Do School Learning Opportunities Compound or Compensate for Background Inequalities? Evidence from the Case of Assignment to Effective Teachers

Manuscript Accepted for Publication in *Sociology of Education*

Paul Hanselman(*)
University of California, Irvine

January, 2018

* paul.hanselman@uci.edu

WORDS: 11,476 (text, references, notes)

ACKNOWEDGEMENTS

Research reported in this paper was supported by the U.S. Department of Education, Grant R305C050055 to the University of Wisconsin-Madison (PI: Adam Gamoran) and Grant R305B120013 to the University of California, Irvine (PI: Greg Duncan); and the Eunice Kennedy Shriver National Institute Of Child Health & Human Development of the National Institutes of Health under Award Number P01HD065704 (PI: Greg Duncan). The content is solely the responsibility of the author and does not necessarily represent the official views of the supporting agencies. The author also gratefully acknowledges feedback from Adam Gamoran, Eric Grodsky, Geoffrey Borman, Felix Elwert, Harry Brighouse, Jeffrey Grigg, Anna Haskins, Elizabeth Wrigly-Field, Thurston Domina, the editor, and three anonymous reviewers.

Abstract

Are equal educational opportunities sufficient to narrow long-standing economic and racial inequalities in achievement? In this paper, I test the hypothesis that poor and minority students benefit less from effective elementary school teachers than their non-poor and White peers, thus exacerbating inequalities. I use administrative data from public elementary schools in North Carolina to calculate value-added measures of teachers' success in promoting learning and assess benefits for different students. Results suggest that differential benefits of effective teachers uniquely exacerbate Black-White inequalities while not contributing to economic achievement gaps. Racial differences are small relative to the benefits for all groups on average, not explained by differences in prior achievement, and largest for low-achieving students. While teacher-related learning opportunities at school are crucial for all students, these differences point to a relative disconnect between typical school learning opportunities and low-achieving minority students.

Research and policy addressing educational equity often focuses on ensuring equal access to learning opportunities in school, and social background disparities remain a particular concern (e.g., Coleman et al. 1966; Condron 2009; Reardon 2011). For instance, attention has long focused on the important if complex opportunities related to classroom teachers (e.g., Coleman et al. 1966; Covay Minor et al. 2015; Goldhaber, Lavery, and Theobald 2015; Lauen and Henry 2015). But differential *access* to valuable learning opportunities is just one potential source of inequality; differential *benefits* of these opportunities may also contribute to disparities. Because students come to school with different resources and dispositions, they may experience the same opportunities differently, especially to the detriment of poor and minority students. As a result, schooling may contribute to social background disparities even if learning opportunities are distributed perfectly evenly among all students.

Theories of social advantage and learning provide diverging expectations about how differential benefits of school learning opportunities influence inequality. On the one hand, opportunities may *compound* existing inequalities by being more beneficial for students from advantaged backgrounds. This pattern is predicted by a model of learning in which opportunities are most valuable for students with greater academic preparation (Sorensen and Hallinan 1977; Stanovich 1986). It is also consistent with the cultural capital perspective that school opportunities align best with the resources enjoyed by advantaged groups, leading to differential profits for school instruction (Calarco 2014a). On the other hand, opportunities may *compensate* for existing inequalities by being most beneficial for students from a disadvantaged background. This pattern is consistent with the notion that school opportunities are in part substitutes for other resources, which would lead in the absence of schooling to even larger achievement gaps (Downey, von Hippel, and Broh 2004; Raudenbush and Eschmann 2015).

Compounding or compensating effects of school highlight potential interactions between home and school resources for learning, which may explain distinct patterns of inequality along different dimensions of social background. For instance, seasonal learning comparisons suggest that schooling exacerbates early Black-White achievement gaps more than economic ones (Downey et al. 2004), but differences in access to observed resources explains little of these differential trajectories (Condron 2009; Fryer and Levitt 2004). A plausible explanation for this set of results is that racial minority students benefit the least from school learning opportunities, reflecting fundamental disparities in how students and families interact with school resources (Lareau and Horvat 1999; Roscigno and Ainsworth 1999). Similarly, benefits may be most different for students facing other challenges, such as low-achieving students.

In this paper, I test for compounding or compensatory influences of schooling related to economic background and race/ethnicity for one of the most important educational resources that students experience in elementary school: assignment to a teacher who effectively promotes learning. Drawing on a large set of administrative records from North Carolina and value-added measures of teacher effectiveness, I test for differential benefits of assignment to a more effective teacher by economic disadvantage and between among White, Black, and Hispanic students. To better understand differential benefits, I then consider whether initial patterns persist net of prior achievement, and whether effects are most different for struggling or successful students.

Background

School Opportunities to Learn and Inequality

As students (and families) with different resources engage with the institution of formal schooling, the results can exacerbate or mitigate social inequalities. Many stratification accounts emphasize that formal education is a domain in which privileged social actors secure unique advantages, with the result of reproducing persistent social inequalities (e.g., Gamoran 1987; Lareau 1989; Lucas 2001). Conversely, others argue that common and compensatory influences of schooling equalize outcomes, especially relative to the stark developmental inequalities observed outside of school (e.g., Downey et al. 2004).

To isolate how schooling contributes to students' development and educational inequality, stratification and education research focuses on the concept of *opportunity to learn* in school. Opportunity to learn encompasses the "the presentation of a certain amount of material" (Sorensen 1989:6), which reflects the quantity of curricular material presented but also the quality of presentation and supportiveness of the social environment (Carroll 1963; Pianta et al. 2007; Wang 1998). Richer learning opportunities—more material, presented in a clear and engaging manner, and in a supportive classroom environment—enable greater student learning. However, they do not guarantee it; learning occurs as individual students interact with particular material, and therefore also depends on the resources, such as academic preparation and effort, that students bring to the classroom (Carroll 1963; Sorensen and Hallinan 1977). Learning opportunities are also difficult to isolate in practice, given the complexity of instruction in school. Yet researchers have emphasized that meaningful clusters of learning opportunities are structured by the organization of schooling (Sorensen 1970, 1989), such as differences between curricular tracks (e.g., Gamoran, Nystrand, and Berends 1995; Kilgore and Pendleton 1993).

In this paper I consider *teacher-related* learning opportunities, which reflect the constellation of relative learning opportunities that result from being assigned to a particular teacher for the school year. As the adult who fundamentally shapes the content, presentation, and social environment of instruction at school, a teacher has a formative influence on the quality of students' learning experiences. For instance, recent research on opportunities to learn highlights aspects related to specific teacher characteristics and styles of instruction (Covay Minor et al. 2015). In addition, a growing body of research also points to more subtle differences among individual teachers, as reflected by substantial impacts on students' development that are poorly captured by traditional proxies for teacher quality (Hanushek and Rivkin 2010; Jennings and DiPrete 2010; Nye, Konstantopoulos, and Hedges 2004; Rivkin, Hanushek, and Kain 2005). This suggests that assignment to an effective teacher is an important source of relatively rich, if complex, school learning opportunities.

It is important to note that teacher-related learning opportunities are not necessarily teacher-caused; they also reflect the classroom and school resources at her disposal and other aspects of local context. Analogous to school effects (Jennings et al. 2015; Raudenbush and Willms 1995), the effects of assignment to a particular teacher likely reflect both educational practices and educational conditions. These distinct influences may not be distinguishable in teacher effectiveness measures, and it is inappropriate to hold teachers accountable for factors outside their control (Raudenbush 2004). However, from the perspective of a student or parent, both practices and environment shape learning opportunities. Therefore, the total impact of assignment to a particular teacher reflects a substantial set of teacher-related learning opportunities. These opportunities have the potential to compound or compensate for social background inequalities.

