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## **School Quality and the Black-White Achievement Gap**

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### **ABSTRACT**

Substantial uncertainty exists about the impact of school quality on the black-white achievement gap. Sizeable achievement differences by race as of 1<sup>st</sup> grade and test error complicate any investigation of this issue, because average test score growth rates may differ across the distribution depending upon the test instrument, curriculum, and other factors. Texas administrative data show that the growth in the achievement gap between 3<sup>rd</sup> and 8<sup>th</sup> grade is higher for students with higher initial achievement. Whether this reflects growth in the actual achievement differential or test error induced changes is difficult to ascertain. However, analysis using quasi-random variation in teacher and peer characteristics shows that peer racial composition and teacher experience likely amplify racial achievement differences.

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# Schools, Peers, and the Black-White Achievement Gap

By Eric A. Hanushek and Steven G. Rivkin

## 1. Introduction

Cognitive skills appear strongly correlated with black and white gaps in school attainment and in wages, and this has motivated aggressive policies to raise the quality of education for blacks.<sup>1</sup> The landmark decision in *Brown v Board of Education* that attacked racial segregation of schools was the modern beginning of concerted federal, state, and local actions directed at improving black achievement.<sup>2</sup> Along with subsequent court cases, *Brown* ushered in a profound change in both school and peer characteristics, while contemporaneous increases in school spending, brought on in part by school finance litigation, further raised the resources devoted to black students in the public schools. Nonetheless, racial disparities have been stubbornly resistant to policy, raising the possibility that schools really cannot be effective policy instruments.<sup>3</sup>

Table 1 provides a stark picture of the black-white differences in academic, economic, and social outcomes that have survived the schooling policies of the last decades. Among men and women 20 to 24 years old, blacks are far less likely to complete or be in the process of completing college, far less likely to work, and far more likely to be in prison or other institution. The rates of incarceration and non-employment for young black men paint a particularly dire picture.

These outcomes, combined with the weak and often contradictory statistical

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<sup>1</sup> O'Neill (1990) and Neal and Johnson (1996) provide evidence on wage differences, and Rivkin (1995) provides evidence on differences in educational attainment.

<sup>2</sup> *Brown v. Board of Education*, 347 U.S. 483 (1954).

evidence on the effects of specific school policies on achievement, raise substantial doubts about the efficacy of policies aimed at boosting school quality for dealing with racial inequalities.<sup>4</sup> Moreover, recent research generally provides additional support for that view. For example, Fryer and Levitt (2004, (2005) find that a substantial racial achievement gap exists at entry to school and increases with age but that the majority of the increase occurs within schools and is not explained by quantifiable school characteristics.<sup>5</sup> Clotfelter, Ladd, and Vigdor (2005) document a large third grade achievement gap in North Carolina that does not increase with schooling. Our past work, on the other hand, highlights substantial achievement impacts of specific peer and teacher inputs whose distributions differ substantially by race, suggesting possible school based explanations of at least a portion of the black-white achievement differences.<sup>6</sup>

Importantly, differences in the achievement distributions for blacks and whites at school entry complicate comparisons if growth rates differ systematically by initial achievement either due to actual differences in skill acquisition or limitations in the measurement of achievement. Several hypotheses have been offered that suggest that the

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<sup>3</sup> Neal (2006) documents black-white gaps in both quantity and quality of schooling and shows evidence that convergence of earlier periods slowed or stopped in the 1980s and 1990s.

<sup>4</sup> Earlier optimism about narrowing gaps (Jencks and Phillips (1998)) largely dissipated with new evidence that the black-white achievement gap stayed constant or even grew during the 1990s (National Center for Education Statistics (2005)). In terms of the specific policies that have been pursued, direct evidence on the benefits of school desegregation remains limited. Review of the evidence surrounding desegregation actions provides limited support for positive achievement effects (Schofield (1995)); Guryan (2004) finds that desegregation reduced the probability of dropping out of high school, though data limitations and methodological concerns raise questions about the findings. Accumulated evidence does not provide strong support for the belief that higher expenditure typically leads to substantial improvements in the quality of instruction, particularly with regard to higher pay for teachers with a masters degree or substantial experience (Hanushek (2003)).

<sup>5</sup> Note that Murnane, Willett, Bub, and McCartney (2005) cannot replicate either the basic school patterns of the achievement gap or the influence of measured family background on the gaps when they go to a different, but in some ways richer, data base. Neal (2006) finds little evidence of a growing gap past entry to school and discounts the role of schools in either creating or ameliorating any gaps.

gap may grow more rapidly for initially high achieving blacks. On the one hand, blacks who excel in the early grades may face the strongest peer pressure against academic success. Alternatively, higher achieving blacks may fall further from the center of their school's achievement distribution and be less likely to participate in an academic program that facilitates continued excellence.<sup>7</sup> Importantly, we consider the effects of test measurement error and regression to the mean on the pattern of racial achievement.

Consistent with this possibility, Texas administrative data show that the growth in the achievement gap between 3<sup>rd</sup> and 8<sup>th</sup> grade is higher for students with higher initial achievement. Whether this reflects growth in the actual achievement differential or test error induced changes is difficult to ascertain, and the pattern of student performance changes raises the possibility that at least some of the growth arises from measurement error induced regression to the mean. However, analysis using quasi-random variation in teacher and peer characteristics shows that peer racial composition and teacher experience likely amplify racial achievement differences.

The next section describes the TSP data set used in this analysis. Section 3 documents changes in the racial achievement gap with age for all blacks and whites and by initial achievement and gender. Section 4 describes the empirical modeling strategy employed and then examines the causal effects of specific school factors on achievement along with their contribution to racial achievement differences. The final section summarizes the findings and discusses potential implications for policy.

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<sup>6</sup> Hanushek, Kain, and Rivkin (2004a) investigate the effects of student mobility, Rivkin, Hanushek, and Kain (2005) investigate the effects of teacher experience, and Hanushek, Kain, and Rivkin (2006) investigate the effects of racial composition.

<sup>7</sup> Fryer and Levitt (2005) consider a related hypothesis through comparing performances of blacks and whites on alternative cognitive tests and suggest that blacks may indeed be doing more poorly on tests of higher order skills. Murnane, Willett, Bub, and McCartney (2005) further question the impact of test content and score calculations on the pattern of achievement gaps.

## **2. TSP Data**

The TSP data set is a unique stacked panel of school administrative data constructed by the UTD Texas Schools Project. The data we employ track the universe of Texas public elementary students as they progress through school. For each cohort there are over 200,000 students in over 3,000 public schools. Unlike many data sets that sample only small numbers from each school, these data enable us to create accurate measures of peer group characteristics. We use data on four cohorts for grades three (the earliest grade tested) through eight. The most recent cohort attended 8th grade in 2002, while the earliest cohort attended 8<sup>th</sup> grade in 1999.

