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ABSTRACT

The call to restructure American education has captured the imagination of reformers across the country, yet it has not produced a coherent agenda for changing schools. This study investigates how the structure of secondary schools affects learning. Using a sample of 9,631 students in 789 U.S. high schools with 3 waves of data from the National Education Longitudinal Study of 1988 (NELS:88), it extends an earlier study that demonstrated positive effects of high school restructuring not only on learning but also on its equitable distribution by social class. The more recent study addresses two questions: Do the positive effects of restructuring practices persist throughout the high school years? Which organizational attributes contribute to these effects? The study examined achievement in mathematics and science at the 8th, 10th, and 12 grades to answer these questions. Although students learned somewhat less in the last 2 than the first 2 years, the positive effects were sustained throughout high school. More important, particular features of the social, structural, and academic organization of high schools explained the restructuring effects identified in the earlier study. The study identifies larger organizational factors that make some high schools better places in which to learn than others. It recommends that educators and policymakers shrink the bureaucracy; create smaller places within schools (for example, schools-within-schools); develop cooperative social relations within schools; and emphasize academic pursuits. Three tables and six endnotes are included. The appendix explains how the measures used in the study were constructed. (LMI)

Understanding High School Restructuring Effects on the Equitable Distribution of Learning in Mathematics and Science

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Understanding High School Restructuring Effects on the Equitable Distribution of Learning in Mathematics and Science

Abstract

This study investigates how the structure of secondary schools affects learning. Using a sample of 9,631 students in 789 U.S. high schools with three waves of data from NELS:88, it extends an earlier study that demonstrated positive effects of high-school restructuring not only on learning but also on its equitable distribution by social class. This study address two questions: Do the positive effects of restructuring practices persist throughout the high-school years? Which organizational attributes contribute to these effects? We examine achievement in mathematics and science at the 8th, 10th, and 12th grades to answer these questions. Although students learn somewhat less in the last two than the first two years, the positive effects are sustained throughout high school. More important, particular features of the social, structural, and academic organization of high schools explain the restructuring effects identified in the earlier study. This study identifies larger organizational factors that make some high schools better places in which to learn than others.

Understanding High School Restructuring Effects on the Equitable Distribution of Learning in Science and Mathematics

The call to restructure American education has captured the imagination of reformers across the country, yet it has not produced a coherent agenda for changing schools. Under a "restructuring" umbrella, proponents have compiled a wide and often contradictory list of school reforms (Conley 1993; Elmore 1990; Murphy and Hallinger 1993; Newmann 1991a). These include changes in school governance and management; the content and practice of teaching and learning; the organization of teachers' work; the quality of relationships between staff, students, and community; even the education of teachers and administrators at the post-secondary level. Motivating the restructuring movement is a belief that significant changes are impossible unless almost every aspect of the U.S. public school system is overhauled.

Three concerns about the U.S. public school system underlie the movement: (1) students do not learn enough, especially compared to what their counterparts learn in other countries; (2) what students do learn is fragmented, rote, and disconnected from the real world, and (3) disadvantaged students learn less than their more advantaged classmates (Newmann 1991a; Quality Education for Minorities Project, 1990). Restructuring is supposed to address one or more of these concerns, although the mechanisms by which it would do so are not well understood (Lee and Smith 1995).

In an effort to better understand the possible effects of restructuring, we extend the results of a prior study that demonstrates positive effects for restructuring practices on achievement gains early in high school, particularly for students of low socioeconomic status. We identify organizational properties associated with these effects for learning in science and mathematics throughout the high-school years. Before presenting these results, we briefly review the literature on school restructuring, including the results of our prior study.

Background

Reforming High Schools

A wave of top-down reform, sparked by A Nation at Risk (National Commission on Excellence in Education 1983), aimed to raise high-school students' achievement by (a) strengthening formal controls over teaching and learning and (b) tightening the loose connection between administation and the technical core. Proponents advocated raising graduation requirements, standardizing classroom practices, and holding teachers accountable for their students' performance on standardized tests.

Though such reforms had some desirable effects, such as increasing the number of academic courses taken by low-achieving students (Clune and White 1992), they also raised concerns about decreased teacher commitment, satisfaction, and performance (Rosenholtz, 1987, 1991). Evaluations indicated that bureaucratic controls of teaching inhibit the acquisition of analytic and higher-order skills (Darling-Hammond and Wise 1985). Some questioned whether higher standards would force low-achieving students to drop out without more fundamental changes in policies and practices (Natriello, McDill and Pallas 1990).

Indirect Evidence on School Restructuring

Modest implementation. Alhough the restructuring movement is in full swing, the evidence that restructuring increases student learning, promotes deeper understanding, or reduces social inequities in achievement is modest. Though the language of restructuring urges radical school change, the reality is far more modest (Berends and King 1994; Conley 1993; Elmore 1990; Murphy and Hallinger 1993; Newmann 1991a). Schools typically implement reforms a little at a time: what Tyack and Cuban (1995) call "tinkering toward utopia." Some reforms have successfully nudged schools toward more organic organization or classroom practices that promote higher-order skills, deeper understanding of subjects, and more authentic learning tasks (Lee and Smith 1995, 1996; Newmann, Marks, and Gamoran 1995). Model programs, sometimes showcased, are usually held at the margins of school life and thus influence core activities or relationships only modestly. Pure models of successful restructuring are rare.

The changes promoted by restructuring, although they sound new, have a long history. Many grow out of tensions between traditional and innovative practices that have been played out again and again in previous reform movements (Cuban 1990; Rowan 1990). As a result, some schools are more "restructured" than others, even though they have not been active participants in the restructuring movement. That is, they engage in practices that are consistent with the movement. Such schools provide a setting for investigating (at least indirectly) the effects of restructuring, in that they offer an opportunity to evaluate organizational forms that promote restructuring goals. We discuss three forms that have been linked empirically to restructuring goals: the common academic curriculum, authentic instruction, and communal school organization. The first two forms characterize the organization of academic work; the last focuses on social relations.

The common curriculum. Students' academic experiences in most high schools are compartmentalized, differentiated, and socially stratified. The curriculum is divided into discrete areas that are typically organized by department. These units organize subjects into course sequences (i.e., tracks), access to which is determined by ability, performance, or aspirations. Such high schools offer students a wide range of courses within 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 horizontally (in terms of tracks) and vertically (multiple offerings within tracks or even multiple versions of the *same* course with different expectations) creates substantial differences in what students study and learn within the same school (Lee et al. 1993).

Disadvantaged students are especially harmed by a highly differentiated curriculm. More of their courses are low-track offerings that require less academic effort, have lower expectations for achievement, and have less high-level content (Oakes 1985; Sedlak, Wheeler, Pullin, and Cusick 1986). A growing body of research suggests 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 more similar in academic content and expectations, students in different classrooms have similar academic experiences. Although this form of academic organization has been associated with Catholic schools, Bryk, Lee, and Holland (1993) suggest that public schools with similar structures would also have high and more socially equitable achievement.

Authentic instruction. One conception of how knowledge is acquired emphasizes the standardization of teaching practices and learning tasks. Evidence is accumulating that this conception fails to provide opportunities for students to develop more advanced thinking skills, higher levels of proficiency in academic subjects, and a sense of themselves as active learners (McCaslin and Good 1992; Newmann 1991a). A different approach to instruction requires that students be involved in constructing (rather than reproducing) knowledge through disciplined and sustained involvement in tasks that resemble real-life problems.

Although all students benefit from authentic instruction, there is evidence that such practices may be particularly beneficial for socially disadvantaged students. Such students, however, are especially unlikely to experience authentic instruction (Cole and Griffin 1987; Quality Education for Minorities Project 1990). Disadvantaged students, often also low-achieving, are typically in classrooms that emphasize lower-order skills, basic knowledge, drill and practice, recitation, and desk work (Levine 1988; Knapp and Shields 1990). However, low-achieving students can master more complex and demanding tasks, and these richer learning environments can lead to dramatic gains in achievement (AAAS 1984; Knapp and Shields 1990; Kozma and Croninger 1992; Levine 1988).