We can distinguish two ways that school learning opportunities, including teacher-related ones, may contribute to inequality. The first is that some students may have less *access* to valuable learning opportunities at school. A long tradition of research highlights how privileged students enjoy greater access to resources that support learning opportunities, such as school financial resources (Condron and Roscigno 2003), teachers with more experience (Kalogrides, Loeb, and Béteille 2013), and higher track placements (Lucas and Berends 2007). In this vein, recent research assesses economic and racial disparities in access to more effective teachers, showing some evidence of small inequalities; however some research fails to find evidence of group differences, suggesting that teacher disparities are less pronounced than often assumed (Goldhaber et al. 2015; Isenberg et al. 2016; Mansfield 2015). The same is true in the data for this study, as presented in Table A2.

The second is that some students may experience fewer *benefits* from exposure to the opportunities that schools provide, as students with different resources and dispositions interact with learning opportunities in the classroom. If socially advantaged students experience greater benefits of school learning opportunities at school, for instance, then even perfectly equitable access would exacerbate existing inequalities, and richer school opportunities would merely exacerbate these differences (Sorensen and Hallinan 1977). In this paper I focus on the how differential benefits may contribute to or mitigate inequality.

Teachers, Differential Benefits, and Inequality

In general, how might opportunities at school, especially those related to teacher assignments, benefit students from different social backgrounds? One hypothesis, often assumed in models of educational inequality, is that school opportunities have similar impacts. Given the interactive nature of learning and differential resources students bring to the classroom, it is implausible that benefits are precisely the same for all students. Still, group differences may be inconsequential if variability is small or if the differential benefits occur primarily among individual students within social background groups rather than between.

A second hypothesis is of *compounding effects*: that students from privileged groups reap the greatest rewards from opportunities in school, compounding pre-existing inequalities. Compounding effects are predicted by two distinct, though not mutually exclusive, mechanisms. One mechanism is differences in students' academic preparation, which may enable greater learning from similar learning opportunities. For instance, a student with stronger vocabulary may understand instructional materials better, therefore learn more from a particular lesson. This type of cumulative advantage process contributes to "rich get richer" dynamics in literacy development (Stanovich 1986) and human capital accumulation (Cunha and Heckman 2007), and it implies that greater school opportunities fundamentally exacerbate social background inequalities (Sorensen and Hallinan 1977). However, this widening of social background differences is not due to social characteristics per se, but merely the legacy of prior inequalities.

There is some empirical support for the notion that high-achieving students especially benefit from assignment a teachers who can provide relatively rich learning opportunities. One example is experienced teachers, who likely provide richer instruction than novice teachers. Clotfelter et al. (2006) present suggestive evidence that the benefits of teacher experience are higher for 5th students in mathematics with above average achievement; however, these estimates are not statistically significant and the pattern does not hold in reading. Another example is teachers placed by the Teacher for America program, who may provide unique learning experiences compared to their peers in hard to staff schools. Applying distributional methods to experimental evaluation data in elementary grades, Penner (2016) finds these teachers have positive effects in mathematics throughout the entire achievement distribution. However, consistent with the compounding hypothesis, Teach for America teachers are especially beneficial for reading at the top of the distribution, and detrimental at the bottom.

Another set of mechanisms for compounding influences of schooling concerns mismatches between students' background and experiences and the school environment. Critical scholarship highlights ways in which schools, still overwhelming staffed by White educators, particularly fail to meet the needs of children of color (e.g., Irvine 1990; Ladson-Billings 2006; Valenzuela 1999). Racial differences in judgments of students' ability (Ready and Wright 2011), perceptions of behavior (Irizarry 2015; Morris 2005), and ultimate expectations for success (McKown and Weinstein 2008) all reflect a climate that potentially mutes the ability for Black and Hispanic students to take advantage of ostensibly similar school learning opportunities (Lewis and Diamond 2015). These problems are likely exacerbated by the demographic distance between students of color and the typical White teacher (Downey and Pribesh 2004; Dee 2004; Egalite, Kisida, and Winters 2015), but they are more fundamental and more complex than the composition of the teaching force alone. As social actors, all teachers are influenced by social stereotypes, and even unconscious biases influence expectations and students' experiences of classroom learning opportunities (Bergh et al. 2010). In turn, the quality of relationships between students and teachers ultimately moderates the how much students gain from instruction (Crosnoe et al. 2010).

The cultural capital literature provides a complementary perspective on how the resources that students and families bring to school may lead to differential success in interacting with educators school institutions (Lareau and Horvat 1999; Lareau and Weininger 2003). For instance, middle class parents are better able to customize the school experiences of their children (Horvat, Weininger, and Lareau 2003), and parents' interventions in school may complement learning opportunities, making them especially effective for advantaged students. Cultural capital also informs how students respond to opportunities in school. Gaddis (2013) traces measures of cultural capital to habitus, dispositions toward schooling, that explain benefits for school performance. Calarco's (2014a, 2014b) work documents how middle class students' help-seeking allows them to take greater advantage of similar lessons and instruction; differences in students' taken for granted "logics of action" in the classroom lead to differential value of features of instruction in the classroom, especially as students navigate ambiguous interactions with their teacher. Thus middle class students may enjoy different profits of school opportunities that compound inequality.

A third, competing hypothesis about differential effects is that opportunities are most beneficial to disadvantaged students, therefore *compensating* for inequality. An example is greater benefits of a high reading group in early elementary school for Black and Hispanic students (Tach and Farkas 2006). Such compensating effects may would result from differences in students' experiences outside of school leading less advantaged students to be more sensitive to the quality of school opportunities. There are two ways that this could occur. First, many of the learning opportunities in schools, especially those relating to basic skills, may overlap with the skills advantaged children are more likely to develop in the absence of school (Engel, Claessens, and Finch 2013). If these opportunities substitute for experiences among advantaged families, then school opportunities may matter the most for disadvantaged students. A second potential source of compensating influences of schooling is parental responses to school opportunities. For instance, middle class parents are more likely than working class families to intervene in school and to provide supplemental educational services such as tutoring (Horvat et al. 2003; Robinson and Harris 2014). To the extent that this effort takes the form of responding to challenging situations at school (e.g., Calarco 2014a), then relatively poor school opportunities may be less detrimental to more advantaged students. If so, then greater opportunities would be more beneficial to disadvantaged students, and therefore compensatory.

In short, theories provide competing and potentially cross-cutting hypotheses about how differential benefits of school learning opportunities may compound or compensate social background achievement inequalities. The patterns may also be different for distinct dimensions of social background. Seasonal learning comparisons, for instance, suggest that compounding effects of school opportunities may be strongest for racial disparities and less relevant for class disparities (Downey and Condron 2016). These possibilities highlight the importance of testing how specific school opportunities compound or compensate for specific social disparities.

