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ABSTRACT

This paper reports the results of a study of changes in the social distribution of mathematics achievement for a cohort of public high school students. Using hierarchical linear modeling (HLM) the study sought to identify school characteristics which were significantly correlated with changes in achievement differences from grade 9 to grade 11 between: (1) white and black students; (2) students from advantaged and disadvantaged socioeconomic backgrounds (SES); and (3) male and female students. The school characteristics considered included indicators of school/community context, school normative climate ("effective schools" indicators), and school instructional setting. While many of the indicators were found to be related to achievement discrepancies at a given point in time, few yielded significant results for changes in the distribution of achievement. School location (suburban), the stability of the student population, and the percentage of low SES children in the school were significant predictors of change over time. It is suggested that effective-schools indicators which are more focused toward equity issues, and those based on student (rather than teacher) input, may be needed if predictors of change are to be found. (Contains 27 references.) (Author)

A Longitudinal Study of the Social Distribution of Mathematics Achievement for a Cohort of Public High School Students

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Running Head: THE SOCIAL DISTRIBUTION OF ACHIEVEMENT

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Abstract

This paper reports the results of a study of changes in the social distribution of mathematics achievement for a cohort of public high school students. Using Hierarchical Linear Modeling (HLM) the study sought to identify school characteristics which were correlated with changes in achievement differences between white and black students; students from advantaged and disadvantaged socioeconomic backgrounds (SES); and male and female students; as they progressed from grade 9 to grade 11. The school characteristics considered included indicators of school/community context, school normative climate ("effective schools" indicators), and school instructional setting. While many of the indicators were found to be related to achievement discrepancies at a given point in time, few yielded significant results for changes in the distribution of achievement.

School location (suburban) , the stability of the student population, and the percent of low SES children in the school, were significant predictors of change over time. The results for one effective schools indictor (student perception of principal and teacher expectations), while not clear-cut, seemed to be predictive of movement toward a more equitable distribution as regards student SES. It is suggested that effective schools indicators which are more focussed toward equity issues, and those based on student (rather than teacher) input, may be needed if predictors of change are to be found.

A Longitudinal Study of the Social Distribution of Mathematics Achievement for a Cohort of Public High School Students

Introduction

The last two decades have witnessed the emergence of a body of research with the expressed purpose of identifying and estimating the impact of school characteristics which influence the distribution of student achievement within schools. Chief among the attributes considered are school policies and practices, school normative climate, and school and community context. Researchers have sought to link these factors to the "social distribution" of achievement within schools--frequently defined in terms of historic achievement disparities between minority and majority children; males and females in certain subject areas; and children from low, middle, and upper socioeconomic backgrounds (e.g., see Brookover et al., 1978; Coleman, Hoffer & Kilgore, 1982; Edmonds, 1979a, 1979b; Purkey & Smith, 1983).

While this literature has done much to promote understanding of the dynamics of schooling, the majority of these studies have relied upon data collected at one or two points in time. It is generally recognized that designs of this type are not well suited to addressing questions of school effects (Bryk & Raudenbush, 1987). Studies designed around cross-sectional variations in achievement outcomes encounter difficulties in disentagling school effects from the effects of student selection (e.g., Lee & Bryk, 1989). Alternatively, while pre- and post-test designs are better suited for addressing questions of simple change or difference, they are not well suited for studying the long-term growth which occurs in schools as students progress from grade to grade (see Bryk & Raudenbush, 1988). To do so requires investigations based on multiple data points and which focus on the trend or rate of change over several years. This position is adopted in the present paper. That is, it is argued that the question of school effects as regards the social distribution of achievement is not whether, say, the correlation of social class with achievement is weaker at one school than another at some specific period, but rather, whether as students progress through school the association grows stronger or weaker. From this perspective the school characteristics of interest would be those which correlate with the <u>trend</u> of this relationship. This becomes significant given that school effectiveness indicators generated by the current literature have been incorporated in school improvement programs across the country. The growth perspective adopted in this study would suggest that while these indicators may be correlated with the social distribution of achievement, they may or may not be related to changes in this distribution.

In this paper we present the results of a longitudinal study of a cohort of public high school students followed over a four year period. The objective of the study was to identify and assess the impact of school characteristics which influence the trend of achievement differences in mathematics for blacks and whites; students from low and upper socioeconomic backgrounds, and males and females;.

Background

School Effects and the Social Distribution of Achievement

For many years educators have debated the merits of public schools as regards the experiences of minorities, females, and students from less advantaged backgrounds. Quite often schools have been depicted as inept organizations which exert little influence on student achievement independent of family background and community context (Jencks, et al., 1972). Alternatively, they are often described as white, middle class, male dominated institutions which perpetuate the status quo by promoting failure for minorities, women and students from the lower social classes (e.g., Bowles, 1977). In recent years, however, a number of studies have concluded that schools can, and often do, have a positive impact on student achievement (Coleman, Hoffer, & Kilgore, 1982). Focusing on achievement disparities between students from upper and lower socioeconomic backgrounds, investigators have reported that organizational and climatic aspects of the school setting tend to be correlated with an overall increase in student achievement and, in particular, with an increase in the equity of student achievement across the socioeconomic spectrum (see also Edmonds, 1981). Students from disadvantaged backgrounds, it has been reported, tend to benefit significantly from settings where academic expectations are high, there is a general perception of the school enviroment as safe, and academically oriented courses are required (Hoffer, Greely, & Coleman, 1985).