The student data contain a limited number of student, family, and program characteristics including race, ethnicity, gender, and eligibility for a free or reduced price lunch (the measure of economic disadvantage). The panel feature of the data, however, is exploited to account implicitly for a more extensive set of background characteristics through the use of a value added framework that controls for prior achievement. Importantly, students who switch schools can be followed as long as they remain in a Texas public school. Given the high rate of school switching, particularly among lower income and minority students, the possibility of following movers is an important asset of the data. Such mobility appears to present a serious sampling problem for survey data sets including the Early Childhood Longitudinal Survey (ECLS) that has been used in recent work on the racial achievement gap. Appendix Table a1 shows that blacks who move between grades 1 and 3 in the ECLS sample exhibit larger test score growth than stayers, a pattern contrary to that observed in administrative data where most movers can be tracked.

This highlights the difficulty of generating a representative sample of a mobile population and suggests that the degree of positive selection of blacks increases over time in the ECLS despite efforts to the contrary. More generally, sample selection problems in survey data almost certainly grow in magnitude with age.

Beginning in 1993, the Texas Assessment of Academic Skills (TAAS) was administered each spring to eligible students enrolled in grades three through eight. The tests, labeled criteria referenced tests, evaluate student mastery of grade-specific subject matter. This paper presents results for mathematics. Because the number of questions and average percent right varies across time and grades, test results are standardized to a mean of zero and variance equal to one.

Notice that the persistence of a constant differential in terms of relative score does not imply a constant knowledge gap. If the variance in knowledge grows with age and time in school, as we believe most likely, any deterioration in the relative standing of blacks on the achievement tests would understate the increase in knowledge inequality.

Because the tests are not vertically linked across grades as is the case with item response theory scaled tests, it is not possible to locate a grade  $g$  test score in a grade  $g+1$  distribution. Consequently we exclude all students retained in grade at any point between grades three and eight. We also exclude students with any missing test observations. Since blacks are more likely to be retained in grade and less likely to have a complete set of test results, the resulting sample of blacks is positively selected relative to the sample of whites. As appendix Table a2 shows, the achievement gap of students who progress with their class understates black-white differences in academic progress at any point in time given the much higher rates of grade retention and missing tests due to special education

classification (particularly for boys) among blacks.

The student database is linked to teacher and school information. The school data contain detailed information on teachers including grade and subject taught, class size, years of experience, highest degree, race, gender, and student population served. Although individual student-teacher matches are not possible, students and teachers are uniquely related to a grade on each campus. Students are assigned the average class size and the distribution of teacher characteristics for teachers in regular classrooms for the appropriate grade, school, subject, and year.

### **3. Racial Achievement Differences in Texas**

This section describes changes in the achievement gap as students progress from 3<sup>rd</sup> to 8<sup>th</sup> grade in Texas public schools. It presents results for all students combined and by initial achievement score. Prior to describing Texas achievement differentials we discuss the approach used to divide students by initial achievement score. The impact of test measurement error evokes particular concern, as does the substantial difference in initial achievement distributions by race.

#### *A. Division by Initial Achievement*

By dividing the 3<sup>rd</sup> grade achievement distribution into quintiles, systematic variation in the change in the achievement gap between 3<sup>rd</sup> and 8<sup>th</sup> grades across initial achievement categories can be identified. This is complicated, however, because test scores measure actual knowledge with error, leading to a misplacement of students into categories and biasing the calculation of gaps across grades. If errors are uncorrelated over time, those initially placed in high achievement categories will tend to draw less positive

errors in the subsequent year, while those placed in the lower categories will tend to draw more positive errors in the subsequent year. Therefore regression to the mean will account for a portion of the observed difference in test score changes across categories.

Such regression to the mean also complicates black-white comparisons by achievement level because of race differences in the actual initial skill distributions. Table 2 illustrates the general problem using a stylized trivariate distribution of actual skill and measurement error that is randomly distributed and does not differ by race. The top panel reports the assumed distributions of actual skill for blacks and whites, where the distribution for blacks is more concentrated in the lower categories than the distribution for whites. The bottom panel describes the resulting distribution of observed test scores, where  $P_{ij}$  is the probability that somebody with true ability in category  $i$  is observed in category  $j$  (e.g.,  $P_{LH}$  is the probability that a low ability person will have an observed test score in the high ability category). Comparison of the top and bottom panels shows that the observed test score distributions distort the actual race differences in skill even with the assumption of random measurement error distributions that do not differ by race. A higher proportion of whites than blacks are misclassified into the lowest observed skill category, while the opposite is true for the highest observed skill category. Strictly as a result of this regression to the mean phenomenon, the expected achievement gain in the next period is higher for whites than for blacks throughout the initial skill distribution if the errors leading to misclassification are uncorrelated over time.

The pattern illustrated in Table 2 invalidates the simple categorization of students on the basis of initial mathematics test scores. To overcome this problem, we use a test in a different subject to categorize students by initial skill level, based on the assumptions of

positive correlations across subjects in true skill and of no correlation in the test measurement errors across subjects. This scheme severs the link between initial category and expected difference in the error realizations for the initial and subsequent periods if the assumption of uncorrelated errors is true. However, the extent of teaching to the test, the probability of cheating (particularly by teachers), the likelihood a student is ill (different subject tests are administered on adjacent days, are likely similar across subjects, raising the possibility of correlated errors and potentially invalidating this approach to categorizing students.

The determination of the group cutoffs provides an additional issue to resolve. Because the distribution for whites has less dispersion than that for blacks and there are far fewer blacks in the sample, we chose to divide the sample on the basis of the 25<sup>th</sup>, 50<sup>th</sup>, and 75<sup>th</sup> percentile 3<sup>rd</sup> grade test scores computed only over the sample of blacks. This leaves blacks split almost evenly into the four categories, while whites are concentrated in the highest quartile.

### *B. Growth in the achievement gap*

Table 3 reports the evolution of the black-white achievement gap for all students combined and by initial test score quantile. The top row shows that the overall gap rises from 0.58 standard deviations at the end of 3<sup>rd</sup> grade to 0.65 in 5<sup>th</sup> grade and to 0.70 in 8<sup>th</sup> grade, and the remainder of the table reports the growth in the achievement gap by initial test score quantile. A clear pattern emerges showing much greater increases as initial score rises. For students in the lowest quantile initially, the gap rises from 0.49 to 0.57 between 3<sup>rd</sup> and 5<sup>th</sup> grade prior to falling to 0.54 in 8<sup>th</sup> grade. By comparison, the gap increases between 3<sup>rd</sup> and 8<sup>th</sup> grade by 0.15 for students in the second quantile, 0.22 for students in

the third quartile, and 0.28 for students in the top quartile.