Despite the potential for differential teacher benefits, there is relatively little evidence about whether more effective teachers are most beneficial for students from different social backgrounds. In one of the most direct assessments to date, Konstantopoulos (2009) tests for differential teacher effects in the Tennessee STAR class size experiment, where randomized classroom assignments enable unbiased estimates of teacher effectiveness. The results suggest compounding effects (greater benefits for White and non-poor students), but estimates are imprecise and few are statistically distinguishable from zero. Clotfelter, Ladd, and Vigdor (2006) find a similar pattern for assignment to an experienced teacher among 5th grade students in North Carolina: suggestive evidence of larger benefits for non-poor students and those with higher parental education. Studies also report evidence that teacher effects are highly correlated across different types of students (e.g., Condie, Lefgren, and Sims 2014; Fox 2015); these imply that the relative ranking of teachers is similar across groups, but they do not directly assess the magnitude of differential benefits that students experience. Therefore, while existing evidence implies that differences in teacher effects are likely to be small relative to teachers' overall impacts, they are ambiguous about the direction and precise size of consequential compounding or compensatory influences.

Research Questions

The primary research question addressed by this paper is: do the benefits of assignment to a more effective teacher differ for students from different racial and economic backgrounds? The compounding hypothesis predicts that assignment to a more effective teacher is most beneficial for White and non-poor students. Conversely, the compensatory hypothesis predicts that the benefits are greatest for Black, Hispanic, and poor students.

I also ask two supplemental questions related to the influence of students' prior academic preparation and individual teacher differences. First, are there different teacher benefits by economic and racial background controlling for differences in prior achievement? Theories that locate differential effects of learning opportunities in students' prior preparation imply that there are not differences independent of prior achievement, while theories that view school practices as fundamentally shaped by race and class hierarchies predict differential benefits even for students with similar scores. Second, I ask whether racial and economic differences in teacher benefits are larger among low- or high-achieving students. An intersectional hypothesis is that social background differences are most pronounced among students facing the greatest academic challenges in school. The benefits of school opportunities for this underserved group (low-achieving poor and minority students) have important implications for how schooling contributes to educational stratification and how improving opportunities is likely to shape inequality.

Throughout, I consider whether the answers to the above questions differ for economic background and race/ethnicity, as these different dimensions of social background may be associated with distinct processes of stratification as students interact with school.

Methods

Data

To calculate estimates of teacher effectiveness and assess differential benefits, I use longitudinal student information covering 1.5 million student-year observations from administrative records of students in grades 3-5 in North Carolina public schools between 2006 and 2013, collected from the Department of Public Instruction and prepared for research use by the North Carolina Education Research Data Center (NCERDC). These data include yearly student achievement scores on standardized tests that allow me to characterize teachers' effectiveness in promoting learning for their students over time. This indicator of teacher-related learning opportunities, available for a large number of students, allows new, precise tests of hypotheses of compounding or compensatory school influences.

I focus on this time period because course enrollment information, not available in previous years, allows for linking students and teachers to individual classrooms. Research using earlier data from North Carolina used the teacher who administered yearly assessments as the basis for student-teacher links, an imperfect proxy that at best precluded considering a substantial number of cases (in recent data, the proctor and classroom teacher do not match for approximately a quarter of cases). Classroom-linkages based on the new enrollment records match closely with independent records of class sizes from school activity reports (correlation above .9 in each year) and match closely for the subset of cases that NCERDC could link unambiguously to teacher records via recorded names (match rate of 98%).

Sample

The analytic sample consists of students linked to single teacher in a focal academic course who is observed with at least 10 students in other years. The latter requirement ensures that an indication of a teachers' effectiveness is available independent of the focal year. It eliminates students that cannot be linked to a teacher, those in a course taught by multiple teachers, and the small number of teachers observed in only one year. The resulting samples for mathematics and reading comprise more than three quarters of the public school students in the state (for descriptive statistics, see the Appendix Table A1).

My analyses focus on the two socially important background dimensions theorized to be related to benefits of school learning opportunities: economically disadvantaged students (relative to not economically disadvantaged students) and Black and Hispanic students (relative to White students).

Measures

Achievement

The dependent variable for all analyses is mathematics or reading achievement, as measured by students' performance on North Carolina's End of Grade tests.[1] These standardized tests assess learning in content standards specified by the state, reflecting an important domain of the academic learning opportunities that schools and teachers are expected to provide. Scores are approximately normally distributed and show no evidence of ceiling or floor effects. To facilitate interpretation and comparison, I standardize achievement scores to have a mean of 0 and standard deviation of 1 in the full population in each year and grade.

Social Background

Measures of social background are based on administrative records. The economic background variable is based on participation in the National School Lunch Program, a standard proxy for economic disadvantage determined by family income less than 185% of the federal

[1] For more information, see: http://www.ncpublicschools.org/accountability/testing/eog/

poverty line or receipt of means-tested transfers, such as food stamps. For expositional simplicity, I also use the labels "poor" and "nonpoor" for eligible and non-eligible students, respectively, throughout the paper. About half of all students are economically disadvantaged by this criteria. Racial/ethnic group membership is collected by schools in accordance with state and federal reporting requirements. I focus on non-Hispanic White (55% of the sample), Black/African-American (25%), and Hispanic (11%) students.

Teacher Effectiveness

To measure differences among teachers in the relative opportunities to learn that students experience, I calculate value-added estimates of teacher effectiveness for teachers in grades 3-5.[2] This approach (for overviews, see Koedel, Mihaly, and Rockoff 2015; McCaffrey et al. 2003) uses longitudinal information to draw conclusions about the effect of being assigned to a specific teacher as opposed to an average teacher, a counterfactual difference that summarizes a wide range of potential differences between classrooms.[3] These inferences would be straightforward if all teachers were assigned comparable students, such as if students were randomly assigned to schools and classrooms. Since this is not the case, value-added models control for observed student and school characteristics to isolate teacher-related influences from differences among students. In this paper I apply standard value-added models, drawing on evidence that this approach identifies substantive differences in teacher effectiveness (described below) and research demonstrating the utility of value-added methods for understanding schooling

[2] Grade 3 teachers are considered only prior to 2011, when pre-tests at the beginning of the year allow value-added estimates during grade 3.

[3] As noted above, not all differences in "teacher effectiveness" are the responsibility of teachers. For instance, assignment to one teacher may include assignment to an inferior classroom space. However, such differences still reflect the relative opportunities related to teacher assignments. This is why I refer to value-added measures as indicators of teacher-related learning opportunities rather than teacher-caused opportunities.

inequalities (Jennings et al. 2015). I then conduct sensitivity analysis to assess whether possible biases in these measures alter the answers to research questions, which are detailed below.

I estimate teacher effectiveness with a value-added model of the following form, where *i* indexes students, *j* indexes teachers, and *t* indexes year:

$$Y_{ijt} = \beta_0 + f(Y_{i,t-1}) + \boldsymbol{\beta} X_{it} + \mu_j + \varepsilon_{it}, \qquad (1)$$

This equation models mathematics or reading achievement at the end of the school year (Y_{ijt}) as a function of several observable characteristics: a function of prior mathematics achievement ($f\left(Y_{i,t-1}\right)$, which I specify as a third order polynomial), a vector of observable student, classroom, and school characteristics (X_{it}: prior achievement in alternate subject, gender, eligibility for free/reduced lunch, race/ethnicity, limited English proficiency designation, disability designation, migrant status, gifted designation in mathematics or reading, an indicator for grade retention, cubic polynomials of classroom and school-level mean prior achievement in reading and mathematics, and grade and year fixed effects), and a teacher effect (μ_j).