Although a number of independent research thrusts have contributed to this literature (e.g., Brookover et al., 1978), the analyses of the High School and Beyond (HSB) surveys reported by Coleman et al. (1982) have been among the most widely debated. In a highly controversal report, Coleman et al. (1982) concluded that private schools, Catholic schools in particular, more closely resemble the notion of the "common school" than do public schools in that achievement tends to be more evenly dispersed across the social spectrum. These sector (public vs. private) differences, they noted, were on the order of about one grade level for the students studied. Using regression analysis with controls for 17 background variables, Coleman et al. (1982) found that sector differences in achievement decreased somewhat due to a "selection" effect but that the private advantage did not disappear.

Coleman et al. (1982) investigated a number of possible explanations of the observed achievement differences between the public and private sectors. Through regression and other analyses the authors concluded that sector differences could be largely attributed to the climate and greater academic course requirements in the private sector. In particular, students in the private sector were found to have a greater sense of security at school, and to have taken more academically oriented courses.

Criticisms of the Coleman et al. (1982) HSB analysis have been extensive and point to two primary weaknesses of this and other research directed at measuring school effects or identifying factors related to school effectiveness. First, school phenomena are hierarchical in nature; that is, students are nested within classrooms, classrooms are nested within schools and schools are subsumed under district policy. In the past, educators have lacked the statistical tools required to explicitly address the multilevel structure of schooling. As a consequence, many of the results regarding school influences on student learning have been questioned (Cronbach, 1976). However, recent advances in statistical modeling, in particular Hierarchical Linear Modelling (HLM), have provided researchers with the statistical tools needed to formulate and test more realistic models of schooling phenomena (Raudenbush & Bryk, 1986). This is possible because HLM allows the investigator of school effects to specify a structural model relating student characteristics to student level outcomes. The parameters from this model then become the outcome variables for models based on school characteristics. The model is very general in that in addition to studying average levels of student outcome achievement, complex multivariate relationships as expressed in regression slopes can also be modeled. For a complete review see Raudenbush and Bryk (1989).

Several investigators have applied the HLM methodology to the HSB data studied by Coleman et al. (1982). Raudenbush and Bryk (1986), for example, reported that after controlling for school social class level, the Catholic school effect on average math achievement disappeared. However, the Catholic school impact on the social class/achievement regression slope held after considering school social class level and the number of homework assignments students received. Employing this same methodology Lee and Bryk (1989) reported that achievement differences between minority and majority students were smaller when the school environment was perceived as orderly. They also reported that the association of social class and mathematics achievement was less if schools were small, most students took many math courses, and the displinary climate was positive.

The Study of Change

The second primary criticism directed at school effectiveness and school effects studies concerns the issue of effects over time. With regard to the relationship of social class to achievement, Lee (1986) has noted that while there is some disagreement about the magnitude of the effect, almost all observers concur that as students progress through school the relationship grows stronger, not weaker. Similarly, research on sex differences in mathematics achievement has shown that while females tend to perform as well as males in the early grades, they tend to fall progressively behind as they progress to the upper grades (see Willms & Kerr, 1987). Unfortunately, the majority of the school effects and effectiveness studies have only considered cross-sectional variation in achievement, and when longitudinal designs have been used, typically, only two data points (e.g., pretest and postest) have been studied. Despite the information provided by these studies, as Bryk and Raudenbush (1987) note, they are not well suited to the study of trends or time related changes in school effects. Those based on cross-sectional designs are open to a number of criticisms. In particular, it can be argued that observed differences in school effects are a product of differences in student inputs and not other school related variables. The pretest/postest longitudinal approach, on the other hand, while an improvement over the cross-sectional design, is not well suited for addressing questions about rate of growth, as distinct from questions about simple change (see Bryk & Weisberg, 1977). To adequately address questions about rate of growth or change requires the simultaneous consideration of several data points.

To deal with these issues, consideration is given to an application of HLM to the problem of growth curve analysis. Arguing that studies of individual change have been plagued with methodological, conceptual, and design problems, Bryk and Raudenbush (1987) propose a two stage formulation based on HLM. At stage 1 the individual is observed or measured on T different occasions. These observations are considered a function of an individual growth trajectory plus random error and is referred to as the within-subject model of change. It is assumed the growth rates and the associated parameters will vary among subjects. In the second stage this variation is modeled as a function of differences between subjects in various attributes, i.e., the between-subject model. According to Bryk and Raudenbush this development allows for "...examining the reliability of instruments for measuring status and change, investigating correlates of status and change, and testing hypotheses about the effects of background variables and experimental interventions on individual growth (p. 148)."

In this paper a modified version of this model is employed. Instead of individual subjects, schools are the unit of analysis. Further, the growth criterion considered was not absolute achievement level, but the distribution of achievement for a cohort of public high school students as they progress from grade to grade. The distribution of achievement is operationally defined in terms of the following contrasts: whites vs. blacks; upper socio-economic background versus lower socio-economic background (hereafter high/low SES); and males versus females. In each instance, the analysis sought to identify school characteristics which were associated with variation in the trend of a given contrast.

Methodology

Sample/Population

The population consist of all public high schools in South Carolina which housed grades 9, 10, and 11 during the period 1988 to 1990. Within each high school only students who were consistently promoted during the period of the study were included in the analyses. The sample of schools and students actually present for these analyses were determined by data availability.

Achievement Data

Student achievement data for the present study were obtained from two testing programs utilized in South Carolina during the study period. The Basic Skills Assessment Program (BSAP) consists of criterion-referenced tests administered annually statewide in the spring in grades 1, 2, 3, 6, 8 and a high school exit examination administered in grade 10. The Statewide Testing Program (STP) involves the administration of a norm-referenced test--The Comprehensive Test of Basic Skills (CTBS) during the study--administered annually statewide in the spring in grades 4, 5, 7, 9 and 11. For the current study, interest is in the mathematics achievement, as reflected in performance on these instruments, of the cohort which entered a public high school in the fall of 1987. The tests, grades, and years of interest are as follows: BSAP Grade 8, Spring 1987; CTBS Grade 9, Spring 1988; EXIT Grade 10, Spring 1989; and CTBS Grade 11, Spring 1990. Note that grade 8 data reflects achievement prior to entering high school and as such constitutes an observation prior to any high school effect. This helps avoid the problem of confounding initial status and school effects discussed by Lee and Bryk (1989).