A closer examination of changes across the distributions reported in Table 4 reveals that the increase in mean differences between 3<sup>rd</sup> and 5<sup>th</sup> grade for students in all quartiles result from the black distributions becoming increasingly left skewed. In none of the initial score quartiles do the gaps at the 75<sup>th</sup> or 90<sup>th</sup> percentiles rise by more than 0.07 standard deviations, while in none of the initial score quartiles do the gaps at the 10<sup>th</sup> or 25<sup>th</sup> percentiles increase by less than 0.16 standard deviations. Most striking is the increase of 0.43 standard deviations in the gap at the 10<sup>th</sup> percentile for students placed in the initial high achieving group.

This pattern raises doubts about the assumption that the errors in mathematics and reading scores are uncorrelated and that the mean differences provide a valid picture of changes in actual achievement by initial knowledge. Consider students in the top initial achievement category. If a small share of students have large, positively correlated errors across subjects and the mean error for blacks is larger than that for whites, regression to the mean would induce far lower scores for these students in the next period and a substantial increase in the achievement gap at the lower end of the distribution. Because any correlation between the error in 5<sup>th</sup> grade mathematics score and 3<sup>rd</sup> grade reading score is almost certainly far weaker, one would expect a very different pattern in the achievement gap change between 5<sup>th</sup> and 8<sup>th</sup> grade if in fact error induced regression to the mean drives the observed elementary school changes.

This turns out to be the case, as the gap at the 10<sup>th</sup> percentile actually falls in the bottom 3 initial achievement groups during middle school, and the 10<sup>th</sup> percentile gap in the top category rises far less. Nonetheless, the larger mean increase in the top two initial

achievement categories than in the 2<sup>nd</sup> and particularly the bottom category between 5<sup>th</sup> and 8<sup>th</sup> grade does indicate that black academic performance declines more relative to whites at the higher end of the initial achievement distribution

#### **4. Teacher and Peer Effects on Achievement Gaps**

We now investigate the extent to which specific teacher and school variables account for the growth in the achievement gap during the school years and differences by initial achievement. Although some recent studies including Fryer and Levitt (2004) have not found that observed school factors account for much if any of the growth in the achievement gap, these results are inconsistent with other research that highlights the significant effects of specific school and peer factors that clearly differ by race.

Our primary goal here is to assess whether schools have a discernible impact on the growth of the racial achievement gap. We focus on teacher experience and school proportion black, two school factors previously shown to be significant determinants of achievement and that are distributed differently by race. Table 5 shows that regardless of initial achievement quartile blacks are more likely to have teachers with little or no experience and on average attend school with a much higher black enrollment share. Note that by concentrating on these two factors we ignore other components of schools such as school leadership that are likely distributed more favorably for whites than blacks, because we do not have a strategy for credible identification of these effects.

##### *A. Empirical Model*

Uncovering the effects of teacher and peer characteristics on achievement is difficult primarily because the distribution of peer and teacher variables is not an accident

but rather an outcome of government, teacher, and family choices. Their endogeneity impedes efforts to isolate exogenous variation in these variables that can be used to identify their causal effects on student outcomes.

Extensive prior work into the effects of class size, teacher experience, peer turnover and racial composition, and other school and peer variables indicates that typically available variables provide inadequate controls for confounding influences related to both the outcome and causal factor of interest. Our approach takes advantage of the stacked panel data from the Texas Schools Project to account for systematic factors related to choices by schools and parents that affect teacher and peer characteristics on the one hand and achievement on the other. These value added models use the quasi-random variation in the teacher and peer characteristics that remains following the removal of the multiple levels of fixed effects to identify the specific peer and teacher characteristic effects.

Equation (1) highlights the key identification issues that must be addressed in the absence of random assignment. Here achievement  $A$  for student  $i$  in grade  $G$  and school  $s$  in year  $y$  is modeled as a function of student, family, school, and peer factors:

$$(1) \quad A_{iGsy} = \alpha_{iGy} + \beta X_{iGsy} + \delta S_{iGsy} + \lambda b_{iGsy} + e_{iGsy}$$

where  $P$  is peer composition and  $T$  is teacher quality in grade  $G$ ,  $X$  is a vector of flows of contemporaneous family background during grade  $G$ ,  $\alpha$  is an individual intercept specific to grade  $G$  in year  $y$  which captures the cumulative effects of family, neighborhood, and school experiences, and  $e$  is a stochastic term capturing other unmeasured influences.<sup>8</sup> If  $P$  and  $T$  were uncorrelated with  $e$  and  $\alpha$ , OLS would yield unbiased estimates of the effects of

peer and teacher characteristics. But as noted above, the complications inherent in the determination of the distribution of students and teachers among schools in combination with existing evidence strongly suggest that typically available variables contained in  $X$  will not account adequately for potentially confounding factors.

Our basic approach is to use the panel data to control for student, family, school, and community factors that could potentially bias the estimated effects, leaving only exogenous variation in the variables of interest to identify the parameter estimates. We begin by expanding the error term  $e$  from equation (1) into a series of components in order to highlight both the types of school and neighborhood factors accounted for directly by the panel data methods and those factors that remain unaccounted for:

$$(2) \quad e_{iGsy} = \eta_s + \xi_G + \psi_y + \pi_{sG} + \phi_{sy} + \rho_{Gy} + \tau_{sGy} + \varepsilon_{iGsy}$$

where the first three terms are fixed school ( $\eta$ ), grade ( $\xi$ ), and year ( $\psi$ ) effects, the next three terms ( $\pi, \phi, \rho$ ) are second level interactions among these three components, the seventh term ( $\tau$ ) is the third level interaction, and the final term ( $\varepsilon$ ) is a random error.

The school fixed effect captures time invariant differences in neighborhoods and schools, many of which are likely related to both achievement and school racial composition. These include school facilities, public services, community type, and working conditions that influence teacher supply.

Because school quality may vary over time and by grade for each school, Equation (2) also includes interactions between school and both grade and year. The school-by-grade component captures any systematic differences across grades in a school that are common to all years, and the school-by-year term accounts for systematic

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<sup>8</sup> We exclude the small number of students retained in grade in order to avoid problems introduced by the

year-to-year differences that are common to all grades in a school. These school-by-year fixed effects remove in a very general way not only school trends but also idiosyncratic variation over time in school administration and in neighborhood and local economic conditions that likely affect mobility patterns including such things as the introduction of new race-related school policies or the myriad changes documented to occur in “transitional neighborhoods.” An economic shock that reduces neighborhood employment and income would not bias the estimates; nor would a shock to local school finances or the quality of the local school board, because each of these would affect all grades in a school. The school-by-grade fixed effect also accounts for the possibility that achievement and racial composition vary systematically with age, as would be the case if white exit from schools rises at the same age as achievement of blacks declines because of peer or community influences.