I estimate the parameters of the model treating teacher effects as fixed, based on evidence of the appropriateness this “dynamic ordinary least squares” approach under several plausible underlying data generating processes (Guarino, Reckase, and Wooldridge 2015). The estimated fixed effects ($\hat{\mu}_j$) provide measures of teacher effectiveness for subsequent analyses. To mitigate the unreliability of estimates based on a single year, all teacher effectiveness estimates are calculated separately for each year, based on a “leave-out” sample of students from all other years. Mean estimated reliability for the sample of math teachers is .91 in this sample, and .78 for reading (reflecting smaller teacher effects on reading outcomes).[4]

In the metric of student achievement, a standard deviation in estimated teacher effectiveness in these data is 0.20 in mathematics and 0.14 in reading in these data, which are consistent with estimates of teacher effects in other contexts (Hanushek and Rivkin 2010). For interpretability, I standardize all effectiveness measures to have mean of 0 and standard deviation 1 among all teachers. Therefore, regression estimates correspond to the estimated impacts of a standard deviation change in observed teacher effectiveness.

Validity and Alternate Effectiveness Specifications

An important question is whether value-added teacher effectiveness measures are valid reflections of relative differences in the quality of learning opportunities students experience in school. A particular concern is that the systematic sorting of students to classrooms and schools would lead some types of teachers to appear to be more effective than they are. Advantaged families tend to secure access to schools and classrooms with teachers with more experience and better credentials (Clotfelter, Ladd, and Vigdor 2005; Lankford, Loeb, and Wyckoff 2002), and teacher labor market and organizational mechanisms also contribute to these disparities (Boyd et al. 2010; Kalogrides et al. 2013). Thus, some teachers may seem more effective from teaching particular students, which could distort comparisons across groups.

The implementation of teacher effectiveness measures here draws on a large and growing literature on these methods, which provides evidence on validity and identifies potential

---

[4] Reliability estimates are calculated as $\frac{\hat{\sigma}_\mu^2}{\hat{\sigma}_\mu^2+\frac{\hat{\sigma}_\varepsilon^2}{N_j}}$, where $\hat{\sigma}_\mu^2$ reflects the estimated variance in teacher effects from the model in Equation 1, $\hat{\sigma}_\varepsilon^2$ reflects estimated variance within teachers, and N_j represents the number of student observations for teacher j.

weaknesses (for a recent review, see Everson 2017). Evidence for validity comes from several complementary approaches. First, the magnitude of variability of observational teacher effectiveness corresponds with experimental and quasi-experimental estimates (Hanushek and Rivkin 2010; Nye et al. 2004; Rivkin et al. 2005). Second, these measures are predictive of effects in studies when teachers have been randomly assigned to classrooms (Kane et al. 2013; Kane and Staiger 2008).[5] Third, quasi-experimental evidence from teacher transfers in large-scale administrative data suggests minimal bias (Bacher-Hicks, Kane, and Staiger 2014; Chetty, Friedman, and Rockoff 2014). Finally, value-added estimates are robust to alternate covariate specifications, including adding detailed family income information not typically available, which suggests that these potentially important characteristics do not confound estimates (Chetty et al. 2014). While research does not definitively rule out teacher value-added biases, a recent review concluded that "most of the reviewed literature appears to suggest that in many cases differences in classrooms due to sorting do not appear to introduce significant bias in effect estimates, especially when several years of data are included in the analyses," although less work directly assesses between-school sorting (Everson 2017:51).[6]

Although these measures reveal some meaningful information about teacher influences, it is important to consider how possible biases may influence the current research design. To assess the potential influences of measurement on the substantive conclusions, I investigate how results

[5] An experimental evaluation also found benefits of providing an opportunity to recruit a teacher previously identified as highly effective (Glazerman et al. 2013). While this does not assess the precise accuracy of value-added estimates, it supports a degree of predictive validity even across different school contexts (at least for teachers willing to transfer).

[6] Skeptical perspectives highlight general agreement about some value in value-added measures, despite debate about the size of possible biases. For example, an influential paper on the limits of these measures concluded that they "have substantial signal but nevertheless introduce important misclassification into any assessment of teacher quality" (Rothstein 2010:206). For more on this paper and subsequent methodological debates, see Everson's (2017) review. The imprecision of estimates remains a concern for conclusions about individual teachers, especially those based on a single year, but this limitation does not threaten their use for aggregate conclusions here.

change with different covariates are included in the teacher effectiveness model (for an example, see Isenberg et al. 2013). By leaving out likely important control variables (the individual and aggregate characteristics in X_{it} in Equation 1), these results provide an indication of how omitted characteristics may influence conclusions about differential effects.

A more specific concern about measurement is that individual teachers might provide different kinds of learning opportunities to different types of students, leading overall effectiveness to be an imperfect proxy for students' experiences.[7] Evidence on this possibility is mixed— student-teacher match effects (based on race or gender) suggest some differences exist (Dee 2004; Gershenson, Holt, and Papageorge 2016), while teacher effectiveness measures show little heterogeneity by student characteristics (Condie et al. 2014; Fox 2015)— but even small differences could influence conclusions about the current research questions. To consider how such heterogeneity (including but not limited to teacher characteristics), I relax the assumption of homogeneous teacher effects by calculating subgroup-specific effectiveness estimates by economic disadvantage and for Black and White students.

Analyses

To test hypotheses about differential benefits of school opportunities, I estimate the effects of being assigned to a more effective teacher and interactions with social background. The basic model for the achievement of student *i* assigned to teacher *j* at the end of year *t* is:[8]

---

[7] For instance, imagine a population of just two teachers: A, a more effective teacher who provides extra enrichment geared toward mainly non-poor students, and B, a teacher who provides lesser, but equivalent, opportunities to all students. The average effectiveness of teacher A would understate the typical opportunities she provides to non-poor students and overstate those opportunities for poor students. The benefits of average teacher effectiveness therefore would seem largest for non-poor students (the benefits of teacher A would be highest), even if there were no interaction between background and opportunities. By contrast, a subgroup-specific measure of effectiveness would more accurately characterize the opportunity differences between classrooms.

[8] Subscripting by teacher j in Equations 2-4 is redundant, since individual students have a single teacher in each year. I include it to highlight that the outcome is the same as Equation 1.

$$Y_{ijt} = \beta_1(TE_{ijt}) + \beta_2(BG_{it}) + \beta_3(TE_{ijt})(BG_{it}) + \beta_4(Y_{i,t-1}) + \beta\boldsymbol{X_{it-1}} + \varepsilon_{it}$$

(2)

In Equation 2, TE_{ijt} represents the estimated effectiveness of the student's teacher ($\hat{\mu}_j$ from Equation 1, calculated from data in years other than *t*), BG_{it} represents an indicator for the student's social background group, $Y_{i,t-1}$ is the lagged dependent variable, $\boldsymbol{X_{it-1}}$ reflects a vector of student covariates measured in the prior year (prior achievement in the other subject, the non-focal social background [economic disadvantage or race/ethnicity], gender, limited English proficiency, academically gifted designation, grade retention, aggregate demographics and prior achievement of the classroom, and grade by year fixed effects), and ε_{it} is a normally-distributed disturbance term. In this model, β_1 reflects the benefits of a more effective teacher for the reference group (nonpoor or White students) and β_2 reflects the expected conditional achievement gap between groups when teacher effectiveness is average. The key parameter is β_3, which provides a test of differential benefits. The compensatory hypothesis predicts $\beta_3 > 0$, while the compounding hypothesis predicts $\beta_3 < 0$.