Since the ability metric for these measures differ and because they were designed for different purposes, the decision was made to transform student scale scores to normal curve equivalents (NCEs). These are equal interval measures which will reflect a student's relative standing in terms of mathematics achievement for each of the years of the study. This scale is based on 1986 South Carolina norms. The number of students tested for the period of the study were roughly 46,000 in grade 8, (1987), 49,000 in grade 9 (1988); 38,000 in grade 10 (1989); and 35,000 in grade 11 (1990).

To satisy the data requirements of education programs mandated by the South Carolina legislature, the South Carolina Department of Education (SCDOE) maintains a data bank of matched case test records. Annually, student records are matched with test results of the previous year. For the current study, these data greatly facilitated the task of following students throughout the period of interest.

Specifically, two data banks of matched student records were obtained. The first was the grade 8, 1987 and grade 9, 1988 matched data set, and the second was the grade 10, 1989 and grade 11, 1990 matched student data. These two files contained all the achievement data needed to follow the cohort over the four years of interest. To link the student records from these two data sets, a computer matching algorithm was used (Mandeville, 1990/91). This algorithm is used to produce the annual matched data banks for the South Carolina testing programs and has been found to yield satisfactory results. From the original matched data sets for grades 8 and 9 (38,217 students) and grades 10 and 11 (30,699 students), the algorithm matched 25961 students. This number was then reduced to 17951 students by eliminating those who were not in the same high school during grades 9-11.

The Within-School Model

The design of the present study requires that some index of the magnitude of achievement differences in mathematics between white and black; high and low SES, and male and female students be obtained for each school. For this purpose we used the standardized mean difference (Glass, 1976), often called the "effect size" statistic. This measure is defined as the difference between the mean mathematics achievement for the two groups contrasted (e.g., white and black students), divided by their pooled standard deviation. It is typically interpreted as an index of the effect of group membership on the outcome of interest. In the present application,the following variance stablizing transformation was applied to these measures (Hedges & Olkin, 1983).

$$H = \ln\left(\frac{G + \sqrt{G^2 + 8}}{\sqrt{8}}\right)$$

For each contrast the standardized mean difference was computed for each of the four years of achievement data examined in this study. For the white/black contrast these indexes are referred to as RACE87, RACE88, RACE89, and RACE90. Mean differences were taken so that a positive value indicates that the math achievement for white students at a given school for the given year was higher than the comparable achievement of black students, a negative value indicates the opposite result and a value of zero indicates no difference. Similarly, for the SES contrast we have SES87, SES88, SES89, and SES90. Positive values of these variables indicate lower math achievement for low SES students, and for the female/male contrast (SEX87, SEX88, SEX89, and SEX90) positive values indicate lower achievement for female students. For each contrast only schools with at least 10 students in each group were retained for analysis. During the HLM analyses, it was determined that convergence was enhanced if the effects were multiplied by 100 so this was done. This does not change any of the substantive interpretations.

To clarify the above discussion, the following example of how the effect size measures were actually operationalized is provided. The data are for a school where the RACE contrast appears to have changed, at least to some extent, toward equity over the three year period.

		1987	1988	1989	1990
Black (N=44)	Mean NCE	49.23	52.56	52.01	52.18
White (N=118)	Mean NCE	62.98	64.20	62.73	62.57
White-Black	Mean Diff	13.75	11.64	10.72	10.39
	Pooled SD	13.16	14.53	15.66	15.10
Glass	Effect Size (G)	1.04	0.80	0.68	0.69
Transformed	Effect Size (H)	0.36	0.28	0.24	0.24
Transf*100	100*H	36.00	28.00	24.00	24.00

Note that the Glass effect size G (and also the transformed version) tend to decrease over the 1988-90 study period indicating the relative improvement of black students vs. their white counterparts. Obviously, however, the largest decrease took place during the first year that these students were in the school, a period during which both racial groups showed increasing means. Thereafter, changes were smaller and due to a slight decrease in the performance of the white group. The slope of the best fitting straight line to the H data for this school is -.03 and the linear relationship accounts for about 82% of the variation, i.e., $r^2=.82$

The Between-School Model

The between-school characteristics considered in the present study fall into three categories: (1) school normative climate, (2) school instructional resources or setting, and (3) school and community context.

Normative Climate

The normative climate or school effectiveness indicators used in the present study are from surveys conducted by the South Carolina Department of Education. The surveys were designed to assess parent, student, and teacher perceptions of a school's status on 6 indicators of school effectiveness adopted by the South Carolina State Board of Education. These are:

1. Instructional Leadership of the Principal
2. School's Emphasis on Academics
3. High Expectations of Student Achievement
4. Positive School Climate
5. Frequent Monitoring of Student Progress
6. Positive Home/School Relations

Data for the present study are from the Spring 1988 administration of these instruments at participating public schools across the state. In each setting a representative sample of students from grades 4 - 12, all teachers, and a sample of parents were surveyed. These instruments consist of ten items for each of the 6 effectiveness indicators listed above. Data on the reliability and validity of the subscales of these instruments can be found in Segars and Gottesman (1989). Only student and teacher data were used in this study.