It is also important to account for statewide factors that might be correlated with overall changes in racial composition and achievement. The grade, year, and year-by-grade fixed effects ( $\xi, \psi, \rho$ ) account for statewide trends in racial composition and achievement by grade and year and other factors including changes in test difficulty.

The seventh term,  $\tau$ , is the full three-way interaction between school, grade, and year, although it cannot be included in our estimation because there would be no variation left in racial composition across time or grades.<sup>9</sup> Ignoring this three-way interaction means

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non-comparability of test results across grades and years.

<sup>9</sup> We restrict attention to variations in racial composition at the grade rather than classroom level. We believe there are conceptual reasons for doing this, but we also have no alternative because our data do not support classroom specific analysis. The complication of any classroom analysis comes from selective placement of students into classrooms, which responds to the choices of school administrators and the preferences of parents and which is likely to reflect some influence of racial composition and parental bargaining skills. The estimator employing grade level aggregation is closely related to the use of grade average percent black as an instrumental variable, although the IV estimator would capture black-white differences in grade average classroom composition. Clotfelter, Ladd, and Vigdor (2003) find significant

that grade specific variation over time in school average teacher quality or other achievement determinants could potentially bias the estimates. Yet, because teacher assignments and other relevant aspects of school decisions are frequently not known until immediately prior to the beginning of school year, we do not expect changes over time in school and teacher quality for specific grades to be systematically linked with family factors through parental behavioral responses.<sup>10</sup> Nonetheless, we do account directly for student heterogeneity as we describe below.

The variation used to identify the parameter estimates can be illustrated by considering racial composition for a single school (In a more general case with multiple schools, the coefficients would reflect the average of these within school relationships across the sample). With multiple years of data for one grade, we could use cohort differences in achievement and racial composition to identify the racial composition effect. However, unobserved changes over time could bias the estimates produced by this school-by-grade fixed effects model. Alternatively, with multiple grades of data for a single year, we could use grade differences in achievement and racial composition to identify the racial composition effect. However, systematic differences by cohort or grade could bias the estimates produced by this school-by-year fixed effects model.

Fortunately, the availability of data for multiple years and grades permits the simultaneous inclusion of school-by-grade and school-by-year fixed effects. In this case the racial composition effect is identified by deviations from a school's average racial

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variations in the racial composition of classrooms by district, school, classroom, and academic track in middle school but much less so in primary school. Their descriptive analysis does not address implications for student performance, but, given our inclusion of school-by-year and school-by-grade fixed effects in regressions estimated separately by race, any such variation likely has a negligible effect on the estimates in this paper.

composition for each grade and year. Although this eliminates primary sources of bias, the possibility that unobserved differences by grade and year including test difficulty and grade specific policy changes at the district or state level could still contaminate the estimates. But, the availability of data for a number of schools enables us to control for average grade-by-year effects across all schools.

In this framework, the remaining variation in racial composition and the other variables comes both from students switching schools and from persistent cohort-to-cohort differences reflecting natural demographic variations in cohort composition within schools. But, because either of these sources of variation may be systematically related to student and family determinants of achievement, we must account for student heterogeneity directly as well as the effects of mobility.

Mobility induced changes, although frequently ignored in research based on cohort comparisons, present serious problems.<sup>11</sup> Hanushek, Kain, and Rivkin (2004a) show that blacks are much more likely to move than whites and thus to contribute disproportionately to year-to-year changes in school racial composition. Moreover, the evidence shows that movers tend to have lower prior achievement. In order to purge these contaminating influences, we control directly for the effects of moving on school changers with a vector of mobility variables that allow for different effects by timing, number, and type of move.<sup>12</sup>

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<sup>10</sup> Among other things, transactions costs and the presence of multiple children in the majority of families would tend to limit family mobility in response to concerns about school quality for a single grade even if relevant teacher and classroom assignments were known in a timely manner.

<sup>11</sup> An identifying assumption in a number of studies that make use of cohort differences is that either raw cohort differences or differences remaining following the removal of school specific trends over time are not correlated with confounding factors. This approach, which builds on the intuition that students close in age in the same school have many similar experiences, has been used in a variety of circumstances (e.g., Ehrenberg and Brewer (1995), Ferguson and Ladd (1996), and more recently generalized by Hoxby (2000)).

<sup>12</sup> Indicator variables differentiate both among those moving during the summer, school year, or at least twice in the same year and among within district changes, district changes within geographic region, and moves across regions.

The key remaining issue is the appropriate method for controlling for student-specific heterogeneity,  $\alpha_{iGY}$  in Equation (1). Equation (3) specifies  $\alpha_{iGY}$  as a function of prior school and family variables, racial composition in previous grades, and unobserved “ability”  $\gamma$ .<sup>13</sup> Notice that this fixed ability component is only one aspect of unobserved heterogeneity.

$$(1) \quad \alpha_{iGY} = \beta \sum_{g=1}^{G-1} \theta^{G-g} X_{igy} + \delta \sum_{g=1}^{G-1} \theta^{G-g} S_{igy} + \lambda \sum_{g=1}^{G-1} \theta^{G-g} b_{igy} + (\gamma_i + \lambda \sum_{g=1}^{G-1} \theta^{G-g} \gamma_i)$$

(note that  $\lambda$  prior to final summation sign should be dropped)

This formulation captures the notion that the families, communities, and schools exert cumulative effects that establishes the knowledge base at the start of grade  $G$  and therefore affect achievement at the end of grade  $G$ .<sup>14</sup> The effects of prior period variables are assumed to decline exponentially as a function of time from the present at a constant rate  $(1-\theta)$ , where  $0 \leq \theta \leq 1$ . At the extreme of  $\theta=0$ , past inputs are not relevant for current achievement, i.e., having a good fourth grade teacher does not have any implications for math achievement at the end of the fifth grade. On the other hand,  $\theta=1$  implies no depreciation of the influence of past inputs, i.e., that the impact of a good fourth grade teacher on 4<sup>th</sup> grade achievement equals her impact on 5<sup>th</sup> grade achievement and achievement in all future grades.

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<sup>13</sup> Boardman and Murnane (1979) and Todd and Wolpin (2003) also highlight the importance of unobserved ability and the cumulative nature of learning.

<sup>14</sup> This representation makes clear the interpretation of the various inputs ( $X$ ,  $S$ , and  $b$ ). These represent the flow of these inputs in each grade, while the cumulative inputs in equation 3, appropriately weighted, provide the stock of each input prior to grade  $G$ . At times the flows are measured by the level of specific inputs that do not change frequently, such as the educational attainment of parents, but the conceptual idea is that parents with different educational attainment provide differing flows of inputs to their child’s learning. Moreover, with separation and new family relationships, these inputs can themselves vary over time.