To assess differences net of academic preparation, I allow for an interaction between prior achievement and teacher effectiveness in the model:

$$Y_{ijt} = \beta_1^*(TE_{ijt}) + \beta_2^*(BG_{it}) + \beta_3^*(TE_{ijt})(BG_{it}) + \beta_4^*(Y_{i,t-1}) + \beta_5^*(TE_{ijt})(Y_{i,t-1}) + \beta\boldsymbol{X_{it-1}} + \varepsilon_{it} \qquad (3)$$

In Equation 3, β_5^* represents how the benefits of assignment to an effective teacher differ for students with different academic preparation, with a positive value signifying that teacher effectiveness is most beneficial to students who arrive with the greatest knowledge. My theoretical interest is whether this inclusion changes the interaction between effectiveness and social background (β_3^*) as compared to β_3 in Equation 2. If prior preparation explains teacher benefit differences, then we would expect β_3^* to be smaller (in absolute value) than β_3 and statistically different; if prior preparation is the sole explanation, then β_3^* should be statistically indistinguishable from 0.

Finally, to test for differential social background differences by academic preparation, I include a three-way interaction term:

$$Y_{ijt} = \beta_1(TE_{ijt}) + \beta_2(BG_{it}) + \beta_3(TE_{ijt})(BG_{it}) + \beta_4(Y_{i,t-1}) + \beta_5(TE_{ijt})(Y_{i,t-1}) + \beta_6(BG_{it})(Y_{i,t-1}) + \beta_7(TE_{ijt})(BG_{it})(Y_{i,t-1}) + \beta \boldsymbol{X_{it-1}} + \varepsilon_{it} \quad (4)$$

Here β_7 reflects how differences in teacher benefits by social background vary by initial achievement level. Positive values of β_7 support the intersectional hypothesis that background differences most compound inequality among low-achieving achieving students.

Across all models, I adjust standard errors for the clustering of observations within schools. In addition to reporting differences in the metric of standardized achievement, I also present interaction estimates as percentages of the main effect for the reference group (non-economically disadvantaged students or White students), based on the ratio $\hat{\beta}_3/\hat{\beta}_2$, with standard errors accounting for uncertainty in both estimates.

Alternate Model Specifications

Because students and teachers are not assigned to classrooms at random, these observational models identify the parameters of interest only if they successfully account for confounding influences on both teacher assignments and student achievement. Although it cannot be tested directly, I implement several alternate analyses to probe the plausibility of this assumption and the robustness of these substantive results.

One critical issue is the sufficiency of observed characteristics, and I assess sensitivity to alternate sets of covariates in Equation 2. As above, specifications that omit demographic or aggregate classroom characteristics help to gauge how these controls change conclusions relative to simpler models with only the primary prior achievement covariates. One particular weakness of the standard covariates is that they do not directly measure educators' assessments of students, which likely inform classroom placement. Therefore, in some specifications I add teacher-reported judgments from the prior year about students' academic proficiency and expected grade in mathematics and reading (information collected to calibrate cut-points in the standardized tests). Finally, I include interactions between teacher effectiveness and classroom characteristics to assess whether compositional differences account for differential teacher effects.

A second approach to assessing potential bias focuses on subsamples of schools where classroom assignments are balanced in terms of observable characteristics, where student sorting may be less systematic and identifying assumptions more plausible (see Clotfelter et al. 2006). I define "balanced assignment" schools as those in which prior achievement (and in separate tests: economic background and race/ethnicity) is not a jointly significant predictor of classroom assignments across within all year-grade combinations in the data. Since student sorting is less pronounced in these schools, different results there may indicate potential problems related to sorting overall.

Finally, for all specifications I consider robustness to the inclusion of schools fixed effects, which focuses on variation within schools. This may exclude some meaningful between-school variation in teacher effectiveness, but is likely to remove spurious differences related to student sorting.

Results

Differences in Access to Effective Teachers

Before addressing the primary research questions, I document disparities in access to effective teachers in this sample by calculating differences in the mean teacher effectiveness of teachers assigned to different groups (full estimates in Appendix Table A2). Consistent with recent research (Goldhaber et al. 2015; Isenberg et al. 2016; Mansfield 2015), the mean differences tend to be small or not detectable. In mathematics, poor students experience teachers with lower effectiveness by 0.04 standard deviations; in reading the disparity is 0.03.[9] However, there is no evidence of disparities for Black or Hispanic students relative to Whites: the differences are not statistically significant in mathematics and imply small advantages for these groups in reading (0.05 standard deviations). As in previous research in other settings, these small differences counter common assumptions about access to high quality teachers, at least with respect to effectiveness in promoting student learning. This also suggests that student sorting related to effectiveness may be less pronounced than for the observable teacher characteristics considered in most previous research on teacher inequalities.

Conclusions about teacher effectiveness disparities are sensitive to the covariates included in the value-added model, however (see also Isenberg et al. 2013). In specifications that do not account for differences in the composition of classroom and school characteristics, there are clear disparities for poor, Black, and Hispanic students. These gaps are larger still when individual covariates (other than prior achievement) are omitted, ranging from 0.1 to 0.3 standard

[9] These disparities can be thought of as standardized differences in exposure to teacher-related learning opportunities, since the effectiveness measure has been scaled to have a mean of 0 and standard deviation of 1 for the teachers in the sample. They differences are smaller in the metric of standardized student achievement since a standard deviation in teacher quality corresponds to 0.20 student standard deviations in mathematics and 0.14 in reading.

deviations. In other words, disparities appear to be larger for effectiveness estimates that less plausibly isolate teachers' influences on learning. This likely reflects selection effects that work in favor of teachers of more advantaged students, highlighting the importance of assessing how selection may influence our understanding of differential benefits.

Do Teacher Benefits Differ by Social Background?

Turning to tests of the interactional hypotheses, key estimates from basic models of teacher effects on student achievement are presented in Models 1 (mathematics) and 4 (reading) of Table 1 (for economic background) and Table 2 (for race/ethnicity) and are summarized in Figure 1. Not surprisingly given previous evidence of the validity of these measures, assignment to a more effective teacher predicts a substantial increase in learning, corresponding to 0.13 of a standard deviation in mathematics achievement at the end of the year, and 0.06 in reading.

Turning to differential benefits of a more effective teacher, patterns are strikingly different between economic and racial/ethnic background. For the latter, there is no evidence that poor students see a larger or smaller benefit of assignment to a more effective teacher. Interactions in both subjects are statistically indistinguishable from zero and precisely estimated. The results are thus not consistent with either the compounding or compensatory hypotheses, at least for this measure of economic background. The story is different by race/ethnicity, however. For Black students, teacher benefits are significantly smaller than for White students in both mathematics and reading, providing consistent support for the compounding hypothesis. The same is true for Hispanic students in reading, but not in mathematics, where there are no discernable differences. The former interaction may reflect language barriers at school that mute the benefits of relative learning opportunities (despite controlling for both Limited English

Proficiency and prior reading achievement), but it may also be spurious given the sensitivity checks presented below.[10]

In short, social background differences in the apparent benefits of assignment to an effective teacher are small relative to the benefits for all types of students. But, these interactions point to diverging effects of this source of school learning opportunities. There is little evidence of differential benefits by economic background, there are mixed results for Hispanic students (little difference in Mathematics; smaller benefits in reading), and the benefits of more effective teachers tend to compound Black-White inequalities.

What is the Substantive Magnitude of These Effects?