Since the main focus of this investigation had to do with what might be called "equity" issues, rather than simply use the results for 12 student and teacher scales, individual survey items were inspected to identify those which might be especially appropriate to the egalitarian aspects of the study. Ten such items--three on the student survey and seven on the teacher survey--were identified. These items were:

Student Survey

21. Teachers and principals expect all students to learn as much as possible. (Expectations)
44. If a student fails a test, he has another chance to learn the material. (Monitoring)
48. When students do not learn with one approach, the teacher uses another approach. (Monitoring)

Teacher Survey

23. Each student has an opportunity for success. (Expectations)
24. Teachers feel accountable for students who don't understand the work. (Expectations)
25. Teachers expect low achievers to respond as often as other students. (Expectations)
27. Unsuccessful students get extra help from teachers. (Expectations)
29. Low achievers receive as much praise as high achievers. (Expectations)
46. Instruction is altered as needed to accomodate the needs of individual students. (Monitoring)
50. Low test scores result in curriculum changes to meed student needs. (Monitoring,)

It was decided to consider whether these item subsets could be used to form subscales apart from the remainder of the items. Thus, the intercorrelations between the items in a potential scale and the scale aggregate (the mean was used) were inspected. Student items #44 and 48 were combined to form a variable called MONISS which correlated .92 and .87 (at the school level) with the two individual items. Similarly, the five items from the teacher survey which had to do with Expectations were combined to form EXPTT and the item-total correlations ranged from .76 to .87. The two Monitoring items from the teacher survey were used to create MONITT which correlated .84 and .93 with the two component items. The lone item from the student survey having to do with Expectations was renamed EXPSS.

For each of these four proposed new variables, it is obvious that the reliability is less than for the scales based on the intended ten items. On the other hand, the fact that school means will be used in the analysis, ameliorates this problem to some extent and, given the exploratory nature of the study, it was decided to use the four variables identified above. Furthermore, the original versions of the four scales involved, i. e., Expectations and Monitoring from each of the two surveys, were redefined to reflect only the "residue" items. They will be referred to as EXPES, EXPET, MONIS, and MONIT. With the possible exception of EXPET, which is based on only five items, these four scales should reasonably reflect their original meanings. The other eight scales were not changed and will be denoted as LEADT, ACADT, CLIMT, and HOMET for teachers, and LEADS, ACADS, CLIMS, and HOMES for student data.

As far as availability is concerned, the effective schools data were not as readily available as would be desireable. Districts were given an option as to whether their data would be made available to researchers, and, unfortunately, some decided against it. A further problem arose because of a desire to insure that the data for a school be representative. That is, the researchers had no control over response rates so the approach taken was to determine whether reasonable percentages of the teachers and students had responded. While we did not have exact teacher or pupil counts, we used average daily attendance (ADA) which was available, and looked at the number of respondents in each category from each school in relation to the ADA. The criteria which were used were that responses be available for a minimum of 10% of the students (in ADA) and that at least one teacher survey was available for each 25 students in ADA. Of the 110 high schools for which any survey data were available, nine were eliminated due to these restrictions. Thus, the maximum school sample size was reduced to 101.

The school variables in the other two categories are briefly described below. The information for each was obtained from data files maintained by the SCDOE.

Instructional Setting

Average Teacher Education (MEDUC). This measure indexes teachers formal education and has a range from 10 (high school GED) to 20 (Doctor of Philosophy). The values presented were averaged for all regular teachers at a given school for the years 1987-88 and 1988-89.

Number of Math Courses (NCOURSE). This variable represents the total number of math courses offered at a school. This measure is considered an indicator of the capability of a school to meet the needs (both advanced and remedial) of students in the subject area of mathematics. These data represent offerings during the 1988-89 school-year.

Advanced Math Course Enrollment (AMATHE). This variable reflects the percent of students enrolled in advanced math courses relative to those enrolled in any math courses during the 1988-89 school-year. Advanced math courses include Algebra I and II; Trigonometry; Calculus, etc.

Female Advanced Math Course Enrollment (FAMATHE). This variable parallels AMATHE but for females only.

Student Retention Rate (RETENT). This variable indexes the percent of students repeating a grade. The percentages averaged are grade 9, 1988, grade 10, 1989 and grade 11, 1990.

School and Community Context

Percent Black (PCTBLK). This measure was defined as the percent of students who recorded their race as "Black" during the annual spring testing. For this study the percentages represent data from spring 1987. This year was chosen because it was felt that these data were the most accurate.

Average Mathematics Achievement (MEANMATH). This variable represents the average mathematics achievement at a given school. The averages are based on BSAP, CTBS and EXIT exam scores for the total matched sample (25999 students), converted to NCEs, and averaged over years and grades.

Student Stability (STABLE). This variable is a measure of the degree of stability of a schools' student population. It was calculated by averaging the percent of students whose test records were matched in grade 9 and the percent whose test records were matched in grade 10.

Percent Free Lunch (PCTFRE). This variable represents the percent of students in a school who reported participation in the free school lunch program. These data were averaged over grades 9, 10, and 11.

School Size (SIZE). This variable represents the average daily membership for a given school averaged for grade 9, 1988, grade 10, 1989, and grade 11, 1990.

Community Type (URBAN, SUBURB, RURAL). These three dummy variables index the type of community served by the school. The data represent principal reports of the origins (rural, urban, mixed) of the majority of their student body. In tables and analyses to follow, RURAL will not be included since it would be redundant. The current data are from the 1989 survey.

Statistical Model

In line with a previous study of elementary school pupils (Mandeville & Kennedy, 1991), the current effort employs an adaptation of the growth curve formulation of Hierarchical Linear Modeling (HLM) as discussed by Bryk and Raudenbush (1987). Specifically, it is assumed that changes in the achievement discrepancy (blacks/whites females/males, low/high SES) within a school as students are promoted from grade 9 to grade 11, can be modeled as a function of a K-degree growth polynomial. In particular, if Y_{it} is the achievement discrepancy in school i (i=1,...,n) at grade t, then

$$Y_{it} = \pi_{0i} + \pi_{1i}a_{it} + \ldots + \pi_{K-1i}a_{it}^{K-1} + R_{it}$$

where π_{ki} is the kth growth parameter for school i, a_{it} is year or grade, and the R_{it} are elements of a T dimensional random error vector assumed to be normally distributed with mean zero and a general covariance matrix Σ_i. The Y_{it} are assumed to be in the same metric and normally distributed; the former assumption is met for these data and the latter was tested using the Kolomogorov D statistic (Stephens, 1974).

