reasonable approach would be to create schools-within-schools: smaller organizational units inside the walls of large high schools. In these schools-within-schools, teachers and students would know one another better, and school members would consider themselves part of a school "family." We suspect that small size is not an end in itself, but acts as a facilitating or inhibiting factor: It is likely to facilitate more personalized social interactions and to inhibit a differentiated curriculum and teachers' specializations (major features of bureaucratic high schools). Once high schools are divided into smaller units, there are likely to be changes in social relations and professional community and a stronger emphasis on academics.

Social Relations and Professional Community

In communally organized schools there are different sorts of social interactions from what one typically finds in comprehensive high schools: less hierarchy, less specialization, and more cooperation. Although we did not measure such organizational features of "good" schools directly, our results suggest that when a form of a professional community of teachers predominates—when teachers take responsibility for the success of all their students—more learning occurs. Teachers in such schools believe they can and should address their students' academic problems, rather than place the cause of such problems on factors outside themselves, such as on the families and the students (see Lee and Smith 1996 for an elaboration of this argument). McLaughlin's (1994:11) description of this notion is compelling: "personalized school environments, settings where teachers and students can come to know one another, and where students feel acknowledged and respected as individuals." However, the communal perspective is somewhat more concerned with the affective than the cognitive dimensions of schooling. What kinds of curriculum and instruction would one find

students experiencing in good high schools?

Academic Pursuits Predominate

Our evidence suggests that "good" schools also have a strong academic structure. Rather than offering a broad range of courses at many different levels and encouraging students to select courses according to their "personal tastes" (the universalistic model), our evidence supports the positive value of a narrow and academic curriculum, with a strong organizational push for all students to take (and master the content of) these courses. In the mathematics and science curricula, we have evidence that instruction should be accomplished more authentically and that this type of teaching should be pervasive, not restricted to classrooms where teachers happen to prefer doing their work this way. In commenting on the ERS, Bryk (1994:7) highlighted our "evidence that a constrained academic structure in high schools plays a key role in the equitable social distribution of achievement."

CONCLUSION

This study offers support for a line of sociological research that concludes that organization matters and that the optimal organizational form for high schools is more communal than bureaucratic. Though we are convinced that this vision of the American high school would improve learning and its equitable distribution, our study offers no guidelines about the best way to accomplish what will surely be a major organizational shift for many high schools. Furthermore, although the effects of practices consistent with the restructuring movement (found in our earlier studies) endure, the results described here underscore the importance of more fundamental differences in the social and academic organization of schools. They suggest that the number and type of practices that schools adopt are much less important for learning and equity than are the forms that social relations,

the curriculum, and instruction take in individual schools.

On the other hand, our findings should not be interpreted to mean that the practices we considered do not matter. Rather, we interpret them as indicating that structural practices and organizational forms are interrelated: High schools that report practices consistent with restructuring also have more favorable social and academic organizations (and vice versa). The structural practices and organizational forms considered here are related both

conceptually and empirically. Our findings do suggest that it is not any individual practice that counts but, rather, deeper and more profound differences in how high schools organize their students' academic experiences. The differences are best reflected in the manner in which practices become enduring attributes of schools' social and academic organization. We suggest that high schools that are organized in the ways we have described are better places to learn, particularly for disadvantaged students.

APPENDIX A

How High Schools Were Classified by Their Structural Practices (from the ERS)

1. Structural Practices and Their Probability in NELS High Schools

Structural Practice	Probability
<i>Traditional or Moderate Practices</i>	
Departmentalization with chairs	.85
Common classes for same curricular track	.76
Staff development focusing on adolescents	.66
PTA or PTO	.64
Parent-teacher conferences each semester	.64
Focus on critical thinking in curriculum	.64
Common classes for different curriculum tracks	.62
Increased graduation requirements	.62
Recognition program for good teaching	.56
Parents were sent information on how to help their children study	.56
Parent workshops on adolescent problems	.46
Students' satisfaction with courses important	.42
Strong emphasis on parental involvement	.38
Strong emphasis on increasing academic requirements	.35
Students' evaluation of course content important	.35
Outstanding teachers are recognized	.34
Emphasis on staff stability	.34
Emphasis on staff development activities	.32
<i>Atypical Practices Consistent with Restructuring</i>	
Students keep same homeroom throughout high school	.30
Emphasis on staff solving school problems	.29
Parents volunteer in the school	.28
Interdisciplinary teaching teams	.24
Independent study, English/social studies	.23
Mixed-ability classes in mathematics/science	.21
Cooperative learning focus	.21
Students' evaluation of teachers important	.20
Independent study in mathematics/science	.18
School-within-a-school	.15
Teacher teams have common planning time	.11