Are these differences substantively meaningful? I offer three ways to gauge the magnitude of the estimated interactions. Perhaps the most natural metric is the size of interactions relative to the estimated benefits of teacher effectiveness for the reference group; estimates of these proportions are presented in Figure 1. For instance, the estimates imply that the effects of assignment to a more effective teacher for mathematics is 6.3% lower for Black students than White (a teacher effectiveness slope that is 0.937 as steep) and 8.5% lower in reading. These disparities reflect modest but meaningful differences. If patterns for the case of teacher-related learning opportunities generalized to all school learning opportunities, these proportional differences would be expected to extrapolate to overall school influences. A relevant comparison is thus differential school year learning, adjusting for summer trajectories.

[10] The Hispanic coefficient in mathematics is notably positive, reflecting an advantage relative to White peers after controlling for prior achievement and other variables, despite a large raw gap and substantial one conditional on prior achievement. This result is surprising, but it echoes previous research noting relatively favorable *trends* for Hispanic, which are in some cases greater than for Whites (Reardon and Galindo 2009). In supplemental analyses (not shown), I find that three variables are most responsible for the positive Hispanic estimate (above and beyond prior mathematics achievement): prior achievement in reading, economic disadvantage, and Limited English Proficiency.

For instance, Downey et al. (2004, Table 3, “Contrasts” Panel), report lower school learning by approximately 5% for socioeconomic status (0.12/2.33 in mathematics; 0.06/1.03 in reading), and 15% lower for Black students (0.34/2.33 and 0.18/1.03), with inconsistent differences for Hispanic students. In comparison, the teacher effectiveness estimates here are less detrimental to Black and poor students.[11]

Second, we might ask how differential benefits contribute to existing achievement gaps, and how these implications compare to differences in exposure to effective teachers. Based on the model parameters in Tables 1 and 2 and the mean teacher value-added for each groups, we can calculate expected achievement for groups if teachers were allocated equally and/or the benefits of a more effective teacher were the same across groups (see supplemental materials for details of the implementation). These calculations (Table 3) show that differential teacher effects explain 5-10% of Black-White achievement gaps conditional on prior performance, meaning up to a tenth of the group disparity in learning experienced in a single year. Not surprisingly, these differences represent a much smaller portion of the larger raw achievement gaps that exist between these groups (0.5-2.5%). However, these calculations also demonstrate the observation from previous research and above that differential exposure to more effective teachers plays an even smaller role, typically explaining less than 2% of the conditional achievement gap. Thus, differential benefits seem to be more consequential for racial disparities related for this aspect of school opportunities.[12]

[11] This comparison is meant to be instructive rather than definitive. For instance, note that Fitzpatrick, Grissmer, and Hastedt (2011) find no statistically significant difference in the effects of additional days of schooling by social background using different methods in the same data, although they do not report estimates or precision of these tests.

[12] Note that while instructive, these implied contributions to gaps are not necessarily practical, because it is not clear even in principle how we might equalize the benefits of learning opportunities. This limitation motivates the next calculation.

A third way to gauge of the size of the estimates is how achievement gaps would be expected to change with plausible changes in teacher effectiveness in a classroom or school. Consider proposals to replace teachers via targeted recruitment and retention policies. If it were possible to replace the bottom 5% of teachers in terms of effectiveness with average ones, we would expect an increase in mean effectiveness of roughly 0.1 standard deviations. Model estimates imply this would increase the conditional Black-White achievement gaps by approximately 0.5% (for mathematics: 0.1 * 0.008/0.147), with similar magnitude for the Hispanic-White reading gap. As an upper bound, consider the local consequences of a more intensive policy, such as targeted transfer incentives to fill positions with top quintile teachers as opposed to average ones (e.g., Glazerman et al. 2013). If such a policy resulted in a standard deviation increase in effectiveness for students in affected classrooms, the current results predict that the Black-White conditional achievement gap would increase by 5% among these students (for mathematics: 1 * 0.008/.147).

Are Background Interactions Estimates Robust to Alternate Specifications?

A fundamental potential threat to the conclusions of these observational analyses is that they do not fully account for students' selection to different teachers. To assess whether such selection effects drive results via either the measurement of effectiveness or model specification, I consider several alternate specifications for the main interaction results.

With respect to alternate covariate specifications of the value-added measures, results are uniformly robust (Appendix Table A3 and Figure A1). The same is not true for the disparities in access to effective teachers reported above, which imply larger disparities in the models that less plausibly isolate teachers' influences on student learning. The relative robustness of the differential benefits estimates suggest that systematic student sorting is less problematic for these conclusions than for those about differential access.

To assess whether results depend on the homogeneous measurement assumption in Equation 1 (and most value-added models), I implement subgroup-specific value-added measures among the subsample of teachers observed with at least 10 of both poor and non-poor students or both Black and White students (see characteristics in Table 1).[13] The pattern of results is similar within this unique subsample and with subgroup-specific effectiveness measures (Table A2 and Figure A1). The main difference is that the tendency of teacher effectiveness to compound Black-White inequalities is more pronounced (15-25% of the White estimate), suggesting that the main results may be conservative. While these subgroup-specific differences highlight the need to better understand how race shapes teaching and local classroom experiences, they bolster the main conclusion that differential effects of school learning opportunities tend to compound racial inequalities but do not alter economic ones.

I also consider several alternate specifications of the outcome model (results presented in Table A4 and Figure A2). The pattern of results is not substantially or systematically different when focusing on within-school variation by including school fixed effects. Similarly, results are robust to excluding covariates from the model (classroom aggregates and/or non-achievement individual variables), and to including additional controls for prior teachers' judgments of students' academic proficiency level. Results are also similar when classroom characteristics (mean achievement or demographics) are allowed to interact with teacher effectiveness. Estimates for Black-White differences are 15% smaller which implies that the types of students assigned to teachers explain a portion of but do not account for differential benefits. While it is

[13] Sample sizes preclude doing the same for Hispanic students.

impossible to gauge the influence of unobserved variables in the observational model, the similarity of the key results across each of these specifications provides some evidence of their robustness.

In a complementary test of the influences of systematic student sorting on the results, I focus on a subsample of schools in which classroom assignments are consistently balanced with respect to prior achievement, including calculating teacher effectiveness based only on these schools. Balanced schools are defined as those for which mean prior achievement, student race/ethnicity, and economic disadvantage do not differ significantly between classrooms across all grade-year cells. Within each school, I regress prior achievement (or social background) on grade-year indicators and individual classroom indicators, then test the joint significance of the classroom indicators.[14] Approximately an eighth of students in the analytic sample are in schools that meet this criteria for prior achievement and demographic characteristics (see Table A1).

Estimates are less precise in these subsamples, but for most groups and subjects the results within the balanced schools do not alter overall conclusions. Within the balanced assigned subsample, there are not statistically significant differences related to economic background, but the point estimate in mathematics is positive and large (7.0% larger than the nonpoor effect), providing some suggestive evidence of compensatory teacher effects for poor students. Black interaction effects remain negative in mathematics (-6.4% and -4.7%, depending on whether teacher effectiveness is estimated only within the subsample, versus -6.3%) and are even more pronounced in reading (-12.8% and -13.2%, versus -8.5%). It is not clear if these differences in magnitude are the result of less biased estimates, a meaningful difference in this particular subsample, or due to chance alone. Nonetheless, all alternate estimates support the basic original

[14] In supplementary testing, I find that the gender composition of classrooms tends to be much more balanced than expected by chance.

conclusion of compounding effects of Black-White inequality. By contrast, the patterns for Hispanic students are quite different in the balanced assignment sample. The point estimates are greater, implying Hispanic advantages in mathematics and no differences in reading. While the reasons for the differences in this subsample are again unclear, these specification tests suggest the need for caution in interpreting the suggestive compounding effects in reading for Hispanic students.[15]

In summary, the sensitivity of results across alternate specifications support the following conclusions: there is not strong evidence for differential benefits related to economic background, but the possible indication of a compensatory effect in mathematics; the lower benefits of teacher effectiveness for Black students are robust to alternate specifications, providing no evidence that conclusions are the result of systematic sorting; and results for Hispanic students are inconsistent across specifications, failing to support the initial suggestive evidence for compounding effects in reading.