Communally organized schools. Bureaucratically structured schools rely on affectively neutral social relationships to facilitate the administration of standardized rules and procedures. Strong personal ties between adults, or between adults and students, make it more difficult for staff to comply with standard practices and procedures. Yet, as Willard Waller (1932) noted long ago, emotional bonds between teachers and students are crucial in engaging and motivating students to learn. The quality of affective ties between staff also directly influences teacher commitment and indirectly affects student achievement (Bryk et al. 1993; Rosenholtz 1991; Lee and Smith 1996). The alienating and disengaging qualities of the typical high school have received much attention (see Firestone and Rosenblum 1988; LeCompte and Dworkin 1991). Restructuring proposals have encouraged downsizing schools, creating stronger bonds and more trusting relationships between students and adults, and facilitating greater collaboration and cooperation between teachers (e.g., Sizer 1984).

Although the importance of creating a sense of community in schools is generally recognized, a distinct theory and empirical studies documenting the advantages of communitarian schools are quite recent.[1] Rather than formal and affectively neutral relationships, in communally organized schools members are committed to a common mission. Staff and students interact outside the classroom; adults see themselves as responsible for students' total development, not just for the mastery of lessons. Teachers share responsibility for students' academic success, exchanging information and coordinating efforts between classrooms and across grades. Outcomes are more positive in such schools both for teachers (e.g. satisfaction, morale, absenteeism) and for students (e.g., class cutting, absenteeism, and dropping out). Attending these more positive and caring schools is especially beneficial for disadvantaged students (Bryk and Driscoll 1988; Bryk et al. 1993; Lee et al. 1993).

School organization and restructuring. A growing body of educational research, mostly sociological in nature, suggests that both the academic and social organization of schools influences not only student learning (including acquiring more advanced competencies) but also the social distribution of learning. Schools that emphasize academics, that present students with fewer non-academic curricular offerings, and that encourage authentic forms of teaching promote the goals of restructuring. Schools that foster more supportive and positive social relationships, both among staff and between staff and students, enhance the commitment of teachers and the engagement of students. Although these forms of school organization may not be a *direct* result of restructuring, assessing their effects can provide indirect evidence that changing the structure of secondary schools can make them more effective. We hypothesize that restructuring activities in schools with these forms are more successful than those initiated in schools without them.

Research Questions

Previous work. The study described here is a longitudinal followup to a study recently published in this journal, "Effects of High School Restructuring and Size on Gains in Achievement and Engagement for Early Secondary School Students" (Lee and Smith 1995). The purpose of that study (hereafter called the Early Restructuring Study, or ERS) was to assess the impact on students, in their early years of high school, of attending schools employing practices consistent with the school restructuring reform movement. Restructuring effects were evaluated on growth in students' engagement and achievement, as well as the social distribution of those gains. Results were strong and consistent: achievement and engagement were significantly higher in schools classified as "restructuring." Those outcomes were also distributed more equitablly in restructuring schools.

Results from the ERS received considerable attention, including a citation in Newsweek (Hancock, 1994) as an example of research countering the conclusions from Herrnstein and Murray's controversial 1994 book, The

Bell Curve. Excitement centered on the findings that (a) high schools with certain organizational forms ("small and cooperative") were shown to have positive effects on students' learning in their first two years, (b) these organizational forms also induced a more equitable distribution of learning among students from different social-class backgrounds ("the gap between the poor and those who were not poor shrank in the more nurturing schools," (Hancock 1994:61), and (c) students in smaller high schools experienced more positive outcomes in learning and equity.

Expanding on the ERS. Although the ERS findings that particular school structures could foster positive effects on both learning and equity were gratifying, we needed to understand the meaning of our findings. Two questions drove this study: "Do the effects of school restructuring in the early years of high school endure?" More important, "What organizational characteristics of high schools help to explain the apparent effects of restructuring practices?" Because the analyses in the ERS were already quite complex, we have restricted our analyses here to achievement growth in two subjects: mathematics and science.

Method

Sample, Data, and Analysis

Sampling design. We drew our sample from the first three waves of the *National Education Longitudinal Study of 1988* (NELS), a longitudinal study of the educational status and progress of U.S. students and schools 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-grade schools. Students were traced to high schools in 1990, with reasonably high response rates.

Data filters. This study is the third in a series using NELS data to study the effects of school restructuring. The sample includes NELS 12th graders who fit these data filters: (1) students had to have full cognitive test-score data for the three waves; (2) there must 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 5 NELS-sampled students in them at grade 10; and (5) they had to be in the same high schools at 10th and 12th grade (Ingels et al. 1993a. 1993b). We used data filters 1-4 for the ERS (Lee and Smith 1995).

The sample for this study includes 9,570 seniors in 789 high schools (all included in the ERS). The nested sample averaged 12.2 students/school. The large majority of sampled schools were public. Because the original NELS sampling design involved oversampling certain types of students and schools, we constructed a school-level weight in order to generalize to the U.S. population of high school students and schools. NELS did not include high school-level design weights in their data files. The procedure for constructing the weights is descibed in Lee and Smith (1995).

Hierarchical approach. Because the research questions for this study focus on how students' learning in mathematics and science is influenced by the organization of the high schools they attend, we use an analytic method designed for such questions: hierarchical linear models [HLM] (Bryk and Raudenbush 1992). We used HLM in our previous restructuring studies (Lee and Smith 1993; 1995). The method, now common in school effect studies, has been described elsewhere. The HLM models in this study have a 3-level nested structure: multiple test scores nested in students, which are in turn nested in schools.

The three-level HLM model of change over time is described in Chapter 6 of Bryk and Raudenbush (1992). How that technique applies here is somewhat restrictive, given the modest number of time points to model change. The NELS test scores allow the estimation of change in a repeated observations model, as each score positions a student on an absolute scale of science or math performance . Differences in scores between time points are framed as "growth," with the difference in scores on the same test between two time points framed as the student's "gain" in performance. We explored two growth parameters: (1) 8th to 10th grade [early], and (2) 10th to 12th grade [late]. Of course, the parameters are not independent, nor is either independent of initial status (8th grade). Readers interested in more detail about this application should contact the authors directly.

Classifying Schools by Their Structural Practices

Logic for grouping schools. The categorization of high schools in this study, identical to that in the ERS, was based on the degree to which they reported practices consistent with the restructuring reform movement. We used three major (and interconnected) criteria: (1) the logic laid out the literature reviewed above; (2) the broader literature on school communal organization (Bryk and Driscoll 1988; Bryk et al. 1993); and (3) definitions developed over several years by the Center on Organization and Restructuring of Schools [CORS] (Newmann 1991b). We categorized schools in a two-step process. Step one involved classifying a set of 30 reform practices on which data were available on NELS high schools. Principals indicated whether their school currently had each practice in place. In step two, we grouped the NELS high schools according to the number and type of reform practices which principals reported were currently in place. Our emphasis was not on whether a practice was new, but on whether it was consistent with practices advocated by the restructuring movement.

Grouping reform practices. We grouped the 30 reform practices as "restructuring" or "traditional" according to these criteria. Our definition of school restructuring, which is consistent with research and theory developed by CORS, combines two ideas: (1) reforms moving the school away from bureaucratic structures and (2) reforms that depart from conventional practice. Reforms classified as "Restructuring Practices" fit both ideas: they moved schools away from a bureaucratic structure and they were also less common.

Classifying schools. Once the reforms were classified as traditional or restructured, we investigated the number and type of reforms in place in each school. Schools were unlikely to engage in reforms along a singular dimension (such as instruction, authority, or social relations), nor did they typically engage exclusively in restructuring practices. Rather, schools were likely to report engaging in reforms of different types simultaneously, consistent with the incremental model of change described above. We classified schools engaging in at least three restructuring practices as *restructured schools*.[2] Schools that engaged in several traditional reforms but fewer than three restructuring reforms were classified as *traditional practice schools*. A small proportion of schools reported engaging in none of the 30 practices, and were classified as *no reform schools*. More detail on item wording for each reform practice, its grouping as traditional or restructured, the probabilitiy of its occurrence in NELS high schools, and the logic underlying the grouping of reform practices and categorization of schools according to these practices is found in Lee and Smith (1995).