It is expected that the rate of growth, and perhaps even the direction, will vary among schools. This variation is then modeled as a function of school level characteristics as follows:

$$\pi_{ki} = \beta_{k0} + \beta_{k1}X_{k1i} + \ldots + \beta_{kP-1}X_{kP-1i} + U_{ki}$$

where π_{ki} is the kth parameter of the within-school model for school i, p = 1,..., P-1 represents the number of between-school variables, β_{kp} depicts the relationship of the school level variable X_{kp} to the kth within-school growth parameter, and U_{ki} is random error. The U_{ki} are elements of a K-1 dimensional vector which is presumed multivariate normal with mean vector 0 and dispersion matrix T. Thus, the π_{ki} are also presumed to follow the multi-normal distribution. This assumption was tested using a method described in Bryk, Raudenbush, Seltzer, and Congdon (1989, p. 73).

As noted by Bryk and Raudenbush (1987), this formulation has several attractive features: (1) an evaluation of the quality of a measure for assessing initial status and change can be obtained, (2) an estimate of the correlation between initial status and rate of change corrected for measurement error is available, and (3) the proportion of parameter variability explained by school level predictors may be estimated.

Analytic Strategy

The first step in these analyses was to determine the degree of the polynomial for the within-school model. Based on a plot of the overall means for the entire sample, the determination can be made as to whether a linear or higher degree polynomial is appropriate. In the second step of the HLM analysis, an unconditional model (i.e., a model with no between school predictors) was fit to the data. This step allowed for testing of the assumptions of normality and for determining if there was sufficient parameter variability in school growth coefficients, the π_{ki}, to attempt to relate this variation to school level characteristics. Additionally, residuals produced in this step were used in an attempt to identify complex relationships such as interactions. In the final step of the analysis, between-school variables were included in the model as predictors of parameter estimates from the within-school model. Nonsignificant predictors were dropped from the between-school model which was then refitted as necessary until it contained only variables with significant (or, in a few casses, nearly significant) test statistics.

Results

Preliminary Results

Table 1 presents demographic and achievement characteristics of the sample and the population of students tested in grades 8, 9, 10 and 11. The achievement data are presented in the original scale score

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Table 1 about here

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metric. The figures in this table are informative of the degree to which the sample is similar to the larger population of students tested statewide. The demographic data indicate that the sample has about the same makeup as the population as regards race and gender. The data on the SES indicator (% Free Lunch) is somewhat inconclusive but it appears that the two groups are comparable. Finally, while the sample appears to have outperformed the population as a whole in math during 1987 and 1989, the results for the other two years are much more comparable. In summary, the differences are not great and consistent with the rather restricted nature of the sample.

During the data preparation, the aforementioned requirement that a minimum of ten student records for each level of each contrast be available in order for the effect size to be meaningful was applied. Of course, for some schools this requirement was not satisfied for one or more years so that that school could not be used for the analysis of the specific contrast under consideration. Since the schools so eliminated were not consistent for the different contrasts, it would have been possible to use the different samples of schools for the different contrasts. However, it was felt that it would be useful to obtain a single sample of schools for which a complete data set were available for all three contrasts for all four years and for which all school-level predictors were available. The resulting sample was reduced to 79 schools. Table 2 lists descriptive statistics for the school level predictors for these 79 schools.

Table 2 about here

Four of the variables listed represent three year averages, and two were computed by averaging two years of data. The indicators with three years of data were SIZE, PCTBLK, PCTFRE, and RETENT. The indicators with two years of data were MEDUC and TURN. The use of averages implies that there have not been important changes in these variables over the period examined. To examine this assumption, standard deviations were computed for each of the six variables for each school and plots were constructed. These plots were positively skewed with a preponderance of small values in the lower tail. These results indicate that for the majority of schools, year-to-year variations in the six indicators were slight.

Pearson correlations among school level variables were generally consistent with previous reports and, therefore, are not presented. For example, correlations among the normative climate measures were generally high for both the teacher and student scales, with values above .40 typical (for similar results see Kijai, 1990). On the other hand, correlations among the instructional and context variables were often in the moderate range and tended to reflect typical patterns (e.g., the percentage of free lunch students had a statistically significant relationship with mean achievement level).

Table 3 lists descriptive statistics for the standardized mean difference (100*H) for the three contrasts studied for the years 1987-1990. While there is some fluctuation, the mean differences for RACE and

Table 3 about here

SES tend to be remarkably stable over the three high school years (1988-1990). Thus, the hoped for decreasing trend did not occur. In each instance, the effects are positive, indicating a tendency for low SES and black students to have lower levels of mathematics achievement than their upper SES and white counterparts.For reference, in the original (G) metric, values of 100*H of 20 and 25 are equivalent to effects of about .6SD and .7SD respectively. The results for SEX yield almost no effect for each of the years considered. While this is unexpected, there is some evidence that sex differences in mathematics have began to disappear in recent years (Willms & Kerr, 1987). Finally, while the averages for the various contrasts do not show much year-to-year change, it is important to note that in each case there is considerable variation among schools in the magnitude of a given effect as indicated by the standard deviation and range statistics.