The term  $\gamma$  is a student fixed effect which is a function of early childhood influences, prenatal care, and heredity. Notice that our formulation is learning-based in that the value of  $\gamma$  affects the quantity of skills and knowledge acquired at each grade, and these increments to achievement are subject to depreciation. This explicitly permits the affects of ability on achievement to increase with age. The exact formulation and interpretation depends, however, on the measurement of achievement. If measured with vertically integrated tests, differences in  $\gamma$  would contribute to a widening of the skill distribution over time as long as  $\theta$  were not equal to zero.<sup>15</sup> On the other hand, if skills were measured by location in the distribution (as we do here with standardized scores), the complicated final term in parentheses could be replaced with  $\gamma_i$ , because ability induced differences in relative achievement would remain constant over time.<sup>16</sup>

Equation (3) includes a mixture of time invariant and time varying differences that could potentially bias estimates of racial composition effects if not incorporated directly into the estimation. But, as can be readily seen by writing equations 1 and 3 for grade G-1, including the student's prior test score on the right hand side of equation 1 captures the cumulative effects of prior school, community, and family influences that might be systematically related to peer and teacher variables without imposing an assumption about the value of  $\theta$ .

This formulation does not account explicitly for the contemporaneous effect of unobserved ability, and a key identifying assumption is that any variation in  $\gamma$  not

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<sup>15</sup> In testing terms this implies having vertically scaled scores that indicate skills and knowledge over time and not just measurement relative to a grade-specific norm for learning.

<sup>16</sup> Note that, more generally, this holds for all time invariant factors. Consequently, if the distributions of school quality and family and community environments were fixed through grade G, current characteristics would fully describe schooling, family, and community histories. Of course this would rule out the use of panel estimators and make it virtually impossible to identify the causal effects of specific factors. Moreover,

correlated with the prior test score is orthogonal to the variation in the teacher and school characteristics that remains following the inclusion of the multiple levels of school fixed effects. We do not believe that conditional on prior score, schools or parents act to alter grade average teacher or peer characteristics for a specific grade in ways that are related systematically to unobserved ability.

### *B. Results*

With the focus on within school and year variations in performance and the direct elimination of the systematic individual initial conditions in each grade, we are in a position to estimate the key underlying school and peer parameters for both blacks and whites in our Texas sample. Although the analysis considers commonly studied school factors such as class size, teacher education and average experience, it focuses on the effects of racial composition and initial teacher experience. These latter factors have been identified in our prior work and that of others as systematic determinants of school achievement, and their distributions differ substantially by race.<sup>17</sup> Preliminary work showed no systematic effect of teacher post-graduate schooling and that the small effect of average experience was driven by gains made in the early years of teaching, and therefore no teacher education variable or measures of experience beyond the initial years are included in the regressions.

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the notion of constant school and teacher quality contradicts evidence of substantial student mobility and within school variation over time in the quality of education.

<sup>17</sup> Hanushek, Kain, and Rivkin (2004a) demonstrate that both individual moves and overall school mobility rates have a direct impact on student performance and differ dramatically between black and white students. Rivkin, Hanushek, and Kain (2005) finds that teacher experience is important in the first two years of a teaching career (but not thereafter) and that class size has small effects in earlier grades. These patterns are consistent with a number of other high-quality recent works including Rockoff (2004), Boyd et al. (2005), and Kane, Rockoff, and Staiger (2006). Hanushek, Kain, and Rivkin (2006) find increased concentration of

Table 6 reports estimates by race and initial achievement quartile and robust standard errors clustered by school for three specifications that progressively add school-by-year and school-by-grade fixed effects estimated separately for elementary and middle school grades. In order to reduce computation time substantially we aggregate the data by race, initial achievement quartile, school, grade, and year and weight by the number of students in each cell. Given that the models are linear, it is not surprising that preliminary estimates of the weighted aggregate and student level models were quite similar in magnitude and significance. Estimates are based on a total of 445,741 observations in the elementary school regressions and 552,382 observations in the middle school regressions.<sup>18</sup>

In addition to the reported estimates, all specifications include indicators for subsidized lunch eligibility, participation in special education, female, a family initiated move, and a transition to middle school (in the middle school regressions), the share of students who are new to the school, and the share of teachers with two years of experience, all fully interacted by initial achievement quartile and race. Preliminary work showed that proportions of students who were Hispanic and Asian were not significantly related to achievement and that their exclusion had virtually no effect on the remaining variable estimates.

The results reported in the first page of Table 6 reveal substantial differences in the effects of proportion black by initial achievement quartile, race, and schooling level. With regards to students in the two lower achievement quartiles, estimated effects of school

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black students has a particularly deleterious effect on black achievement. This finding is consistent with Guryan (2004), Angrist and Lang (2004), and Hanushek and Raymond (2005).

proportion black on blacks and whites are quite similar in both elementary and middle school. In the elementary school regressions, the hypothesis that racial composition has no effect on elementary school achievement cannot be rejected at conventional levels for blacks or whites in any specification. In the middle school regressions, by comparison, the effects are larger and more precisely estimated though still quite similar in magnitude for blacks and whites, significant at the five percent level in the specification with school by grade fixed effects and only slightly smaller and almost significant at the five percent level in the model that also includes school by year fixed effects. The fact that the addition of school by year fixed effects causes slight reductions in coefficient magnitudes and slight increases in standard error magnitudes is consistent with possibility that the additional fixed effects exacerbate any measurement error induced attenuation bias. If the influences of omitted factors were introducing bias, one would expect the elimination of all within school variation over time common to all grades to lead to larger changes in the estimates.

In contrast to the findings for students in the two lower initial achievement quartiles, there are substantial differences by race in the estimates for students in the two higher quartiles, particularly those with the highest initial scores. The full fixed effect estimates of proportion black on achievement for blacks in the top initial achievement quartile are -0.20 (significant at the 5 percent level) in elementary school and -0.35 (significant at the one percent level) in middle school, while the estimated effects for whites in the highest initial quartile are small and statistically insignificant in all specifications with campus by grade fixed effects.

All in all, the pattern of proportion black estimates suggests the existence of peer

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<sup>18</sup> Only black and white nonHispanic students who remain with their cohort and have nonmissing test scores for grades three through eight are included in the sample. A small number of observations are excluded

influences that are largest for high achieving blacks. Not only does the stability of the estimates across specifications support the notion that the estimates identify a causal effect, they also suggest that the underlying mechanism relates to peers and not to school factors such as curriculum that are unlikely to vary substantially from year to year. The finding of larger effects in middle school and for initially high achieving blacks is also consistent with the beliefs that peer influences strengthen as students enter adolescence and that high achieving blacks are pressured not to achieve.

The results reported in the second page of Table 6 also reveal a negative relationship between achievement and the share of teachers with little or no experience. All coefficients for the share with no prior experience reported in the top panel are negative, and many are significant at the five percent level for blacks and all are significant at the five percent level for whites. For whites, a similar pattern to that observed for peer proportion black estimates appears, as the coefficient magnitudes decline in both elementary and middle school as initial achievement rises, though in this case estimated effects tend to be larger in the younger grades. No such clear ordering appears for blacks, though the lack of precision in the estimates may conceal a true underlying pattern.