Does Academic Preparation Explain Background Differences?

To test whether differential effects by academic preparation explain group differences, Models 2 and 5 in Tables 1 and 2 allow for interactions between a student's prior achievement and the effectiveness of the teacher to whom she was assigned. These interactions suggest that students with lower prior preparation benefit most from assignment to a more effective teacher. These differences are small compared to main teacher effects—a more effective teacher is more beneficial for all students—but they imply overall compensatory benefits of teacher-related

[15] As shown in Figure A2, the inclusion of school fixed effects also makes the largest difference for Hispanic interactions in the balanced classroom assignment school subsample, providing more reason to interpret these results with caution.

learning opportunities. This could reflect the relative importance of higher quality school resources for students who arrive at school with relatively poor academic preparation.

Accounting for prior achievement leads to lower estimated interactions in all cases, implying that achievement differences masked some tendency of teacher-related learning opportunities to compound background disparities. For economic background, the mathematics interaction switches sign but remains negligible.[16] In reading, the conditional background-teacher is significant and negative, implying benefits for poor students that are 8% (-0.005/0.059) lower than nonpoor students.

Racial differences in teacher benefits are even more pronounced net of prior achievement interactions. The expected benefit of a more effective teacher is 10% (-0.013/0.136) lower for Black students than Whites in mathematics and 16% (-0.010/0.061) in reading. Hispanic benefits are also 4% (-0.005/0.136) and 21% (-0.013/0.061) lower, respectively. Differential preparation therefore seems to mask some of the unique advantages that White students experience from teacher-related learning opportunities.

In short, more effective teachers seem to be compensatory with respect to prior achievement in elementary school. These differences do not explain differential teacher benefits by social background, but this dynamic tends to mask differences in the benefits of assignment to a more effective teacher, especially to the detriment of students of color. This suggests that these school opportunities uniquely complement White students' non-academic resources for learning, and is consistent with a cultural mismatch perspectives on schooling.

[16] For the estimates suggesting a compensatory effect in the balanced assignment school subsample, controlling for prior achievement interactions reduces the positive point estimate by approximately half (not shown).

Are Social Background Differences More Pronounced for Struggling Students?

The above analyses suggest that Black (and possibly Hispanic) students tend to experience smaller benefits of assignment to a more effective teachers (compared to Whites) while lower-achieving students experience somewhat stronger benefits (relative to high achievers). But these analyses ignore the potential for these two dimensions of educational inequality amplify one another. An intersectional perspective highlights the possibility that learning opportunities may most compound inequality for struggling minority students.

Three-way interaction models (Model 3 and 6 in Tables 1 and 2, summarized in Figure 2) show differences in estimated teacher benefits related to both social background dimensions and prior achievement. Negative estimates imply that differential teacher benefits compound both economic and racial differences among low achieving students, with little difference among high-achieving students. To interpret these estimates, Figure 2 represents predicted effects of assignment to a more effective teacher for students one standard deviation above and below the mean. In mathematics, poor, Black, and Hispanic students' benefits are 10-18% lower (relative to non-poor or White students) among low-achievers and 3-14% higher among high achievers. In reading, disadvantages are 20-30% among low-achievers and not statistically distinguishable from zero among high achievers. These differences are driven by especially large benefits of an effective teacher for low-achieving White and non-poor students, which compounds social inequalities among struggling students.

In contrast, successful students experience similar benefits of a more effective teacher regardless of their social background. One way of interpreting these results is that teacher-related learning opportunities seem to help struggling non-poor and White students to catch up but struggling Black, Hispanic, and poor students are left behind. These differences suggest a combination of home advantages among non-poor and White students that complement school opportunities for struggling students and unique barriers to connecting with those opportunities for poor and minority students.

In short, the compounding hypothesis seems to be most true for students facing dual dimensions of disadvantage in school—based on both social background and academic preparation. Smaller benefits of learning opportunities for these students suggests a form of intersectional inequality in how students experience school.

Discussion

A long-standing hypothesis in research on schooling and inequality is that greater opportunities to learn necessarily compound existing inequalities (Sorensen and Hallinan 1977). I find mixed support for this hypothesis for the important case of learning opportunities associated with assignment to a more effective elementary school teacher. There do not seem to be differences related to economic background, at least as indicated by eligibility for free or reduced price lunch. The troubling finding for educational equality is that Black students tend to experience smaller benefits from assignment to a more effective teacher, meaning that teacher-related learning opportunities compound racial disparities, especially among academically struggling students. Since these racial differences are not explained by differences in prior achievement, they seem to reflect unique barriers faced by minority students to the full advantages of school opportunities. School inequalities cannot be viewed merely in terms of access to valuable resources.

These results have the most direct implications for proposals to promote school equity by improving teacher quality, which has increasingly been defined in terms of the tendency to improve student achievement. The current findings certainly justify focusing policy attention on teachers; like previous research, I find that assignment to more effective teacher is associated with greater learning on average for all student groups. However, results also imply that equalizing access to high-quality teachers may do less than previously imagined to narrow racial achievement gaps. Teachers who provide high-quality learning opportunities do not necessarily meet the needs of all students equally, and these differences do not seem to be explained by differences in prior academic preparation. Policies must also consider how to promote culturally responsive pedagogy that enables success for socially marginalized groups (Ladson-Billings 1995). More generally, the compounding influences of effective teachers suggest that merely providing equal school opportunities, without addressing potential differential benefits, will exacerbate some social background inequalities.

It is important to note several limitations of the current approach. While teachers are an instructive case as an important source of learning opportunities that students experience in school, they are one specific source. While these patterns echo some broader patterns, but additional work is required to assess whether these findings generalize to other aspects of learning opportunities. In particular, the present focus on teachers cannot speak to the influence of resources common to all classrooms, such as curricular standards, or differences in opportunities that students experiences within the classroom. These analyses also only consider opportunities related to achievement as measured on standardized tests, while many important opportunities in schools are in other domains. For instance, it remains to be seen whether similar interactions hold for teachers' impacts on social and behavioral skills. Moreover, this large-scale research design does not reveal any of the nuanced mechanisms by which students experience assignment to a more effective teacher differently, beyond demonstrating that Black-White differences are not a function of pre-existing achievement. Rather, these results should be seen as a complement to qualitative work on how home advantages are enacted in school learning. In that context, these results point in the direction of focusing attention on the unique racial dimensions of these differences.

Despite these limitations, the current results demonstrate the importance of considering the potentially compounding or compensating impacts of learning opportunities at school. Two specific patterns within these results provide intriguing contributions to recent trends in our understanding of how schools contribute to educational inequality. First, findings highlight differences in school influences on economic and racial inequalities. Downey and Condron (2016) have recently proposed the metaphor of "refraction," emphasizing that different social disparities may be altered in distinct ways as students pass through school. Uniquely racial differences in the benefits of learning opportunities, differences not reflected between poor and non-poor students, offer a specific example. Because these differences persist when controlling for prior academic preparation, they seem to reflect disconnects between minority students' needs and the opportunities schools typically provide. Such compounding effects help to explain how school experiences may be less equalizing for racial gaps than class disparities (Downey et al. 2004).