2. Two-Step Decision Rule for Classifying Schools, Based on Their Structural Practices (from the ERS)

Step 1: Grouping practices. We grouped the 30 reform practices according to a definition consistent with research and theory developed by CORS. Our decision rule combined two ideas: (1) practices that are more consistent with organic than bureaucratic structures and (2) practices that depart from conventional educational experiences. Practices that were classified as consistent with restructuring fit both ideas: They have less of a bureaucratic structure and are less common.

Step 2: Classifying schools. Once we classified practices as traditional or consistent with restructuring, we investigated the number and type of these practices in place in each school. Schools were unlikely to engage in these practices along a single dimension (such as instruction, authority, or social relations) and did not engage exclusively in nontraditional practices. Schools that engaged in at least three practices consistent with restructuring were classified as schools with atypical structural practices. Schools that engaged in several traditional practices but fewer than three restructuring-like practices were classified as schools with traditional practices. The small proportion of schools that reported engaging in none of the 30 practices were classified as schools with no structural practice.

The decision to use three restructuring practices as a cutpoint, which may seem arbitrary at first glance, was confirmed with a series of sensitivity analyses in the ERS (see Lee and Smith 1995, Figures 1 and 2, pp. 260–61, for details). Learning was the greatest and its distribution was the most equitable in schools with three or four reform practices classified as restructuring.

APPENDIX B

Details of the Construction of Measures Used in This Study That Were Not Described in the ERS

Variables Measured on Students

1. Achievement Outcomes

F22XMIRR: Mathematics IRT-estimated number right (12th grade)

F22XSIRR: Science IRT-estimated number right (12th grade)

2. Demographic Controls

SES, minority status, and gender as used in the ERS

3. Academic Controls

Engagement as used in the ERS

- Achievement: Z-score of sum of BY2XRIRS, BY2XHRS, BY2XMIRS (8th-grade measures)

- Course taking in mathematics and science early in high school: For modeling science gains between Grades 8 and 10 (Outcomes 1 and 2), we summed 10th graders' self-reports of course taking in mathematics and science. Variables coded 0 = none; 1 = 0.5 to 1 year; 2 = 1.5 to 2 years. Thus, the sum represents the number of semesters of mathematics and science course work. For the HLM analyses, the variable was z-scored ($M = 0$, $SD = 1$). The variables were, How much course work in . . .

- F1S22B: Prealgebra
- F1S22C: Algebra I
- F1S22D: Geometry
- F1S22E: Algebra II
- F1S22F: Trigonometry
- F1S22G: Precalculus
- F1S22H: Calculus
- F1S23B: Physical science
- F1S23C: Biology
- F1S23E: Chemistry
- F1S22F: Principals of technology
- F1S23G: Physics

- F1S22H: Other science courses
- Course taking in mathematics and science late in high school: For modeling gains between Grades 10 and 12 (Outcomes 3 and 4), we summed several variables, each of which measured the number of Carnegie units (a year-long course) in several courses over the four years of high school, taken from students' transcripts. For the within-school model on late achievement gains, we selected only those courses from the foregoing list that were taken in Grades 11 and 12 (F2GRLEV = 11, 12). The variables were Carnegie units in . . .
 - F2RAL1_C: Algebra I
 - F2RAL2_C: Algebra II
 - F2RGEO_C: Geometry
 - F2RTRI_C: Trigonometry
 - F2RPRE_C: Precalculus
 - F2RCAL_C: Calculus
 - F2REAR_C: Earth science
 - F2RBIO_C: Biology
 - F2RCHE_C: Chemistry
 - F2RPHY_C: Physics
 - F2ROSC_C: Other science courses

Variables Measured on Schools

1. Demographic Characteristics

Average SES, minority concentration, sector, and size, as used in the ERS.