Measures

Outcomes. This study examines school effects on achievement growth in mathematics and science. Three rationales guided our choice of outcomes:

(1) we restricted the number of NELS subject areas to limit the complexity of results; (2) we selected math and science because data on classroom instruction collected by NELS was limited to these subjects; and (3) NELS information on students course taking in these subjects was much more precise than in other subject, both from self-reports and from transcripts. Actually, we investigated four outcomes for each subject: early and late achievement gain (Outcomes 1 and 2) and the social distribution of these early and late gains according to students' social class [SES] (Outcomes 3 and 4). These outcomes are displayed schematically in Figures 1 and 2. Figure 1 displays Outcomes 1 and 2: early (8th-10th) and late (10th-12th) achievement growth in math and science. Results are reported in standard deviation (SD) units to facilitate comparison across tests with different numbers of items. It is clear that although students gained knowledge in both subjects over both periods, they learned more early (Outcome 1) than late (Outcome 2) in high school. Figure 2 represents Outcomes 3 and 4, which represent the social distribution of achievement gain in mathematics (A) and science (B) within each school.

Insert Figures 1 and 2 about here

Three trends are relevant. First, students learn more earlier than later high school in both subjects (i.e., the slopes are steeper for Outcome 1 than 2). Second, students don't learn very much over either period (i.e., the learning slopes are not very steep). Third, the learning rates are not constant across subjects: students learn more mathematics than science, particularly in the early high school years. Using terminology suggested by Bryk and Raudenbush (1992), Outcomes 1 and 2 are *effectiveness parameters* in our HLM models.

Figure 2 displays effects computed from within-school HLMs. Displayed graphically is the relationship between SES and achievement gains in mathematics (Panel A of Figure 2) and science (panel B) over these two periods, the *equity parameters*. Outcome 3 represents the SES slope on math and science learning early in high school, whereas Outcome 4 is the SES slope on learning in the last two years. Figure 2 suggests that the relationship (or slope) between SES and gain in both subjects varies over time and over SES level. While the slope decreases over time, it is steeper for higher-SES students. Outcomes 1 and 3 were explored in the ERS study.

<u>Independent variables</u>. Independent variables describe both students and schools. Our major focus is on the latter group. More detail on construction of some variables are found in the Appendix. Because variables used in the ERS study are described elsewhere (Lee and Smith 1995), the Appendix provides details only on measures that are new to this study. We describe all control variables used in the study, however.

Controls on students. Within-school controls are of three types: demographic characteristics, academic status at high-school entry, and course taking. Demographic controls include: SES (a z-score with mean [M] = 0, SD = 1); a dummy-coded measure of minority status (Hispanic or Black = 1, non-minority = 0); and gender (female = 1, male = 0). Two measures control for status at the beginning of high school: achievement (in either math or science, depending on the outcome) and engagement with academic activities. We also include controls for students' course taking patterns in mathematics (self-reports of courses in the first two years of high school for Outcome 1; a measure of all high-school courses in math and science taken from students' transcripts for modeling Outcome 2). These controls were also included in the ERS.

Variables describing schools. Between-school controls measuring school organization are of four types. The first type, *composition and structure*, includes average SES; minority concentration (a 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, *restructuring status*, also captures school structure. Based on the school categorizations described above, we include two dummy-coded contrasts: (1) restructuring schools compared to traditional schools, and (2) schools without reform practice compared to traditional practice schools. Although school composition and structure measures are used as statistical controls, the restructuring contrasts represent a central construct in the study.

Variables of the third type tap *school social organization*. Although we investigated several such measures, our HLM models include a single variable: collective responsibility for learning. This composite of items capturing teachers' attitudes about their personal willingness and ability to alter teaching methods to respond to the learning difficulties of their students was shown elsewhere to have strong effects on student learning (Lee and Smith 1996).

School measures of the fourth type tap the construct of *academic organization*. One variable, the school average of students' course taking in academic mathematics and science courses, is meant as a proxy measure of the common curriculum. We also used the standard deviation of course taking to indicate variability in students' intellectual experiences. Academic press is a composite of principals' reports about 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 colescence among school members around an academic mission for the school.

Also capturing elements of schools' academic organization are two measures that focus on 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.[3] Rather than factor analyis, the construction of this variable was with a technique, Rasch modeling, more commonly used to rescale test score items or rating scales. Rasch scaling is based on an *accumulation* of individual instruction practices, rather than the use of certain practices in place of others (Rasch 1980). We use the composite as a measure of instructionally rich classrooms that use multiple practices associated with constructivist teaching or active learning; what Newmann labels authentic pedagogy (Newmann 1991b; Newmann, Marks, and Gamoran 1995). Another variable, the standard deviation of the Rasch scales from student items, taps variability in authentic instruction within a school.

In order to understand how high school organization influences learning and its equitable distribution, and to gauge the relationship between school organization and school restructuring, we first investigate how these school characteristics are related to the categorication of schools by restructuring practices.

Characteristics of Schools in the Restructuring Categories

School characteristics. In Table 1, descriptive information on the characteristics of the 789 schools in the sample is broken down by the schools grouped as those without reform practices (column 1), those with traditional practices (column 2), and schools with restructuring practices (column 3). Group means were computed and tested using one-way ANOVA with two contrasts: (1) no-reform compared to traditional schools, and (2) restructuring practice schools compared to traditional schools. Almost half (46 percent) are restructuring practice schools, 43 percent are traditional practice schools, and 11 percent are schools without reform practices. The schools' organizational characteristics are distinctive in several ways.

Insert Table 1 about here

Composition and structure. Schools without reform practices are significantly disadvantaged compared to traditional practice schools on several social demographic factors (more minority students and students of lower ability). More striking is the advantage of restructuring practice schools compared to the same group in terms of average SES and average 8th grade achievement. Distribution by sector explains some of the social background differences. Private schools represent 14 percent of the school sample, the majority of which are restructuring practice schools. Nevertheless, the overwhelming majority of all groups are public schools. Traditional schools are smaller than either restructuring or no-reform schools.

Social organization. School social organization focuses on reports from teachers about how much responsibility they take for the learning of their students. The pattern of group differences that favors restructured schools suggests that social organization may be intertwined with school restructuring, although the causal direction of relationships is unclear.

Academic organization. A similar pattern is evident among measures of academic organization. Restructuring practice schools are significantly advantaged on all these measures: students take more math and science courses and there is less variability in course taking, instruction is more authentic, authentic instruction is more homogeneous across classes in restructuring practice schools, and these schools have higher levels of academic press. Although again the causal direction is unclear, the pattern is not: restructuring schools have stronger academic organizations.

The patterns from Table 1 are distinct. Restructured schools are advantaged in the types of students who go to them, including (and not independent of) the larger proportion of private schools in their ranks. Therefore, the demographic and structural organization of schools should be taken into account in any analyses that compare these schools, above and beyond controlling for the types of students who go to the schools. It is evident that restructuring practice schools are also advantaged in terms of organizational characteristics. Thus, these factors are probably important in understanding any restructuring effects on student learning.

Results

Revisiting Restructuring Effects Early in High School

Summary of the ERS. As stated, the ERS study evaluated the effects of school restructuring, based on the categorization of schools we described, on achievement gains over the early high school years (Lee and Smith 1995). The pattern of effects was clear and consistent: students learned more in mathematics, reading, history, and science in restructuring schools compared to traditional schools (Outcome 1 in Figure 1). Effect sizes (ES) of the "restructuring school advantage" on learning averaged between .35 and .59 SD, moderate to large effects. Equally important, achievement gains in all subjects for students attending restructuring schools were more equitably distributed by student SES (effects on Outcome 3 averaged about -.3 SD). Students in schools without reform practices were disadvantaged on these outcomes compared to their counterparts in traditional schools, although ESs were somewhat smaller. Results were estimated in HLM models that included within-school controls for students' minority status, gender, SES, 8th-grade ability, and 8th grade engagement. Between-school controls included average school SES, minority concentration, school size, sector, average course taking, and variability in course taking.