Table 4 presents ranges of correlations of school level predictors with standardized mean differences for each contrast for each of the high school years, i.e., 1988-1990. The results are encouraging for

Table 4 about here

proponents of the type of school effectiveness indicators utilized in the current study (Edmonds, 1981). Several scales from the student questionnaire (but only one from the teacher survey) are consistent predictors of achievement differences between black and white students, and students from low and upper socio-economic backgrounds. For the SES contrasts the magnitude of these correlations rival those of the mean achievement level at the school and the percent of low SES students. Additionally, while school mean achievement level (MEANMATH) and enrollment in advanced math courses (AMATHE) yield positive correlations with the SES contrasts--indicating that as average achievement and advanced math enrollment in a school increases the relative standing of low SES students deteriorates--the student climate scales yield negative measures indicating a more equitable outcome. These statements also apply, but to a lesser extent, to the RACE contrast. These results are supportive of school effectiveness measures as indexes which can differentiate between schools with respect to the social distribution of student achievement. However, the data presented are at most correlational and can not be taken as evidence that these measures actually induce the more equitable distribution. This particular problem, attributing causality, has plagued much of the school effects literature. For example, in a recent paper Lee and Bryk (1989), despite the sophisticated multilevel techniques employed, urge caution in attributing their results to "school effects". The position adopted in this study is that inference regarding causality requires that changes in the social distribution of achievement be linked to school characteristics. The HLM results presented below are directed toward this problem.

HLM Results

One of the first considerations in the growth application of HLM involves determining the degree (linear, quadratic, etc.) of the polynomial for the within-school model. For the current application, the standard practice of plotting the sample averages for the within-unit data was followed. These plots indicated that a linear model was adequate for these data. To further facilitate interpretation of results, the within-school time variable was coded to reflect years beyond the high school entry point of 1987. With this coding, the intercept of the within-school model reflects a particular contrast prior to entering high school, 1987, and the slope or linear term represents rate of change over grades 9, 10, and 11.

Part one of the analysis involved fitting the so-called "unconditional" model to the data. These results were used to assess the tenability of the normality assumption regarding the within-school estimates. For each of the three contrasts, no significant departures from normality were noted. The unconditional model also yielded tests of the hypotheses that the intercept and linear term of the within model were not significantly different from zero. As presented in Table 5, while the intercept terms are all clearly

Table 5 about here

significantly different from zero, the results for the linear term involving the SEX contrast does not achieve significance. This result is not problematic, however, since the primary focus is on explaining variation among schools around the average growth rate or linear term. The results for the intercepts indicate that, at the end of grade 8, white, high SES, and to a much lesser extent, males, were achieving at higher levels than black, low SES, and female students. The significant mean slope estimates are also positive for RACE and SES, indicating a worsening of these conditions over time. However, when these estimates of .72 and .61 units per year are transformed back to the original Glass effect size metric, they correspond to the rather modest value of .02SD.

Table 6 presents estimates of parameter variance for the various contrasts studied. Because only

Table 6 about here

true parameter variance is potentially explainable, the results of this table are used to determine if an attempt should be made to model variation in specific parameters. The Chi-square statistics indicate that there is significant parameter variability associated with the intercept and slope for the RACE and SES contrasts but that only the intercept for SEX has significant parameter variability. The "reliability" data presented in the table indicate the proportion of total variability (parameter variability + sampling error) for terms of the within-school model which is parameter variability. Large values mean that most of the observed differences between schools reflects true distinctions, and small values suggest that most school-to-school differences are due to sampling error. The reliabilities for the intercepts are typically large, but for the slope values, especially for the male/female contrast, they tend to be small. This latter result will lessen the likelihood of finding significant between-school predictors. In fact, the small reliability for the SEX slope coupled with the fact that the parameter variance is nonsignificant, indicates that the linear term should be considered "fixed" and, therefore, not subject to future modeling. Since the slopes are the parameters of primary interest in this study, the SEX contrast will not be considered further. The final statistics presented in Table 6 are estimates of the correlation of the intercept (initial status) and linear (rate of growth) terms corrected for error. These values are negative for RACE and SES and not meaningful for SEX. The implication for the SES contrast is that in schools where the pre-high school achievment for low SES students was relatively low, the tendency is toward a more equitable distribution as the cohort moved from grade 9 to grade 11 (r = -.51). A similar but weaker (r = -.24) conclusion is implied for black students.

Fitted HLM models, following the procedures described above, are presented for the RACE and SES contrasts in Tables 7 and 8. Each of the two contrasts had some school level predictors of growth rate.

Tables 7 and 8 about here

For the white/black slope, three predictors--SUBURB, STABLE, and EXPSS--had significant negative coefficients. Apparently MONISS, while nonsignificant, acts as a supressor for EXPSS since if MONISS is excluded from the model, EXPSS is no longer significant. Thus, the interpretation of these effective schools variables is a bit ambiguous. Negative signs on these coefficients indicate that larger values of the predictors were associated with reductions in the values of the contrasts. Thus, a significant reduction in the RACE contrast is to be found in suburban schools and schools with more stable student populations. If EXPSS is to be interpreted, this would mean that schools in which students perceive that principals and teachers have high expectations for all students are also schools where white/black differences are decreasing. At the bottom of Table 7, it is reported that these predictors account for slightly over half (50.29%) of the true variance in the slope parameter, a surprisingly large value.

Turning to the slope for the SES contrast, the significant predictors again include SUBURB, (only significant at the p=.10 level, however) but this time along with the percent of students eligible for free lunch. Again, the signs are negative leading to an interpretation that schools with larger percentages of low SES children do tend to address the needs of these low SES students. This is not surprising, since it is possible that these low SES students make up a majority of the school. It might be conjectured that, in some cases, the needs of the (possibly small group of) high SES students are not well met so that a lowering of the value of the contrast is due to increased achievement for the low SES students but little or no progress for the high SES group. These two predictors account for a little over one-fourth (26.51%) of the true variance in the SES slope parameter.