2. Measures of Structural Practices (from the ERS; see Appendix A).

3. School Social Organization.

- Collective responsibility for learning: Variables come from teacher questionnaires. The order in which the variables are listed reflects the item-specific factor loadings. The variables were combined into a factor from principal components analysis, with a reliability (Cronbach's alpha) of .81. The composite was aggregated and z-scored ($M = 0$, $SD = 1$). The variables were as follows:
 - F1T4_5E: There's little I can do to ensure high achievement (reversed).
 - F1T4_5A: I can get through to the most difficult student.
 - F1T4_5D: Different methods can affect a student's achievement.
 - F1T4_5F: Teachers make a difference in students' lives.
 - F1T4_2J: It is a waste of time to do my best at teaching (reversed).
 - F1T4_5B: Teachers are responsible for keeping students from dropping out.
 - F1T4_2N: Students' attitudes reduce academic success (reversed).
 - F1T4_11F: I try to create lessons so students enjoy learning.
 - F1T4_1D: Students' success, failure due to factors beyond me (reversed).
 - F1T4_1I: Students are incapable of learning the material (reversed).
 - F1T4_5C: I change my approach if students aren't doing well.
 - F1T4_5E: Students' misbehavior interferes with my teaching (reversed).

4. School Academic Organization

- Average academic course taking in mathematics and science aggregated from students' reports of course taking described under "course taking in mathematics and science late in high school" over the four years of high school. Only courses taken in high school were included, using the F2RGRLEV variable matched to the school's grade level. The aggregate was standardized ($M = 0$, $SD = 1$).
- Variability in mathematics and science course taking: SD of students' course taking, from transcripts. Variable was standardized ($M = 0$, $SD = 1$).
- Authentic instruction in mathematics and science: Details on the Rasch modeling

methods used to construct this measure are available from the authors. The technique itself is fully described in Rasch (1980). Items in the following four categories were drawn from teachers' and students' reports of instruction in each subject in the sophomore year (first NELS follow-up). The science items from students were How often . . .

- F1S29G: design and conduct own experiments, projects
- F1S29F: make up own scientific problem, analytic method
- F1S29B: choose own scientific or problem to study
- F1S29M: discuss career opportunities in science, technology
- F1S29D: write up reports of lab or practical work
- F1S29N: watch teacher demonstrate or lead experiment
- F1S29E: use book or written instructions to do experiments
- F1S29C: copy teachers' notes from blackboard
- F1S29L: listen to teacher lecture in class

The mathematics items from students were how often

- F1S32E: use computers
- F1S32F: use hands-on materials or models
- F1S32B: use books other than math textbook
- F1S32H: participate in student-led discussions
- F1S32I: explain math work orally
- F1S32G: use calculators
- F1S32D: do story problems or problem-solving activities
- F1S32C: copy teachers' notes from blackboard
- F1S32A: review yesterday's work

The mathematics items from teachers were

- F1T2_18H: Have students give oral reports
- F1T2_18E: Have student-led whole-group discussions
- F1T2_18F: Have students work in small groups
- F1T2_18C: Use whole-group discussion
- F1T2_18G: Have students complete individual assignments in class
- F1T2_18D: Have students respond orally to questions

The science items from teachers were

- F1T2_18H: Have students give oral reports
- F1T2_18E: Have student-led whole-group discussions
- F1T2_18F: Have students work in small groups
- F1T2_18C: Use whole-group discussion
- F1T2_18G: Have students complete individual assignments in class
- F1T2_18D: have students respond orally to questions
- Variability in Authentic Instruction: The standard deviation of the Rasch-constructed measure of authentic instruction in each school. The variable was standardized ($M = 0$, $SD = 1$).
- Academic Press: Variables from reports by school principals were combined into a composite, formed with principal components factor analysis and z-scored ($M = 0$, $SD = 1$). Reliability (Cronbach's alpha) was .81. The variables were as follows:
 - F1C93G: Students' morale is high.
 - F1C93D: Teachers press students to achieve.
 - F1C93F: Teachers' morale is high.
 - F1C93B: Students place high priority on learning.
 - F1C93E: students are expected to do homework.