Revisiting the research questions. But what do the consistent and encouraging results of school restructuring on learning early in high school really mean? Because we know that learning builds on prior learning, we need an analytic model that takes early gains into account -- one that considers a student's learning trajectory rather than simple status changes investigated so far. First, we want to know whether the effects of attending schools classified by their restructuring status are sustained on learning later in high school, with a model that takes early learning into account. More important is to understand the implications of the restructuring effects we have shown. Thus, the second research question asks, "Are there other organizational characteristics of these high schools that would help us understand why schools classified by restructuring practices have such favorable effects on their students?" As stated, we limited these analyses to learning in science and mathematics.

Organizational Effects on Early and Late Achievement Gains

Within-school (level 2) HLM model. NELS measured students' achievement at three important time points: near the end of 8th grade (entry into high school); in 10th grade (midway through high school); and at the end of 12th grade (just before graduation). We stuctured our HLM analyses as described in the Methods section. Figures 1 and 2 indicated the four outcomes we investigated in the two subject. The two gains (early and late) in science and mathematics achievement we call "Outcome 1" (from 8th to 10 grade) and "Outcome 2" (between 10th to 12th grade). Outcomes 3 and 4 focus on the relationship between SES and those gains. The distributions of Outcomes 1 and 2 are described in the top panel of Table 2.

Insert Table 2 about here

The average early gain on the 25-item science test is larger (2.86 points) than the later gain (1.60). The average early gain on the 40-item math test (8.47) is larger than the later gain (4.66). Students learn little science over the course of high school, at least as measured by NELS test items; they learn somewhat more mathematics.[4] Although SDs of the two science gains are similar (and large), the SDs of the math gains differ; the late gain is less variable. HLM variance estimates of within-school gains in both subjects, pooled across schools (tau-pi), are much larger than between-school variances (tau-beta). In a 3-level HLM model, most of the variation in the outcome is captured by the measurement (Level-1) model. All four gains are quite reliable (.85-.95), as extimated by HLM, despite modest between-school variances.

The Level-2 (within-school) HLM model for the learning outcomes (early and late gain in science and math) are shown in the bottom panel of Table 2. As before, we present effects of student characteristics on on Outcomes 1 and 2, estimated simultaneously for each subject, in effect size (ES) units, computed by dividing the estimated gamma coefficients by the SD of each outcome estimated with a fully unconditional HLM. We remind readers that the HLM growth model includes control for early gain on late gain, as well as a control for ability. Several patterns are evident. While engagement has no effect on learning, prior achievement (measured at 8th grade in each subject) has a substantial effect. In both subjects, effects are very large on early gains (ESs over 2 SD). Other student characteristics exert quite different effects for the two subjects. For example, 8th-grade achievement has no effect on late gain in science, but it is related to late gains in math (ES = .9 SD). The number of academic courses taken in math and science early in high school has no effect on early science gain, but is an important predictor of early math learning (ES = .5 SD). We note that courses taken in these subjects in the last half of high school exert no residual effect on late gain, once other variables are controlled.

Demographic effects differ by subject. Social class (SES) has stronger effects on late than early gains in both subjects, particularly in mathematics (ES = 1.2 SD for late gain, compared to .7 SD on early gain). The SES effect on science gain is more similar for the two gain measures (ES = .6 SD on early gain, .7 SD on late gain). Gender effects are large and favor males, especially in science (ES= -1.4 SD for both time spans). Although the gender effect also favors males in math, it is much larger for late (ES= -.8 SD) than early gain (ES = -.2 SD). The effects of minority status are unusual. For early gains in both math and science, minority status is negatively related, although the effect is much large on early science gain (ES= -1.3 SD) than early math gain (ES= -.6 SD). Minority effects on late gains are positive, however, and they also increase over time. Many of these effects are important and interesting; however, because they do not relate to the research questions in this study we discuss them no 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).

Are the Effects of School Restructuring Sustained?

Between-school (Level 3) HLM restructuring model. Using the within-school HLM models shown in Table 2, we estimated a set of 3-level HLM analyses on Outcomes 1 to 4 with a a growth modeling format. Although the intent of this analysis is similar to the ERS described earlier, it differs from that study in two important respects: (1) it uses a growth trajectory design, whereas the ERS used a simpler 2-level HLM design that used test score differences as outcomes; and (2) it compares restructuring effects on gains early and late in high school. Besides the statistical controls on students, the models also include the following school-level controls: average school SES, minority concentration, school sector, and school size.

Results, shown in Table 3, are also presented in ES units. In general, the results confirm the stability of restructuring effects, over time and over subject matter.

Insert Table 3 about here

For Outcomes 1 and 2 (the *effectiveness parameters*), the learning of students attending restructuring practice schools was significantly higher in both subjects. In fact, effects increased later in high school (in science, ES=.7 SD for Outcome 1, 1.5 SD for Outcome 2; in math, ES=.7 SD for Outcome 1, 1.1 SD for Outcome 2). Students in no-reform schools are disadvantaged in learning in both subjects. On the *equity parameters* (Outcomes 3 and 4), learning in science and math is more equitable among students in restructuring practice schools; again the restructuring effects increase later in high school. Effects of attending schools without reforms suggest that learning in both subjects is both lower and also more socially inequitable. Our results here confirm and expand the positive findings from the ERS and provide a positive answer to our first research question. Quite simply, attending schools that are categorized as restructuring according to the definition laid out above has sustained, positive, and equitable effects on students' learning in science and mathematics.

<u>Understanding Restructuring Effects Through Organizational Factors</u>

Technically, our method of addressing the third research question involves an attempt to "explain away" the restructuring effects by including characteristics of the schools' academic and social organization in our HLM models. The results of the HLM organizational models that answer this question are displayed in Table 7.[5] It is evident that organizational effects on the four outcomes (early and late achievement gains in science and mathematics and the SES slopes on each of these gains) are large, consistent, and logical. We organize our discussion of effects around the constructs the independent variables represent rather than by outcomes.

Insert Table 7 about here

<u>Demographic and structural effects</u>. The effects of both social composition (average school SES, minority concentration) and school sector are

generally non-significant. However, even after taking into account several related organizational characteristics of schools, the effects on both the effectiveness and the equity parameters of *school size* are large. Learning in science and mathematics is higher in smaller schools, both early and late in high school. Even larger effects accrue on the equity parameters; smaller schools are more equitable. The size effects are somewhat larger on late than early gains.

Restructuring effects. In the organizational models, restructuring effects, which were statistically significant in Table 3, have generally moved to non-significance. However, the pattern of restructuring effects is in the same direction: attending restructuring practice schools has a positive effect on the effectiveness parameters, a negative effect on the equity parameters. These results provide allow us to respond positively to the second research question. That is, the organizational characteristics of schools we consider have "explained away" the restructuring effects demonstrated in the ERS and in Table 3 of this study. Of course, this finding provides only a first-cut answer to the original question. We would like to know *which* organizational effect matter.

Social organization. School social organization, measured here as collective responsibility for learning, is strongly and positively associated with both effectiveness and equity in learning in both subjects, with effect sizes in the moderate to large range.[6] Its effects, although consistently positive, differ over time and subject. The effect of collective responsibility on science learning increases in magnitude from the beginning to the end of high school (from .39 SD to 1.0 SD), but declines somewhat for math learning (from .89 SD to .40 SD). Effects on equity are large and increase over time in both subjects.

Academic organization. Our strongest organizational effects on both learning and its equitable distribution in science and mathematics are, not surprisingly, associated with schools' academic organization. We discuss measures of the average levels of academic course taking in mathematics and science and the variability in course taking as a set. We interpret them as a combined indicator of a school that offers a narrow curriculum that is academic in content, one where most students take the same courses of this type (i.e, variability in course taking is low). Results here indicate, quite consistently, that in such "core curriculum" schools, students learn more, and learning is more equitably distributed. A general pattern is larger effects in math than science for early gains, but larger in math than science for later gains.