The fitted models for the intercepts are of less interest in the present formulation, for they represent contrasts prior to entering high school. The fact that an effective schools variable is predictive of the intercept in both Tables 7 and 8 is curious. This says that high schools with relatively high values on these two ES variables begin with RACE (Table 7) and SES (Table 8) groups which are not as discrepant in terms of math achievement as the typical high school. One possibility is that some district level factor is operating. The significance of RETENT for the RACE contrast might be a spurious reflection of the research design used here, i.e., the fact that only data for continuously promoted students were used.

Summary and Conclusions

Unlike many previous studies in the school effects or effectiveness literature, this study was concerned with finding school level correlates of changes in the social distribution of achievement defined as differences in mathematics achievement for black and white students, female and male students, and students from lower and upper socioeconomic backgrounds. The list of school characteristics considered was extensive and covered three general areas: school/community context, school normative climate, and school instructional setting. Most of the variables considered are similar to those frequently used in this literature and many of the results of this study which examined school-to-school variations at one point in time supported previous conclusions. In particular, student normative climate scales were found to correlate well with achievement differences between students from low and upper socioeconomic backgrounds and, to a more limited extent, with achievement differences between black and white students. However, when the emphasis changed to "rate of change" in the three contrasts considered, only expectations as expressed by students (the specialized variable EXPSS) was found to be a significant predictor of changes in the slope for the RACE contrast, and this result is not even very clear-cut. While selected ES variables were also demonstrated to be related to intercepts for both RACE and SES, the meaning of these results is unclear (because the intercepts reflect pre-high school conditions) and are at best only consistent with a "point in time" rather than a "trend" interpretation.

The results provide some evidence that suburban schools have been better able to promote equity (both vis-s-vis RACE and SES) than schools located in a rural or urban setting. Further, the stability of the student population and the proportion of disadvantaged students in the school also had a significant effect on the social distribution of math achievement.

At the begining of this paper it was noted that many school improvement programs are based on indicators generated from the school effects and school effectiveness literature. Use of these measures is generally based on the assumption that if schools improve on these indicators, achievement and the distribution of achievement will improve. This study, in addition to exploring other characteristics of schools, attempts to test this assumed causal link between effectiveness indicators and changes in the distribution of student achievement. The results are not generally supportive of a causal link and may help explain the often disappointing results associated with these indicators (Miller, Cohen & Sayre, 1985). However, schools are especially complex organizations. The current formulation, while not in conflict with, does not explore interesting questions about student characteristics which can be explored with newer three-level multilevel models (see Bryk & Raudenbush, 1988). Additionally, the school indicators studied were static in that they reflected averages and not changes which might have occurred over the years of the study. The assumption implied by this operational definition may not be tenable.

The (possible) significance of the variable EXPSS, tailored as it was to focus on equity, suggests that general ES measures are not sufficient to deal with the issues of this study. Finally, the fact that data derived from teachers provided few significant correlations with the contrasts even at a point in time (Table 4), suggests that students are the more relevant source for this information.

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Table 1
Demographic and Achievement Characteristics for Population and Matched Sample.

Variable	Population				Matched Sample			
Year	1987	1988	1989	1990	1987	1988	1989	1990
Characteristics								
% Black	39	40	38	37	40	40	40	40
% Free Lunch	31	NA	19	NA	24	24	24	24
% Male	51	51	49	49	48	48	48	48
Mean Math	748	732	778	741	774	738	791	742

Note: The number of students in the population was 45,636 in 1987, 48,901 in 1988, 38,246 in 1989, and 24,891 in 1990. The number of students in the matched sample was 17,951.

Table 2.
Descriptive Statistics for School Level Predictors (n=79)

Variable	M	SD	Min	Max
Normative Climate-Teacher				
LEADT	4.03	0.26	3.0	4.6
ACADT	3.98	0.15	3.5	4.4
EXPET	3.95	0.14	3.7	4.3
EXPTT	3.80	0.16	3.5	4.2
CLIMT	3.59	0.32	2.7	4.4
MONIT	3.73	0.19	3.4	4.2
MONTT	3.80	0.19	3.4	4.3
HOMET	3.95	0.22	3.4	4.4
Normative Climate-Student				
LEADS	3.47	0.22	2.9	4.2
ACADS	3.34	0.13	3.1	3.7
EXPES	3.29	0.14	3.0	3.6
EXPSS	4.07	0.20	3.5	4.4
CLIMS	3.04	0.27	2.5	3.8
MONIS	3.44	0.15	3.1	3.7
MONSS	2.87	0.20	2.5	3.3
HOMES	3.34	0.17	3.0	3.9
Instructinal Setting				
MEDUC	17.18	0.24	16.4	17.6
RETENT	8.19	6.32	1.0	43.0
NCOURSE	12.46	1.98	9.0	18.0
AMATHE	45.56	10.90	23.0	84.0
FAMATHE	48.34	10.79	23.0	86.0
School/Community Context				
MATHMEAN	57.62	4.38	47.6	67.2
SIZE	249.52	123.33	61.0	634.0
PCTBLK	41.50	18.18	8.0	89.0
PCTFRE	20.90	13.86	3.0	61.0
STABLE	89.40	4.34	69.0	97.0
URBAN	0.29	0.46	0.0	1.0
SUBURB	0.34	0.48	0.0	1.0

Table 3.
Descriptive Statistics for Standardized Mean Differences (100*H)
By Contrast and Year (n=79 schools)

Contrast-Year	M	SD	Min	Max
White/Black-1987	23.92	8.29	2.35	46.44
White/Black-1988	26.58	7.94	10.83	44.92
White/Black-1989	27.70	6.79	13.48	48.60
White/Black-1990	25.95	8.90	1.13	52.80
High/Low SES-1987	20.16	10.15	-.93	45.95
High/Low SES-1988	22.22	10.67	-2.68	47.02
High/Low SES-1989	21.58	9.37	1.10	40.92
High/Low SES-1990	22.41	9.36	-1.98	47.17
Male/Female-1987	3.57	7.23	-24.44	16.72
Male/Female-1988	.23	6.59	-20.49	14.58
Male/Female-1989	5.78	7.23	-15.09	20.58
Male/Female-1990	.65	6.76	-17.93	15.49

Table 4 .
Ranges of Pearson Correlations Between Each of the Three Standardized Differences and School Level Predictors for 1988, 1989 and 1990.