NOTES

1. Because this approach to modeling achievement growth with NELS is new, a few details of our technique may be useful to readers who are interested in replicating it. In this three-level HLM, our Level-1 model (test scores within individuals) for achievement (Y) for person i at time t is as follows:

$$Y_{ti} = P_{0i} + P_{1i} (\text{GROWTH10}) +$$

$$P_{2i} (\text{GROWTH12}) + e_{ti}$$

The P parameters represent 8th-grade achievement (P_0), growth from the 8th to the 10th grade (P_1) and growth from the 10th to the 12th grade (P_2). To estimate two separate growth parameters in this model, we constructed two variables—GROWTH10 (change in science score, grades 8–10) and GROWTH12 (change in science score, grades 10–12), based on the following design matrix:

Variable	Grade		
	8	10	12
GROWTH10	0	1	1
GROWTH12	0	0	1

The growth parameters P_1 and P_2 , adjusted for initial status (P_0)—which is treated as “fixed” in the model—are simultaneously modeled as functions of students’ characteristics (Level 2) and school characteristics (Level 3). Bryk and Raudenbush (1992) referred to the Level-1 model used here as “piecewise linear growth.” The Level-2 and Level-3 models are similar to HLM models described elsewhere (see, for example, Lee and Bryk 1989).

2. Although the lines look relatively steep, the metric (SD units) is somewhat deceptive. These results reflect findings reported by Jencks (1985:133) from High School and Beyond that gains in the test scores of high school students are actually modest (.15 SD per year for public schools).

3. Communitarian models of school are more complex than we describe here. Their features are not limited to the social relations that characterize interactions among staff members or between staff and students. For a fuller description and examination of the effects of school professional community, see the work of Louis and her colleagues

(Louis 1990; Louis, Kruse, and Associates 1995; Louis, Marks, and Kruse 1996). The effects of communal organizational forms on students are shown in Bryk and Driscoll (1988), Bryk et al. (1993), and Lee et al. (1993).

4. The construction of this variable used a Rasch modeling technique, more commonly used to rescale items on test scores or rating scales and based on the accumulation of individual instruction practices, rather than on the use of certain practices in place of others (Rasch 1980). Our reasons for combining data about mathematics and science instruction focus on maximizing both the sample and the quality of data: (1) We wanted to include the entire sample of students (in both the base year and follow-ups, NELS collected data from two of each student’s teachers—either English or social studies and either mathematics or science), and (2) we included data from both students and teachers about instruction in their schools to produce a more reliable measure of this construct. The technical details of the application of the Rasch method in this instance are available from the authors.

5. We decided not to include student-level information about authentic instruction in the within-school part of the HLM models. Each student reported information about the particular science class he or she was taking in the second semester of his or her sophomore year (the F1S variables were collected from students in February of the first follow-up year). Thus, the report is only about instruction in a single class at a particular time, rather than about all the students’ classes or classes over the four years of high school. Teachers’ data were also about a particular student’s class, but came from either mathematics or science teachers, not both, and only in the first follow-up.

6. The NELS high school mathematics tests were “tailored” or “adaptive” (Ingels et al. 1994a). At the first follow-up, students with low scores in the base year were given easier items than those with moderate or high scores in that year. Tailoring makes the tests more responsive to effects of the high school mathematics curriculum (which is typically tracked by ability), avoids ceiling effects for the most able students, and

locates the discrimination of the test differentially by ability. Although the science test was not tailored, more difficult items were introduced and simpler ones were dropped over the testing periods. Tailoring may explain the larger proportional gains in mathematics than in science.