The measures of instruction in a school, the level and distribution of authentic instruction, should also be considered together. On average, students attending schools that are instructionally rich and incorporate active learning, and where this type of instruction is shared widely (i.e., the variability of authentic instruction is constrained), gain more in science and math achievement both early and late in high school. Less variability in authentic instruction is also associated with gains that are more equitably distributed. A similar pattern of timing and subject matter is evident for both authentic instruction and curriculum structure.

For these variable pairs measuring school academic organization, there is an important pattern of effects. The school average of both measures (academic coursetaking, authentic instruction) are more strongly related to the effectiveness parameters (i.e, learning), whereas the variability in these measures shows stronger association with equity parameters (the SES slopes on learning). That distributional measures are associated with distributional outcomes, and aggregate measures are related to aggregate outcomes, makes good sense but is also substantively important.

Yet another measure of academic organization, school academic press, follows the same general pattern of effects as the other measures of this construct. Academic press is positively associated with both early and late learning, and is negatively associated with the SES/gain slopes. The effects here are subject-specific (at least in terms of statistical significance): in schools with more academic press, students learn significantly more in science and that learning is more equitably distributed.

Discussion

School Restructuring and School Organization

Organization counts. The results of our two studies of the influence of high-school restructuring on students' learning yield consistent conclusions. One important and obvious finding is that resturucturing practices, as we have identified them, really matter. Another is that some attributes of school organization may help to explain the success of recent efforts to restructure schools.

Effects endure. One important finding resulted from trying to "unpack" the notion of school restructuring by targeting organizational features that help us understand the effects we had shown in the ERS. The restructuring categories we considered were meant to capture schools' willingness to adopt and stick to reforms that moved them away from bureaucracies and toward communities. Rather than disappearing after the early years of high school, when we might expect students to be most influenced by schools that are relatively new to them, effects on learning persisted or increased somewhat in the latter years of high school.

Distributions are important. The outcomes we considered incorporated the joint notions of effectiveness and equity which we have used to define "good" schools. Although the general trends of effects for our academic and social organization measures showed favorable effects on both, the pattern was specific. For both the common curriculum and authentic instruction constructs, *levels* of course taking or authentic instruction in each school are associated with average learning, whereas the *pervasiveness* of such practices among school members is associated more with social equity in learning. Small school size, although related to both effectiveness and equity, is most strongly associated with the distribution of learning. This pattern of association points out the importance of considering both levels and distributions as outcomes, when evaluating organizational effects.

Organization, Learning, and Community

Shrink the bureaucracy. We revisit here arguments we have made elsewhere that focus on the contrast between schools as bureaucracies or communities. Scholars agree about the dominance of the bureaucratic model of U.S. public secondary schools. Historically, there were valid reasons to structure schools in that way. Even recently, increased technological and human resources, coupled with modern management techniques, have been seen as the most appropriate means to foster student achievement. The modern bureaucracy seemed to be the best way to provide equal educational opportunities to students disadvantaged by race, poverty, or immigrant status. Through expanded curricular offerings and specialized teachers' work, high schools aimed to become universal institutions that offered something for everyone. But such idealistic aims do not seem to have been realized. Our two studies of school restructuring give hints about this failure.

Create smaller places. Our findings support a move to smaller high schools. Without new bricks, mortar, bond issues, or millage increases, a reasonable approach would be to create schools-within-schools: smaller organizational units inside the existing walls of large high schools. Here, teachers and students would know one another, and school members would see themselves as part of a "school family." We suggest that small size is not an end in itself, but rather acts as a facilitating or inhibiting factor. It is likely to facilitiate more personalized social interactions. But it inhibits a differentiated curriculum and teacher specialization (major features of bureaucratic high schools). Recent reforms in New York City suggest that this idea has caught hold, at least in that venue (Dillon and Berger 1995). Once high schools are restructured into smaller units, what might we see if we walk inside?

A new type of social relations. A different sort of social interactions than is typical in today's high schools would predominate: less hierarchy, less specialization, more cooperation. Our results suggest that teachers in "good" schools believe that they can (or should) succeed with all of their students. Rather than laying the cause of academic problems on the students and their families (i.e., outside the schools and outside themselves), such teachers take responsibility for correcting them. The measure, in collective terms, surely taps a pervasive type of social relations. We find McLaughlin's (1994:11) comment compelling: "...personalized school environments, settings where teachers and students can come to know one another, and where students feel acknowledged and respected as individuals." What kinds of activities would we find students involved with in such schools?

Academic pursuits predominate. The communal perspective is more concerned with affective than cognitive dimensions of schooling. But evidence suggests that "good" schools also have a strong academic structure. Rather than a broad range of courses at many different levels, rather than many students selecting courses according to their "personal tastes" (the universalistic model), our evidence supports the positive value of a narrow and academic curriculum, with a strong orgnizational push for all students to take (and master) these courses. Within the courses, we have evidence that instruction should include more authentic practices, and that this type of teaching should be pervasive rather than restricted to classrooms where teachers happen to prefer teaching this way. In commenting on th 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."

These studies seem to offer support for a body of sociological research that school organization matters, and that the optimal organizational form for high schools is more communal than bureaucratic. Although convinced that this vision of the American high school would improve student learning and also its equitable distribution, we are far from sanguine about the best way to accomplish what will is a major organizational shift. School restructuring as a "reform movement" is difficult to conceptualize. Much of the term's appeal lays in its vagueness, so that people may "see" in it whatever they wish to see (Newmann 1991a). Our results may clear up some of the vagueness, making the direction for change clearer.

Technical Notes

1. Communitarian models of school are more complex than we describe here. Their features are not limited to the social relations that characterize interactions between staff or staff and students. A fuller description and examination of the effects of school professional community can be found in work of Louis and her colleagues (Louis 1990; Louis, Kruse, and Associates 1995; Louis, Marks, and Kruse 1994). The effects of communal organizational forms on students are shown in Bryk and Driscoll, 1988; Bryk et al. 1993; and Lee et al. 1993).

2. 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 Figures 1 and 2 [pp. 260-261] in Lee and Smith 1995 for details). Learning was greatest, and its distribution most equitable, in schools with 3 or 4 reform practices classified as restructuring.

3. We have two reasons for combining data about mathematics and science instruction. One reason concerns the sample: we want to include the entire sample of students. In both the base year and followups, NELS collected data from two of each student's teachers -- either English or social studies, and either mathematics or science. Thus, students do not have data from both science and math teachers, but rather from one or the other. The second reason has to do with data quality. Including data from both students and teachers about instruction in their schools produces more reliable measures.

4. As Ingels et al. (1993a) explain, the NELS math tests were "tailored". That is, at the first follow-up, initially lower scoring students were given a set of simpler math items than those with moderate or high scores at the base year. This tailoring was introduced to make the tests more responsive to effects of the high school mathematics curriculum (which is typically tracked by ability), to avoid ceiling effects for the most able students, and to locate the discriminating power of the test differentially by student ability. The NELS science test was not tailored, although more difficult items were introduced and simpler items dropped over the three testing periods. Tailoring might explain the larger proportional gains in mathematics than science.

5. Although results on the four outcomes are presented in separate columns, it is important to note that all the effects 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. But those effects did not change much, nor were they the focus of our analyses, so we did not include them in Tables 3 or 4.

6. 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 non-significance and was deleted from the model.