Variable	RACE88-90	SES88-90	SEX88-90
Normative Climate-Teacher			
LEADT	-.08 to .03	-.11 to -.02	-.11 to .00
ACADT	-.03 to .03	-.09 to .06	-.10 to .01
EXPET	.09 to .11	.03 to .12	-.16 to -.01
EXPTT	.04 to .11	.02 to .08	-.07 to .08
CLIMT	-.07 to .01	-.05 to -.02	-.13 to -.06
MONIT	-.07 to -.01	-.06 to .02	-.13 to .02
MONTT	-.09 to -.04	-.13 to -.04	-.09 to .05
HOMET	.03 to .11	.12 to .22*	-.14 to -.08
Normative Climate-Student			
LEADS	-.25 to -.11*	-.41 to -.36**	-.27 to -.17*
ACADS	-.09 to .01	-.17 to -.15	-.05 to -.01
EXPES	-.11 to -.03	-.22 to -.11*	-.10 to -.07
EXPSS	-.38 to -.16**	-.45 to -.32**	-.23 to -.11*
CLIMS	-.10 to .00	-.08 to -.07	-.02 to .01
MONIS	-.19 to -.13	-.33 to -.29**	-.10 to -.06
MONSS	-.19 to -.07	-.40 to -.35**	-.21 to -.16
HOMES	-.19 to -.06	-.34 to -.29**	-.24 to -.19*
Instructinal Setting			
MEDUC	.01 to .10	.09 to .17	-.21 to -.09
RETENT	-.15 to -.09	-.19 to .08	-.10 to .01
NCOURSE	-.10 to -.03	.20 to .27*	-.04 to -.04
AMATHE	.18 to .27*	.33 to .48**	-.11 to .05
FAMATHE	.17 to .26*	.30 to .44**	-.18 to -.03
School/Community Context			
MATHMEAN	.13 to .34**	.34 to .49**	-.02 to .07
SIZE	-.01 to .01	.13 to .22*	-.11 to -.10
PCTBLK	-.18 to -.07	-.33 to -.29**	-.01 to .12
PCTFRE	-.19 to -.11	-.35 to -.21**	-.05 to .14
TURN	-.13 to .06	-.16 to -.03	.11 to .14
URBAN	.14 to .22*	.12 to .30**	-.03 to .02
SUBURB	-.17 to -.13	-.01 to .08	-.17 to -.03

Note: * $p < .05$, ** $p < .01$ (both two-tailed) for at least one of the three correlations. The critical values of r which were used were .220 and .286 for the .05 and .01 levels.

Table 5.
Estimated Mean Growth Parameters.

Contrast	Parameter	Estimate	SE	T
White/Black				
	Intercept	24.9571	.8708	28.66**
	Linear	.7221	.2680	2.70*
High/LowSES				
	Intercept	20.6718	1.1658	17.732**
	Linear	.6118	.2816	2.172*
Male/Female				
	Intercept	2.8583	.7330	3.90**
	Linear	-.2767	.2349	-1.18

Note: * p<.05, ** p<.01

Table 6
Estimated Parameter Variability, Reliabilities and
True Correlations of Initial Status and Growth.

Contrast Parameter (Reliability)	Estimates of Parameter Variance	Degrees of Freedom	Chi Square
White/Black			
Intercept	45.07	78	315.1**
(Reliability)	(.752)		
Linear	1.44	78	104.4*
(Reliability)	(.253)		
Estimated True r Status & Growth	-.24		
High/Low SES			
Intercept	94.26	78	639.0**
(Reliability)	(.878)		
Linear	2.52	78	130.5**
(Reliability)	(.253)		
Estimated True r Status & Growth	-.51		
Male/Female			
Intercept	27.79	78	236.22**
(Reliability)	(.654)		
Linear	.15	78	48.8
(Reliability)	(.034)		
Estimated True r Status & Growth	NA		

Note: * p<.05, ** p<.01

Table 7
Fitted HLM Model for White/Black Differences
in Mathematics Achievement.

Parameter	Estimate	SE	T
Intercept			
RETENT	-.248	.119	-2.08*
EXPSS	-8.734	4.236	-2.06*
Variance Explained			
Percent of Total	5.81		
Percent Parameter	7.72		
Linear			
SUBURB	-1.157	.464	-2.49*
STABLE	-.131	.051	-2.56*
EXPSS	-3.118	1.536	-2.03*
MONISS	2.030	1.472	1.38
Variance Explained			
Percent of Total	12.73		
Percent Parameter	50.29		

Note: ! p<.10,* p<.05, ** p<.01

Table 8
Fitted HLM Model for High/Low SES Differences
in Mathematics Achievement.

Parameter	Estimate	SE	T
Intercept			
MEANMATH	.577	.225	2.57*
LEADS	-10.446	4.162	-2.51*
Variance	Explained		
Percent of Total	10.67		
Percent Parameter	12.15		
Linear			
PCTFRE	-.053	.016	3.27**
SUBURB	-.863	.444	1.94!
Variance	Explained		
Percent of Total	10.67		
Percent Parameter	26.51		

Note: ! p<.10,* p<.05, ** p<.01