7. Our reason for presenting coefficients as ESs is to facilitate comparison across outcomes measured in different units. However, because the ESs were computed by dividing by different *SD* units across subject and time (see Table 3), readers should exercise some caution in comparing them (especially across time).

8. Although results on the four outcomes are presented in separate columns, it is important to note that effects on all four outcomes in Table 4 were estimated in a single HLM model for each subject. The model was, in fact, even more complex; it included the within-school controls shown in Table 2. Since those effects did not change much from those estimated in Table 2 and were not the focus of our analyses, we did not include them in Tables 3 or 4.

9. Another measure of school social organization, staff cooperation, was statistically significant in an HLM model without the responsibility-for-learning measure. Once the latter variable was introduced, staff cooperation dropped to nonsignificance and was deleted from the model. In a separate study of the effects of collective responsibility for learning (Lee and Smith 1996), we found that these effects overshadowed those of staff cooperation and teacher empowerment in a multivariate model. It is not surprising that these several measures of teacher professional community are not independent of one another.

REFERENCES

- Bryk, Anthony S. 1994, Fall. "More Good News that School Organization Matters." Pp. 6-8 in *Issues in Restructuring Schools* (Issue 7). Madison: Center on Organization and Restructuring of Schools, University of Wisconsin.
- Bryk, Anthony S. and Mary E. Driscoll. 1988. *The School as Community: Theoretical Foundations, Contextual Influences, and Consequences for Students and Teachers*. Madison: National Center on Effective Secondary Schools, University of Wisconsin.
- Bryk, Anthony S., Valerie E. Lee, and Peter B. Holland. 1993. *Catholic Schools and the Common Good*. Cambridge, MA: Harvard University Press.
- Bryk, Anthony S. and Stephen W. Raudenbush. 1992. *Hierarchical Linear Models: Applications and Data Analysis Methods*. Newbury Park, CA: Sage.
- Carnegie Council on Adolescent Development. 1989. *Turning Points: Preparing American Youth for the 21st Century*. New York: Carnegie Corporation of New York.
- Cole, Michael and Peg Griffin, eds. 1987. *Improving Science and Mathematics Education for Minorities: Contextual Factors in Education*. Madison: Wisconsin Center for Educational Research, University of Wisconsin.
- Firestone, William A. and Sheila Rosenblum. 1988. "Building Commitment in Urban Schools." *Educational Evaluation and Policy Analysis* 10:285-300.
- Ingels, Steven J., Kathryn W. Dowd, John D. Baldridge, James L. Stripe, Virginia H. Bartot, and Martin R. Frankel. 1994a. *National Education Longitudinal Study of 1988. Second Follow-Up: Student Component Data File User's Manual* (NCES Publication 94-374). Washington, DC: U.S. Department of Education.
- Ingels, Steven J., Lisa Thalji, Paul Pulliam, Virginia H. Bartot, and Martin R. Frankel. 1994b. *National Education Longitudinal Study of 1988. Second Follow-Up: School Component Data File User's Manual* (NCES Publication 94-376). Washington, DC: U.S. Department of Education.
- Jencks, Christopher. 1985. "How Much Do High School Students Learn?" *Sociology of Education* 58:128-35.
- Knapp, Michael S. and Patrick M. Shields, eds. 1990, January. *Better Schooling for Children of Poverty: Alternatives to Conventional Wisdom* (Vol. 2). Washington DC: U.S. Department of Education, Office of Planning, Budget, and Evaluation.
- Kozma, Robert B. and Robert G. Croninger. 1992. "Technology and the Fate of At-Risk Students." *Education and Urban Society* 24:440-54.
- LeCompte, Margaret D. and A. Gary Dworkin. 1991. *Giving Up on School: Student Dropout and Teacher Burnouts*. Newbury Park, CA: Corwin Press.
- Lee, Valerie E. and Anthony S. Bryk. 1989. "A Multilevel Model of the Social Distribution of High School Achievement." *Sociology of Education*