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Table 1: **Organizational Characteristics of High Schools With No Reform Practices, With Traditional or Moderate Practices, and With Restructured Practices** (n = 789 schools)

Variable (a)	Schools Without Reform Practices (n=88)	Schools With Traditional Practices (n=338)	Schools With Restructured Practices (n=363) (b)
A. Compositional and Structural Organization			
Average SES (c)	-.43~	-.19	.33***
% Minority Enr.	34.14***	10.73	13.78
% Public	98.80	96.01	83.02***
% Catholic	0.[illegible]5~	3.50	9.73***
% NAIS	0.3[illegible]	0.48	7.25***
Average Ach.,8th(c)	-.52*	-.16	.30***
School Size	1,091***	632	769**
B. Social Organization			
Collective Responsibility for Learning (c)	-.74***	-.14	.31***
C. Academic Organization			
Average Number of Math & Science Courses, 9 ->12	4.52	4.73	5.14***
Variability in Math, Science Course Taking (SD)	2.05	2.00	1.83***
Authentic Instructional Practices, Sci.& Math (c,d)	-1.63***	-.58	1.04***
Variability in Authentic Inst.Practices (SD)(c)	.56**	.13	-.26***
Academic Press (c)	-.25	-.21	.31***

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

a. Group mean differences tested with one-way ANOVA and contrasts. Both "No Reform Practices" and "Restructured Practices" schools were contrasted (separately) with "Traditional Practice" schools.
b. Sample sizes reported on this table are unweighted. Group means are weighted, using the NELS constructed school weights.
c. These variables are z-scored, with M=0, SD=1.
d. Created with Rasch-model scaling, and then z-scored.

Table 2: **HLM Within-School Model for Early and Late Achievement Gains in Science** (N=9,631 Students in 789 Schools)

	Dependent Variables			
	(Outcome 1) Early Gain (Gr. 8 -> 10)		*(Outcome 2)* Late Gain (Gr. 10 -> 12)	
	SCIENCE	**MATHEMATICS**	**SCIENCE**	**MATHEMATICS**
A. Descriptive Information				
Mean Between-School Gain	2.86	8.47	1.60	4.66
Standard Deviation 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
B. HLM Within-School Model Results				
Fixed Effect (a)				
Estimated Intercept (Base)	4.002***	8.903***	1.981***	4.816***
Independent Variables (b)				
8th Grade Engagement	-.138	-.352*	.061	-.099
8th Gr.Achievement (c)	2.402***	2.326***	-.202	.936**
Academic Coursetaking in Math and Science, 8-10th	.083	.509**		
HS Academic Coursetaking in Math and Science, 10-12th			.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*

* $p \leq .05$; ** $p \leq .01$; *** $p < .001$

a. In these HLM models, the fixed effects of 8th-grade achievement scores are: Science, 19.799***; Mathematics, 37.538***.

b. All effects are presented are in a standardized effect-size metric, computed by dividing the HLM gamma coefficient for each outcome by the adjusted HLM school-level standard deviation (SD) of that outcome.

c. The 8th-grade ability control is constructed as a composite test scores at that grade in the three curricular areas not measured by each gain score.

d. In these HLM models, SES is allowed to vary randomly between schools, while the other controls are employed as fixed parameters. SES is centered around the sample mean, while the other controls are centered around their respective school means.

Table 3: **HLM Between-School Restructuring Model for Early and Late Achievement Gains in Science and Mathematics** (N=9,631 Students in 789 Schools)

Dependent Variables (a)

	Outcome 1 Early Gain Grade 8->10		Outcome 3 SES-Slope on 8->10 Gain		Outcome 2 Late Gain Grade 10->12		Outcome 4 SES-Slope on 10->12 Gain	
	Science	**Math**	**Science**	**Math**	**Science**	**Math**	**Science**	**Math**
Base Estimate (b)	3.86***	9.12***	.67***	.14**	1.90***	4.62***	.27	1.51***
A. Demographic and Structural Characteristics (c)								
Average SES	.49	.97-	.86	.12	.67	1.28*	.56	1.26
Hi-Minority Enrl.	.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*
B. Restructuring Effects (c)								
Restructing v. Trad.School	.69*	.69*	-2.75**	-1.45**	1.53*	1.11**	-3.26***	-2.97*
No Reform v. Trad.School	-.70*	-.95**	2.18*	1.03*	-1.30-	-.89*	2.23-	2.71*
HLM-computed SD	.927	1.774	.315	.942	.443	1.087	.181	.477

- $p \leq .10$; * $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$

a. The numbering of these outcomes refers to designations in Figure 1.

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

c. All effects are presented are in a standardized effect-size metric. Effects computed by dividing the HLM gamma coefficient for each outcome by the school-level standard deviation (SD) that outcome. These SDs are shown in the bottom panel of this table.

Table 4: **HLM Between-School Model for Early and Late 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 Grade 8->10		Outcome 3 SES-Slope on 8->10 Gain		Outcome 2 Late Gain Grade 10->12		Outcome 4 SES-Slope on 10->12 Gain	
	Science	**Math**	**Science**	**Math**	**Science**	**Math**	**Science**	**Math**
Base Effect(b,c)	3.50***	6.92***	2.66*	1.01**	4.36***	2.73*	1.63	2.35*
A. Demographic and Structural Characteristics								
Average SES	.26	.90	.99	.43	.95	.70	.74	.16
Hi-Minority Enrl.	.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*
B. Restructuring Effects								
Restructing v. Trad. School	.24	.52	-1.56-	-1.21	2.01	.23	-3 69	-1.31
No Reform v. Trad. School	-.31	-.24	1.40-	1.35	-1.82-	-.66	4.40-	.72
C. Social Organization								
Collective Responsibility for Learning	.39*	.89**	-1.01*	-.59*	1.00*	.40*	-1.48**	-1.37**
D. Academic Organization								
Average Number of Math & Science Courses	.49*	.74*	-.76	-.95	1.04*	.37***	-2.04-	-1.34-
Variability in Math, Science Course Taking	-.26	-.44	1.17*	.59*	-.45	-.12	2.30*	1.88*
Authentic Instructional Practices in Science & Math	.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*

- $p \leq .10$; * $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$

a. The numbering of these outcomes refers to designations in Figure 1.

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

c. All effects are presented are in a standardized effect-size metric, computed by dividing the HLM gamma coefficient for each outcome by the HLM adjusted school-level standard deviation (SD) of that outcome. These SDs are displayed in the bottom panel of Table 6.

Appendix: **Construction Details of Measures Used in This Study Which Were *Not* Described in the Lee and Smith (1995) ERS Study**

I. <u>Variables Measured on Students</u>

A. Achievement Outcomes

- **F22XMIRR** -- Mathematics IRT-estimated number right (12th grade).
- **F22XSIRR** -- Science IRT-estimated number right (12th grade).

B. Demographic Controls

- *SES, Minority Status, Gender* as used in the ERS.

C. Academic Controls

- *Engagement* as used in the ERS.

o *Achievement*

- Z-score of sum of BY2XRIRS, BY2XHIRS, BY2XMIRS (8th-grade measures)

o *Coursetaking in Mathematics and Science Early in High School*

For modeling science gains between 8th and 10th grade (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 numbers of semesters of mathematics and science coursework. For the HLM analyses, variable was z-scored (M = 0, SD = 1).

- F1S22B -- HOW MUCH COURSEWORK IN PRE-ALBEBRA
- F1S22C -- HOW MUCH COURSEWORK IN ALGEBRA I
- F1S22D -- HOW MUCH COURSEWORK IN GEOMETRY
- F1S22E -- HOW MUCH COURSEWORK IN ALGEBRA II
- F1S22F -- HOW MUCH COURSEWORK IN TRIGONOMETRY
- F1S22G -- HOW MUCH COURSEWORK IN PRE-CALCULUS
- F1S22H -- HOW MUCH COURSEWORK IN CALCULUS
- F1S23B -- HOW MUCH COURSEWORK IN PHYSICAL SCIENCE
- F1S23C -- HOW MUCH COURSEWORK IN BIOLOGY
- F1S23E -- HOW MUCH COURSEWORK IN CHEMISTRY
- F1S22F -- HOW MUCH COURSEWORK IN PRINCIPALS OF TECHNOLOGY
- F1S23G -- HOW MUCH COURSEWORK IN PHYSICS
- F1S22H -- HOW MUCH COURSEWORK IN OTHER SCIENCE

o *Coursetaking in Mathematics and Science Over 4 High-School Years*

For modelling gains between 10th and 12th grade (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 high school from students' transcripts. The summed variable was then aggregated to the school level as a school mean. For HLM analyses, the aggregate was z-scored (M = 0 , SD = 1).