The coefficients for the share of teachers with only one year of prior experience tend to be smaller and less precisely estimated. Regardless of initial achievement, all of the coefficients for whites in the elementary school regressions are much smaller in magnitude, and none are significant at the five percent level. In contrast, the middle school estimated effects of proportion with one year experience for whites are quite similar to the corresponding coefficients for the proportion with zero years of experience with the exception of students in the bottom initial achievement category for whom the estimate is

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because of missing information on teachers.

quite small and imprecise. Similar to whites, the proportion of teachers with one year of experience coefficients tend to be fairly similar to the proportion of teachers with zero years of experience coefficients in the middle school regressions but quite imprecisely estimated in the elementary school regressions.

## 5. Conclusions

By any measure, black-white differences in schooling outcomes are a matter of enormous concern. The early progress toward racial convergence that followed *Brown v. Board of Education* and the civil rights legislation of the 1960s has slowed if not stopped over the past two decades (Neal (2006)). The implications of this slowdown for earnings inequality and the economic well-being of blacks have been magnified by the substantial increase in the return to skill experienced over the past 30 years.

The differences in measured skills between blacks and whites are enormous. By age 17, the average black student is performing at around the 20<sup>th</sup> percentile of the white distribution.<sup>19</sup> This performance feeds directly into further schooling and into the labor market, ensuring continued disparities.

Our work concentrates, however, on earlier ages, building upon several recent studies that have pointed to the existence and importance of early achievement gaps.<sup>20</sup> A variety of authors, building upon existing research into achievement gaps, have raised

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<sup>19</sup> See data on the National Assessment of Educational Progress, or NAEP (National Center for Education Statistics (2005)).

<sup>20</sup> Fryer and Levitt (2004, (2005) and Murnane, Willett, Bub, and McCartney (2005) have addressed the early time period of racial achievement, and both have raised questions about whether or not schooling plays a role in achievement. In a larger set of papers, James Heckman argues that early investments are much more productive than later schooling investments and discounts any significant role for schools; see, among others, Cunha, Heckman, Lochner, and Masterov (2006), Heckman (2006). This paper does not discount the potential importance of early learning deficits but instead is best thought of as providing more balance in terms of changes that are possible after students enter schooling.

serious doubts that school quality differences are an important determinant of black-white achievement differences and that schools are unlikely to be an instrument of policies aimed at ameliorating racial achievement gaps. Our work provides a different perspective.

Using the Texas administrative data, we document the growth in the mean racial achievement gap from kindergarten to 8<sup>th</sup> grade by initial achievement quantile. A clear pattern emerges: the magnitude of the increase rises as initial achievement quantile rises. However, a closer examination of movements in the test score distributions suggests that error induced regression to the mean contributes to the observed changes in the elementary school achievement gap by initial achievement quantile. Consequently the observed increases likely overstate the actual increases in the knowledge differentials during elementary school. Nonetheless, the similar qualitative pattern observed during middle school does suggest that blacks in the higher initial score distributions tend to have more difficulty relative to whites, though the magnitudes are much smaller than those observed for elementary school.

The substantial widening of the gap during elementary and middle school years raises the possibility that school quality differences contribute to the black-white differential and that appropriate school policies can improve academic outcomes for blacks. We find that specific characteristics of teachers and peers – ones with systematic differences by race that have been found previously to have significant effects on achievement – appear to contribute to the pattern of widening gaps observed by initial quantile.<sup>21</sup>

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<sup>21</sup> These findings differ from those of Fryer and Levitt (2004), Murnane, Willett, Bub, and McCartney (2005) and others who do not focus on those variables for which there exist large differences by race and strong evidence that they are important determinants of achievement. Murnane et al. find that racial

Perhaps most important, we find that differences in school proportion black exacerbate racial achievement differences, particularly for students with higher initial achievement. Not only is there a substantial difference by race in proportion black, but the estimated adverse effect of proportion black is much larger for blacks than whites in the highest achievement quartile. Although similar differences in proportion black hold for the other initial achievement quantiles, the coefficients do not reveal sizeable effect size differences by race.

We also find that having a teacher with little or no prior experience adversely affects students, but the coefficient magnitudes are quite similar for blacks and whites.<sup>22</sup> Moreover, the effects appear to be larger for students with lower rather than higher initial achievement.

All in all, the central finding is that school quality plays an important role in the determination of achievement and has direct implications for racial achievement gaps. Indeed, the impact of schools is almost certainly much larger than we show here: As Rivkin, Hanushek, and Kain (2005) indicate, easily quantifiable variables do not explain the bulk of the variance in teacher and school quality. Our analytical strategy focuses entirely on identifying causal impacts, and thus a portion of the systematic influences of schools was undoubtedly ignored because we could not ensure that any relationships observed is truly

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composition appears to be a simple proxy for SES and that initial teacher experience has no impact, but they are unable to claim that they have credibly identified causal impacts.

<sup>22</sup> Our data do not permit disentangling the possible avenues for the teacher experience effects. It may be that teachers improve more in their teaching of lower achieving students for whom learning comes less easily, it may be that students tend to be more disruptive in schools with more lower achievers and that an important component of the return to experience is learning to manage disruption, or it may be low achievers are much more likely to attend schools that struggle to find teachers skilled in the teaching of mathematics. We are unable to unravel these possibilities.

causal.<sup>23</sup>

Nonetheless, implications for policy remain uncertain. Perhaps the most easily identified policies revolve around ensuring that black students do not draw a disproportionate share of beginning teachers. However, because a substantial portion of the existing teacher experience differential appears to result from the teacher preferences, the solutions are not entirely clear (Hanushek, Kain, and Rivkin (2004a)). Reducing the gap in peer composition also presents considerable difficulties, and the benefits for blacks may be considerably smaller than those suggested by the coefficients reported in Table 5. As Rivkin and Welch (2006) report, housing patterns account for the bulk of school segregation, and court decisions limit interdistrict desegregation programs. Moreover, our sample covers a period without much systematic desegregation activity, and the relationship between achievement and racial composition might depend upon both programmatic and historical factors that determine school attendance patterns in a given district. Consequently, active initiatives designed to increase substantially black exposure to whites might produce a different relationship between achievement and racial composition.

The implication is that, while we identify specific school and peer factors that systematically affect racial achievement gaps, policy directed at just these factors is unlikely to be very successful. Instead, looking at a more comprehensive set of policies aimed at improving the quality of schools attended by blacks – such as improving teacher quality in those schools – will be required. Nonetheless, the magnitude of the achievement

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<sup>23</sup> One example is the possible importance of the race match of students and teachers. Ehrenberg and Brewer (1995), Dee (2004), and Hanushek, Kain, O'Brien, and Rivkin (2005) find that black students do better when matched with a black teacher. However, because we cannot investigate classroom linkages here, we cannot pursue this element of schools.

gaps is truly large, and the large gaps at entry to school point to the further need for a broader set of policies.