- 62:172-92.
- Lee, Valerie E., Anthony S. Bryk, and Julia B. Smith. 1993. "The Effects of High School Organization on Teachers and Students." Pp. 171-268 in *Review of Research in Education* (Vol. 19), edited by L. Darling-Hammond. Washington, DC: American Educational Research Association.
- Lee, Valerie E. and Julia B. Smith 1993. "Effects of School Restructuring on the Achievement and Engagement of Middle-Grade Students." *Sociology of Education* 66:164-87.
- . 1995. "Effects of High School Restructuring and Size on Gains in Achievement and Engagement for Early Secondary School Students." *Sociology of Education* 68:241-70.
- . 1996. "Collective Responsibility for Learning and Its Effects on Gains in Achievement for Early Secondary School Students." *American Journal of Education* 104:103-47.
- Levine, Daniel U. 1988. "Teaching Thinking Skills to At-Risk Students: Generalizations and Speculations." Pp. 117-37 in *At-Risk Students and Thinking: Perspectives from Research*, edited by B. Z. Presseisen. Washington, DC: National Education Association.
- Louis, Karen Seashore. 1990. "Social and Community Values and the Quality of Teacher Work Life." Pp. 17-39 in *The Context of Teachers' Work in Secondary Schools*, edited by M. McLaughlin, J. E. Talbert, and N. Bascia. New York: Teachers College Press.
- Louis, Karen Seashore, Sharon D. Kruse, and Associates. 1995. *Professionalism and Community*. Thousand Oaks, CA: Corwin Press.
- Louis, Karen Seashore, Helen M. Marks, and Sharon D. Kruse. 1996. "Teachers' Professional Community in Restructuring Schools." *American Educational Research Journal* 33:757-98.
- McCaslin, Mary and Thomas L. Good. 1992. "Compliant Cognition: The Misalliance of Management and Instructional Goals in Current School Reform." *Educational Researcher* 21:4-17.
- McLaughlin, Milbrey W. 1994, Fall. "Somebody Knows My Name." Pp. 9-11 in *Issues in Restructuring Schools* (Issue 7). Madison: Center on Organization and Restructuring of Schools, University of Wisconsin.
- National Association of Secondary School Principals. 1996. *Breaking Ranks: Changing an American Institution*. Reston, VA: Author.
- Newmann, Fred M. 1991. "Linking Restructuring to Authentic Student Achievement." *Phi Delta Kappan* 72:458-63.
- . 1993. "Beyond Common Sense in Educational Restructuring: The Issues of Content and Linkage." *Educational Researcher* 22(2):4-13, 22.
- Newmann, Fred M., Helen M. Marks, and Adam Gamoran. 1996. "Authentic Pedagogy and Student Performance." *American Journal of Education* 104:280-312.
- Oakes, Jeannie. 1985. *Keeping Track: How Schools Structure Inequality*. New Haven, CT: Yale University Press.
- Powell, Arthur G., Eleanor Farrar, and David K. Cohen. 1985. *The Shopping Mall High School: Winners and Losers in the Educational Marketplace*. Boston: Houghton Mifflin.
- Quality Education for Minorities Project, MIT. 1990 January. *Education that Works: An Action Plan for the Education of Minorities*. Cambridge, MA: Author.
- Rasch, Georg G. 1980. *Probabilistic Models for Some Intelligence and Attainment Tests*. Chicago: University of Chicago Press.
- Rosenholtz, Susan J. 1991. *Teachers' Workplace: The Social Organization of Schools*. New York: Longman.
- Rowan, Brian. 1990. "Commitment and Control: Alternative Strategies for the Organizational Design of Schools." Pp. 353-89 in *Review of Research in Education* (Vol. 16), edited by C. B. Cazden. Washington, DC: American Educational Research Association.
- Sedlak, Michael W., Christopher W. Wheeler, Diana C. Pullin, and Philip A. Cusick. 1986. *Selling Students Short: Classroom Bargains and Academic Reform in the American Classroom*. New York: Teachers College Press.
- Sizer, Theodore R. 1984. *Horace's Compromise: The Dilemma of the American High School*. Boston: Houghton Mifflin.
- Waller, Willard. 1932. *Sociology of Teaching*. New York: Russell & Russell.

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