- F2RAL1_C -- CARNEGIE UNITS IN ALGEBRA I
- F2RAL2_C -- CARNEGIE UNITS IN ALGEBRA II
- F2RGEO_C -- CARNEGIE UNITS IN GEOMETRY
- F2RTRI_C -- CARNEGIE UNITS IN TRIGONOMETRY
- F2RPRE_C -- CARNEGIE UNITS IN PRE-CALCULUS
- F2RCAL_C -- CARNEGIE UNITS IN CALCULUS
- F2REAR_C -- CARNEGIE UNITS IN EARTH SCIENCE
- F2RBIO_C -- CARNEGIE UNITS IN BIOLOGY
- F2RCHE_C -- CARNEGIE UNITS IN CHEMISTRY
- F2RPHY_C -- CARNEGIE UNITS IN PHYSICS
- F2ROSC_C -- CARNEGIE UNITS IN OTHER SCIENCE COURSES

II. Variables Measured on Schools

A. Demographic and Structural Characteristics

+ *Average SES, Minority Concentration, Sector, Size* as used in the ERS.

B. Measures of School Restructuring *(Used in ERS study and described in Lee and Smith (1995))*.

C. School Social Organization

o *Collective Responsibility for Learning*

Variables come from teacher questionnaires. The order in which the variables are listed reflects the item-specific factor loadings. Variables combined into a factor from principal components analysis, with reliability (Cronbach's alpha) .81. Composite was aggregated and z-scored (M = 0 , SD = 1).

+ F1T4_5E -- 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 (Rev)
+ F1T4_5B -- TEACHERS RESPONSIBLE, KEEPING STUDENTS FROM DROPPING OUT
+ F1T4_2N -- STUDENT 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 (Rev)
+ F1T4_1I -- STUDENTS ARE INCAPABLE OF LEARNING THE MATERIAL (Rev)
+ F1T4_5C -- I CHANGE MY APPROACH IF STUDENT AREN'T DOING WELL
+ F1T4_5E -- STUDENT MISBEHAVIOR INTERFERES WITH MY TEACHING (Rev)

D. School Academic Organization

o *Average Academic Coursetaking in Math and Science* -- aggregated from student reports of coursetaking, described above and z-scored (M = 0, SD = 1).

o *Variability in Mathematics, Science Coursetaking*

Standard deviation of student coursetaking, from transcripts. Variable was standardized (M = 0, SD = 1).

o *Authentic Instruction in Mathematics and Science*

Details on the Rasch modelling methods used to construct this measure are available from the authors. Items in four categories listed below are drawn from teacher and student reports about instruction in each subject at the sophomore year (first NELS followup).

Science Items from Students

+ F1S29G -- HOW OFTEN DESIGN AND CONDUCT OWN EXPERIMENTS. PROJECT
+ F1S29F -- HOW OFTEN MAKE UP OWN SCIENTIFIC PROBLEM, ANALYTIC METHOD
+ F1S29B -- HOW OFTEN CHOOSE OWN SCIENTIFIC OR PROBLEM TO STUDY
+ F1S29M -- HOW OFTEN DISCUSS CAREER OPPORTUNITIES IN SCIENCE, TECH.
+ F1S29D -- HOW OFTEN WRITE UP REPORTS OF LAB OR PRACTICAL WORK
+ F1S29N -- HOW OFTEN WATCH TEACHER DEMONSTRATE OR LEAD IN EXPERIMENT
+ F1S29E -- HOW OFTEN USE BOOK OR WRITTEN INSTRUCTIONS TO DO EXPERIMENTS
+ F1S29C -- HOW OFTEN COPY TEACHERS' NOTES FROM BLACKBOARD
+ F1S29L -- HOW OFTEN LISTEN TO TEACHER LECTURE IN CLASS

Mathematics Items from Students

+ F1S32E -- HOW OFTEN USE COMPUTERS

+ F1S32F -- HOW OFTEN USE HANDS-ON MATERIALS OR MODELS
+ F1S32B -- HOW OFTEN USE BOOKS OTHER THAN MATH TEXTBOOK
+ F1S32H -- HOW OFTEN PARTICIPATE IN STUDENT-LED DISCUSSIONS
+ F1S32I -- HOW OFTEN EXPLAIN MATH WORK ORALLY
+ F1S32G -- HOW OFTEN USE CALCULATORS
+ F1S32D -- HOW OFTEN DO STORY PROBLEMS OR PROBLEM-SOLVING ACTIVITIES
+ F1S32C -- HOW OFTEN COPY TEACHERS' NOTES FROM BOARD
+ F1S32A -- HOW OFTEN REVIEW YESTERDAY'S WORK

Mathematics Items from Teachers

+ F1T2_18H -- HAVE STDS GIVE ORAL REPORTS
+ F1T2_18E -- HAVE STD-LED WHOLE GROUP DISCUSSIONS
+ F1T2_18F -- HAVE STDS WORK IN SMALL GROUPS
+ F1T2_18C -- USE WHOLE GROUP DISCUSSION
+ F1T2_18G -- HAVE STDS COMPLETE INDIVIDUAL ASSIGNMENTS IN CLASS
+ F1T2_18D -- HAVE STDS RESPOND ORALLY TO QUESTIONS

Science Items from Teachers

+ F1T2_18H -- HAVE STDS GIVE ORAL REPORTS
+ F1T2_18E -- HAVE STD-LED WHOLE GROUP DISCUSSIONS
+ F1T2_18F -- HAVE STDS WORK IN SMALL GROUPS
+ F1T2_18C -- USE WHOLE GROUP DISCUSSION
+ F1T2_18G -- HAVE STUS COMPLETE INDIVIDUAL ASSIGNMENTS IN CLASS
+ F1T2_18D -- HAVE STDS RESPOND ORALLY TO QUESTIONS

o *Variability in Authentic Instruction*

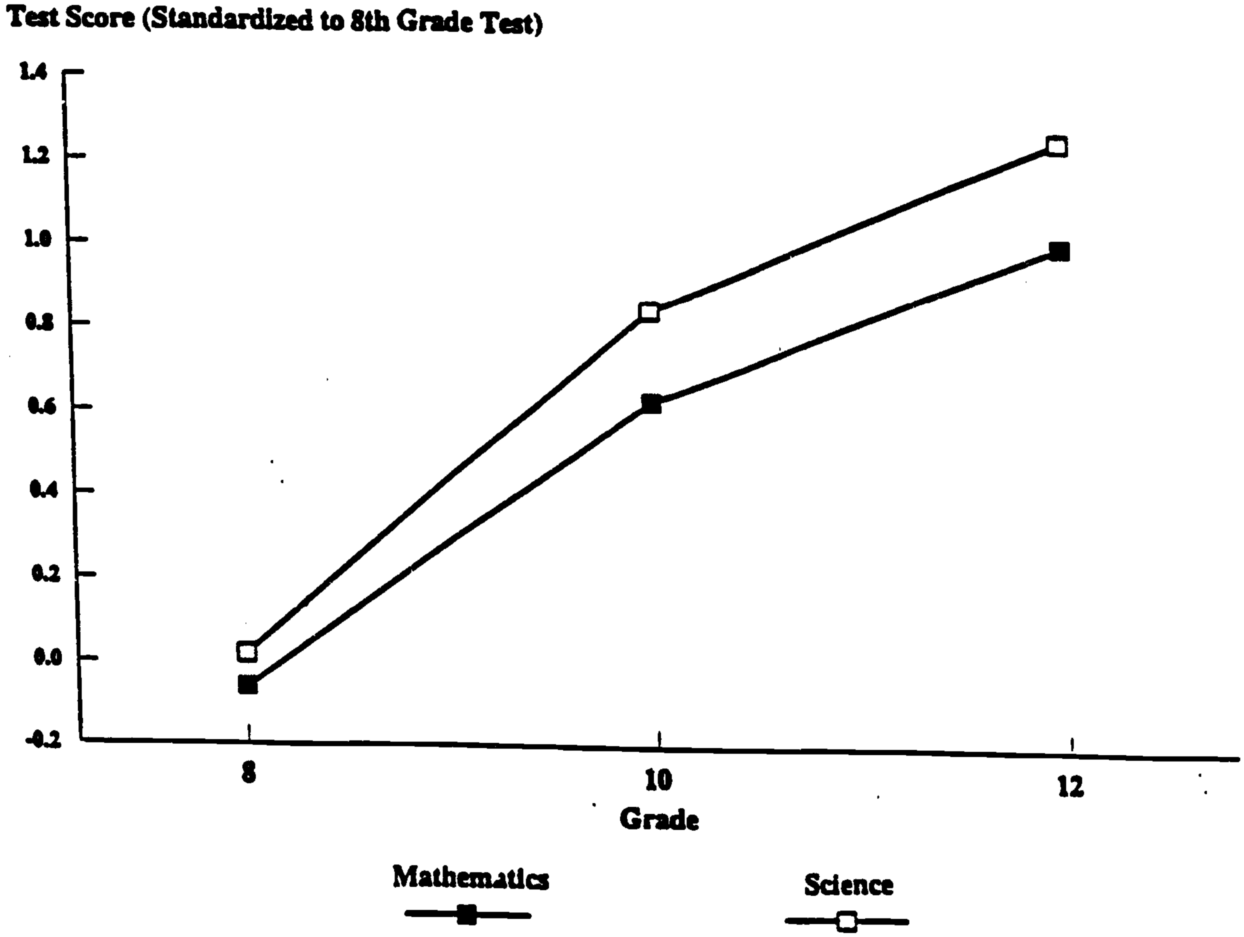
The standard deviation of the Rasch-constructed measure of authentic instruction in each school. Variable was standardized (M = 0, SD = 1).