Finally, it is crucial to recognize that test score differences do not provide adequate information for those not in the test sample, which in this case includes students retained in grade or those excused from test taking because of a disability or other circumstance. Given the much higher rate of special education classification and grade retention for blacks than for whites and for black boys in particular, the achievement comparisons do not capture fully the gap in education progress and do not illustrate the educational difficulties of many at the lower end of the achievement distribution including those that will likely experience poor academic, social, and labor market outcomes in the future.<sup>24</sup>

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<sup>24</sup> The low rates of test taking for blacks and to a lesser extent whites among those who participate in all five waves in the ECLS sample raise the possibility that the reported growth in achievement differences understates the actual increase during the early elementary school years.

Table 1. Distribution of 20 to 24 year olds by School Status, Employment Status, Years of Schooling, and Institutionalization Status in 2000 (percentage by Gender and Race)

	Institutionalized	High school dropout		High School Graduate				College Graduate		Total observations
		Not employed	Employed	Attending school Not employed	Employed	Not Attending school Not employed	Employed	Not employed	Employed	
Men										
Blacks	14.1%	10.3%	6.7%	12.7%	13.2%	15.0%	23.3%	1.2%	3.8%	10,459
Whites	2.7%	4.2%	9.5%	13.6%	22.5%	6.3%	29.0%	2.3%	10.0%	53,820
Women										
Blacks	0.9%	10.3%	5.6%	15.6%	20.0%	17.2%	21.3%	2.2%	7.0%	10,728
Whites	0.3%	6.4%	4.7%	13.9%	26.8%	9.8%	19.5%	3.1%	15.5%	50,664

Note: Row percentages add to 100 percent.

Source: Author calculations from Census 2000 Public Use Microdata Use Sample (PUMS).

Table 2. Simulated Observed and Actual Test Score Distributions for Blacks and Whites  
(P<sub>ij</sub> = probability of being actual category i but observed as category j)

**Initial Actual Skill Distributions**

	Low	Middle	High
Blacks	0.4	0.4	0.2
Whites	0.2	0.4	0.4

**Observed Test distribution**

Blacks		
Low		$0.4 * P_{LL} + (0.4 * P_{ML} + 0.2 * P_{HL})$
Middle		$0.4 * P_{MM} + (0.4 * P_{LM} + 0.2 * P_{HM})$
High		$0.2 * P_{HH} + (0.4 * P_{LH} + 0.4 * P_{MH})$
Whites		
Low		$0.2 * P_{LL} + (0.5 * P_{ML} + 0.3 * P_{HL})$
Middle		$0.5 * P_{MM} + (0.2 * P_{LM} + 0.3 * P_{HM})$
High		$0.3 * P_{HH} + (0.2 * P_{LH} + 0.5 * P_{MH})$

Table 3. Texas Public School Mean Black/White Math Test Score gap (TAAS standardized test scores) for Intact Cohorts, by reading test score quartile determined by 3rd grade Black scores (All students remain with entering cohort from grades 3 to 8 and are tested each year)

grade	Overall Gap			blacks	whites
	3	5	8		
overall	0.58	0.65	0.70	89,563	344,833
reading quartile					
lowest	0.49	0.57	0.54	22,491	30,258
2nd	0.31	0.42	0.46	21,840	52,284
3rd	0.23	0.36	0.45	21,863	85,961
highest	0.20	0.38	0.48	22,676	173,582

Table 4. Texas Public School Black/White Math Test Score gaps at the 10th, 25th, 50th, 75th and 90th percentiles of the black and white test score distributions, by reading test score quartile

initial reading quartile	lowest			2nd			3rd			4th		
	Grade 3	Grade 5	Grade 8	Grade 3	Grade 5	Grade 8	Grade 3	Grade 5	Grade 8	Grade 3	Grade 5	Grade 8
Percentile												
10 <sup>th</sup>	0.58	0.74	0.62	0.45	0.68	0.57	0.40	0.70	0.65	0.33	0.76	0.85
25 <sup>th</sup>	0.64	0.80	0.65	0.41	0.63	0.59	0.29	0.47	0.58	0.28	0.56	0.73
50 <sup>th</sup>	0.51	0.66	0.62	0.29	0.43	0.50	0.25	0.36	0.50	0.17	0.31	0.44
75 <sup>th</sup>	0.41	0.46	0.49	0.23	0.28	0.40	0.13	0.17	0.35	0.12	0.19	0.28
90 <sup>th</sup>	0.28	0.26	0.39	0.17	0.22	0.28	0.13	0.12	0.23	0.07	0.11	0.15

Table 5. Average Proportion of Schoolmates Who are Black, Proportion of Teachers With Have No Prior Experience, and Proportion of Teachers With Only One Year of Prior Experience, By Race and Initial Achievement Quartile for Elementary School

	initial reading quartile			
	lowest	2nd	3rd	highest
<b>Blacks</b>				
proportion of schoolmates that are black	0.382	0.375	0.374	0.394
proportion of teachers with no prior experience	0.086	0.083	0.082	0.083
proportion of teachers with one year of prior experience	0.078	0.077	0.077	0.077
<b>Whites</b>				
proportion of schoolmates that are black	0.096	0.092	0.089	0.087
proportion of teachers with no prior experience	0.066	0.063	0.060	0.058
proportion of teachers with one year of prior experience	0.065	0.062	0.060	0.058

Table 6. Estimated Effects of Proportion of Students Who Are Black, Proportion of Teachers With Zero Years of Experience and Proportion of Teachers With One Year of Experience on Achievement, by Race and Initial Test Score Quartile (robust standard errors clustered by school in parenthesis)\*

	elementary school			middle school		
campus by year fixed effects	no	no	yes	no	no	yes
campus by grade fixed effects	no	yes	yes	no	yes	yes
<b>Blacks</b>						
bottom quartile	-0.005 (0.065)	-0.122 (0.077)	-0.010 (0.095)	-0.317 (0.084)	-0.279 (0.132)	-0.245 (0.141)
second quartile	0.056 (0.045)	-0.096 (0.071)	-0.077 (0.089)	-0.286 (0.059)	-0.257 (0.112)	-0.226 (0.119)
third quartile	0.003 (0.039)	-0.147 (0.069)	-0.118 (0.087)	-0.301 (0.057)	-0.266 (0.115)	-0.234 (0.118)
top quartile	-0.076 (0.040)	-0.240 (0.069)	-0.202 (0.088)	-0.402 (0.067)	-0.381 (0.111)	-0.348 (0.114)
<b>Whites</b>						
bottom quartile	-0.166 (0.084)	-0.127 (0.085)	-0.106 (0.102)	-0.219 (0.093)	-0.232 (0.123)	-0.214 (0.128)
second quartile	-0.057 (0.060)	-0.033 (0.072)	-0.002 (0.090)	-0.189 (0.075)	-0.226 (0.112)	-0.211 (0.118)
third quartile	-0.017 (0.044)	0.007 (0.067)	0.035 (0.085)	-0.068 (0.056)	-0.111 (0.109)	-0.091 (0.118)
top quartile	-0.011 (0.029)	0.038 (0.065)	0.069 (0.084)	-0.058 (0.042)	-0.078 (0.105)	-0.060 (0.115)