o *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) of .81.

+ F1C93G -- STUDENT MORALE IS HIGH
+ F1C93D -- TEACHERS PRESS STUDENTS TO ACHIEVE
+ F1C93F -- TEACHER MORALE IS HIGH
+ F1C93B -- STUDENTS PLACE HIGH PRIORITY ON LEARNING
+ F1C93E -- STUDENTS ARE EXPECTED TO DO HOMEWORK

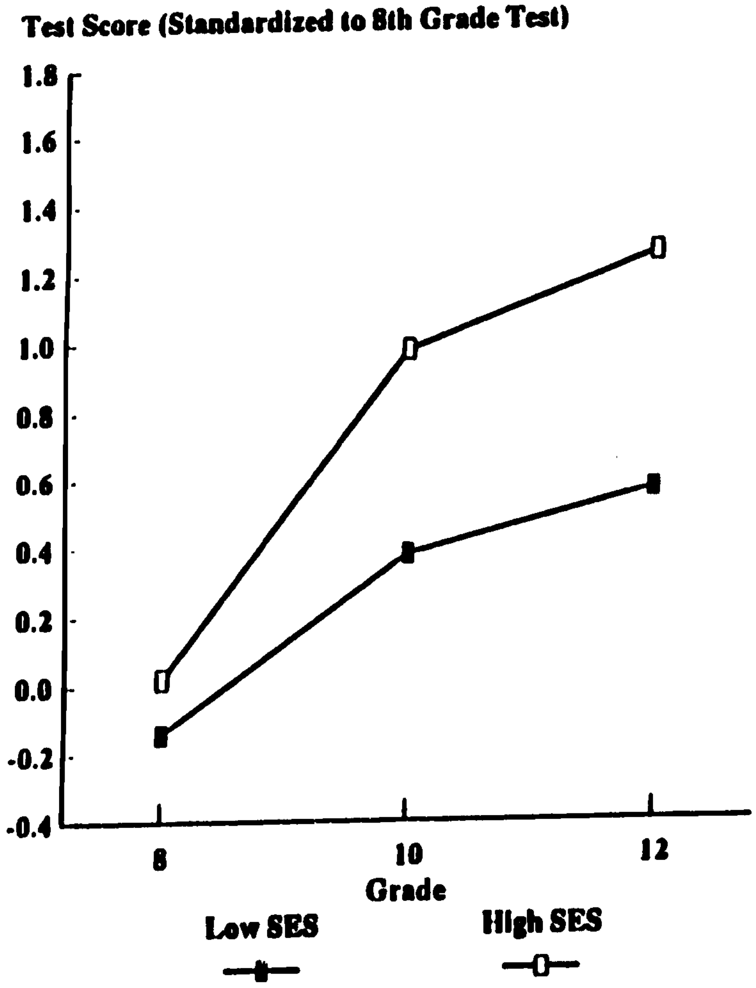
Figure 1. Gains in Mathematics and Science 8th to 12th Grade



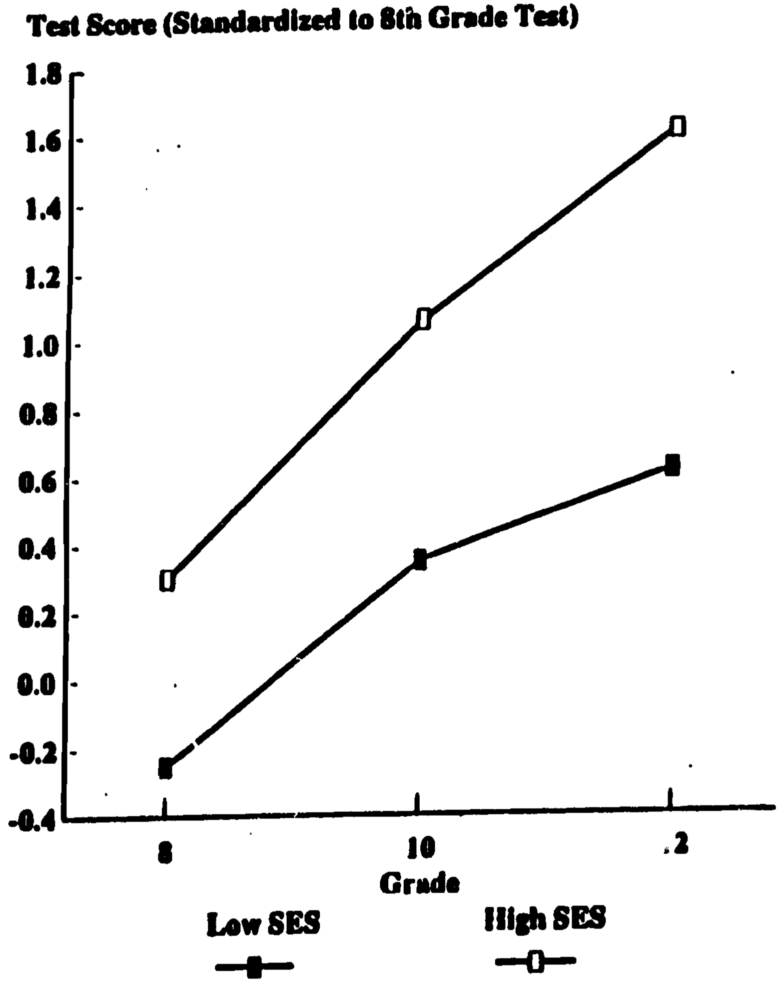
Note: The numbers shown in this figure are derived from a three-level HLM estimation of student growth in mathematics and science. The raw score for 8th grade, along with the raw gains estimated for 10th and 12th grade, are estimated after taking social class, gender, ethnicity, individual coursetaking through 12th grade in academic mathematics and science, and 8th grade ability into account. These 8th grade raw scores were then converted to a standardized metric based on the 8th grade test overall mean (19.68 for science and 8.25 for mathematics) and overall standard deviation (4.83 for science and 12.04 for mathematics). The raw gains were then divided by this 8th grade standard deviation and added to the 8th grade standardized score in each subject. Therefore, the picture shows how much gain students make on average in 10th and 12th grades relative to the initial performance in 8th grade.

Figure 2: Gains in Achievement in Mathematics and Science for Low- and High-SES Students

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



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



Note: The numbers shown in the figure correspond to the average test scores, as computed in Figure 1, for students of low SES (i.e., 1 SD below the population mean) and high SES (i.e., 1 SD above the population mean). SES is a Z-score variable (i.e., M=0, and SD=1).