Table 6 cont.

	elementary school			middle school		
campus by year fixed effects	no	no	yes	no	no	yes
campus by grade fixed effects	no	yes	yes	no	yes	yes
<b>1.Proportion of Teachers with 0 Yrs Experience</b>						
<b>Blacks</b>						
bottom quartile	-0.155 (0.064)	-0.134 (0.060)	-0.126 (0.061)	-0.125 (0.060)	-0.057 (0.045)	-0.106 (0.047)
second quartile	-0.137 (0.049)	-0.080 (0.044)	-0.074 (0.050)	-0.115 (0.048)	-0.077 (0.039)	-0.128 (0.040)
third quartile	-0.222 (0.058)	-0.197 (0.057)	-0.178 (0.047)	-0.067 (0.042)	-0.039 (0.034)	-0.085 (0.036)
top quartile	-0.191 (0.076)	-0.153 (0.077)	-0.087 (0.043)	-0.003 (0.044)	0.015 (0.034)	-0.033 (0.037)
<b>Whites</b>						
bottom quartile	-0.302 (0.053)	-0.252 (0.049)	-0.268 (0.053)	-0.133 (0.042)	-0.124 (0.034)	-0.146 (0.035)
second quartile	-0.175 (0.036)	-0.141 (0.031)	-0.153 (0.036)	-0.049 (0.026)	-0.041 (0.022)	-0.064 (0.024)
third quartile	-0.122 (0.025)	-0.091 (0.023)	-0.107 (0.030)	-0.044 (0.023)	-0.044 (0.018)	-0.063 (0.021)
top quartile	-0.082 (0.016)	-0.054 (0.018)	-0.069 (0.026)	-0.032 (0.140)	-0.034 (0.014)	-0.054 (0.018)

Table 6 cont.

campus by year fixed effects	no	no	yes	no	no	yes
campus by grade fixed effects	no	yes	yes	no	yes	yes

2. Proportion of Teachers with 1 Yr Experience

**Blacks**

bottom quartile	-0.222 (0.071)	-0.158 (0.065)	-0.110 (0.070)	-0.180 (0.062)	-0.113 (0.048)	-0.143 (0.051)
second quartile	-0.088 (0.050)	-0.026 (0.047)	0.005 (0.050)	-0.062 (0.054)	-0.003 (0.039)	-0.031 (0.042)
third quartile	-0.045 (0.045)	0.025 (0.045)	0.034 (0.045)	-0.090 (0.048)	-0.050 (0.035)	-0.074 (0.036)
top quartile	-0.033 (0.040)	0.049 (0.048)	0.053 (0.042)	-0.073 (0.049)	-0.026 (0.031)	-0.054 (0.033)

**Whites**

bottom quartile	-0.093 (0.050)	-0.102 (0.047)	-0.078 (0.049)	0.002 (0.041)	0.010 (0.036)	-0.011 (0.038)
second quartile	-0.027 (0.037)	-0.050 (0.034)	-0.034 (0.036)	-0.048 (0.028)	-0.039 (0.022)	-0.053 (0.025)
third quartile	-0.038 (0.026)	-0.050 (0.023)	-0.035 (0.026)	-0.042 (0.024)	-0.035 (0.018)	-0.050 (0.022)
top quartile	-0.024 (0.015)	-0.028 (0.018)	-0.016 (0.021)	-0.040 (0.016)	-0.033 (0.014)	-0.051 (0.020)
observations		445,741			552,382	

\*All specifications include a black and female indicators, indicators for a transition to junior high, subsidized lunch eligibility, special education participation, and a non-structural move (all fully interacted with black), and a full set of grade by year variables.

**Appendix Table a1. Average Mathematics Test Score by Mobility, Race, and Grade in ECLS for Students Who Participate in All Five Survey Waves** (weighted by sampling weights)

	fall K	spring K	Grade spring 1st	spring 3rd	spring 5th	number
<b>Blacks</b>						
no school change	19.3	27.9	48.5	77.8	97.5	702
moves between K and first grade	18.9	27.0	49.2	77.3	95.2	76
moves between first and third grade	20.4	29.1	50.8	83.5	106.4	106
moves between third and fifth grade	18.8	27.2	48.0	77.8	95.3	169
<b>Whites</b>						
no school change	25.3	36.3	62.0	97.7	118.5	4,085
moves between K and first grade	24.2	34.9	62.0	96.4	116.7	295
moves between first and third grade	23.9	34.6	60.2	96.6	117.2	487
moves between third and fifth grade	24.5	35.9	60.3	96.0	117.0	738

Source: Author calculations from ECLS data.

Appendix Table a2. **Distribution of Texas Public School Students by Test and Grade Retention Status, by Race, Gender, and Grade**

	Grade					Grade				
	4	5	6	7	8	4	5	6	7	8
	<b>blacks</b>					<b>whites</b>				
<b>Girls</b>										
has test score	88.2%	89.3%	88.6%	89.3%	87.8%	93.3%	94.3%	94.1%	94.0%	92.5%
<i>no test score:</i>										
special education	8.4%	9.1%	9.2%	7.5%	7.5%	4.1%	4.1%	4.1%	3.7%	4.0%
Other	2.5%	1.0%	1.1%	1.6%	3.9%	2.2%	1.2%	1.2%	1.5%	3.0%
Retained in grade	0.8%	0.6%	1.1%	1.6%	0.8%	0.4%	0.4%	0.5%	0.8%	0.5%
<b>Boys</b>										
has test score	80.3%	81.2%	79.9%	80.8%	79.1%	90.3%	91.2%	90.6%	90.5%	88.9%
<i>no test score:</i>										
special education	15.9%	16.8%	16.8%	14.4%	14.3%	7.0%	7.0%	7.0%	6.4%	7.1%
Other	2.7%	1.1%	1.4%	1.8%	5.2%	2.1%	1.2%	1.3%	1.6%	3.2%
Retained in grade	1.2%	0.9%	2.0%	3.1%	1.7%	0.6%	0.6%	1.1%	1.6%	1.0%

Source: Author calculations from TSP data

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