A second notable pattern in these results is the tendency for teacher benefits to most compound racial and economic inequalities among low-achieving students. The troubling implication is that low-achieving students from socially disadvantaged groups are not only at risk of being exposed to lower quality learning opportunities, but also fewer benefits of these opportunities. Viewed through the lens of intersectionality, academically struggling poor and minority students find themselves in a particularly precarious position. It is not merely that these students struggle, but that they benefit the least from teachers with a record of classroom success.

Unfortunately, these analyses do not reveal exactly why this occurs, or conversely, what enables low-achieving non-poor and White students to see relatively large benefits of richer opportunities in school. But the descriptive results highlight the importance of improving the school experiences for students facing overlapping challenges.

Overall, the case of the school learning opportunities related to teachers suggests differential effects by social background are small relative to main effects. Access to high quality learning opportunities remains the first-order concern for educational equity. But the differential benefits observed highlight that equal opportunities in school can exacerbate some background inequalities, and may do more to contribute to gaps in learning throughout the year. Therefore, in addition to monitoring access to learning opportunities, we must also devote attention to how the impacts of these opportunities shape inequality.

Citations

Bacher-Hicks, Andrew, Thomas J. Kane, and Douglas O. Staiger. 2014. *Validating Teacher Effect Estimates Using Changes in Teacher Assignments in Los Angeles*. National Bureau of Economic Research. Retrieved May 28, 2015 (http://www.nber.org/papers/w20657).

Bergh, Linda van den, Eddie Denessen, Lisette Hornstra, Marinus Voeten, and Rob W. Holland. 2010. "The Implicit Prejudiced Attitudes of Teachers Relations to Teacher Expectations and the Ethnic Achievement Gap." *American Educational Research Journal* 47(2):497–527.

Boyd, D., H. Lankford, S. Loeb, M. Ronfeldt, and J. Wyckoff. 2010. "The Role of Teacher Quality in Retention and Hiring: Using Applications to Transfer to Uncover Preferences of Teachers and Schools." *Journal of Policy Analysis and Management* 30(1):88–110.

Calarco, Jessica McCrory. 2014a. "Coached for the Classroom Parents' Cultural Transmission and Children's Reproduction of Educational Inequalities." *American Sociological Review* 79(5):1015–37.

Calarco, Jessica McCrory. 2014b. "The Inconsistent Curriculum Cultural Tool Kits and Student Interpretations of Ambiguous Expectations." *Social Psychology Quarterly* 77(2):185–209.

Carroll, John B. 1963. "A Model of School Learning." *Teachers College Record* 64(8).

Chetty, Raj, John N. Friedman, and Jonah E. Rockoff. 2014. "Measuring the Impacts of Teachers I: Evaluating Bias in Teacher Value-Added Estimates." *American Economic Review* 104(9):2593–2632.

Clotfelter, C. T., H. F. Ladd, and J. Vigdor. 2005. "Who Teaches Whom? Race and the Distribution of Novice Teachers." *Economics of Education Review* 24(4):377–92.

Clotfelter, Charles T., Helen F. Ladd, and Jacob L. Vigdor. 2006. "Teacher-Student Matching and the Assessment of Teacher Effectiveness." *Journal of Human Resources* 41(4):778–820.

Coleman, James S. et al. 1966. *Equality of Educational Opportunity*. Washington, DC: U.S. Government Printing Office.

Condie, Scott, Lars Lefgren, and David Sims. 2014. "Teacher Heterogeneity, Value-Added and Education Policy." *Economics of Education Review* 40(0):76–92.

Condron, Dennis J. 2009. "Social Class, School and Non-School Environments, and Black/White Inequalities in Children's Learning." *American Sociological Review* 74(5):683–708.

Condron, Dennis J. and Vincent J. Roscigno. 2003. "Disparities Within: Unequal Spending and Achievement in an Urban School District." *Sociology of Education* 76(1):18–36.

Covay Minor, Elizabeth, Laura M. Desimone, Kristie J. R. Phillips, and Kailey Spencer. 2015. "A New Look at the Opportunity-to-Learn Gap across Race and Income." *American Journal of Education* 121(2):241–69.

Crosnoe, Robert et al. 2010. "Instruction, Teacher-Student Relations, and Math Achievement Trajectories in Elementary School." *Journal of Educational Psychology* 102(2):407–17.

Cunha, Flavio and James Heckman. 2007. "The Technology of Skill Formation." *American Economic Review* 97(2):31–47.

Dee, Thomas S. 2004. "Teachers, Race, and Student Achievement in a Randomized Experiment." *Review of Economics and Statistics* 86(1):195–210.

Downey, Douglas B. and Dennis J. Condron. 2016. "Fifty Years since the Coleman Report Rethinking the Relationship between Schools and Inequality." *Sociology of Education* 89(3):207–20.

Downey, Douglas B., Paul T. von Hippel, and Beckett A. Broh. 2004. "Are Schools the Great Equalizer? Cognitive Inequality During the Summer Months and the School Year." *American Sociological Review* 69(5):613–35.

Downey, Douglas B. and Shana Pribesh. 2004. "When Race Matters: Teachers' Evaluations of Students' Classroom Behavior." *Sociology of Education* 77(4):267–82.

Egalite, Anna J., Brian Kisida, and Marcus A. Winters. 2015. "Representation in the Classroom: The Effect of Own-Race Teachers on Student Achievement." *Economics of Education Review* 45:44–52.

Engel, Mimi, Amy Claessens, and Maida A. Finch. 2013. "Teaching Students What They Already Know? The (Mis)Alignment Between Mathematics Instructional Content and Student Knowledge in Kindergarten." *Educational Evaluation and Policy Analysis* 35(2):157–78.

Everson, Kimberlee C. 2017. "Value-Added Modeling and Educational Accountability: Are We Answering the Real Questions?" *Review of Educational Research* 87(1):35–70.

Fitzpatrick, Maria D., David Grissmer, and Sarah Hastedt. 2011. "What a Difference a Day Makes: Estimating Daily Learning Gains during Kindergarten and First Grade Using a Natural Experiment." *Economics of Education Review* 30(2):269–79.

Fox, Lindsay. 2015. "Playing to Teachers' Strengths: Using Multiple Measures of Teacher Effectiveness to Improve Teacher Assignments." *Education Finance and Policy* 11(1):70–96.

Fryer, Roland G. and Steven D. Levitt. 2004. "Understanding the Black-White Test Score Gap in the First Two Years of School." *Review of Economics and Statistics* 86(2):447–64.

Gaddis, S. Michael. 2013. “The Influence of Habitus in the Relationship between Cultural Capital and Academic Achievement.” *Social Science Research* 42(1):1–13.

Gamoran, Adam. 1987. “The Stratification of High School Learning Opportunities.” *Sociology of Education* 60(3):135–55.

Gamoran, Adam, Martin Nystrand, and Mark Berends. 1995. “An Organizational Analysis of the Effects of Ability Grouping.” *American Educational Research Journal* 32:687–715.

Gershenson, Seth, Stephen B. Holt, and Nicholas W. Papageorge. 2016. “Who Believes in Me? The Effect of Student–teacher Demographic Match on Teacher Expectations.” *Economics of Education Review* 52:209–24.

Glazerman, Steven, Ali Protik, Bing-ru Teh, Julie Bruch, and Jeffrey Max. 2013. “Transfer Incentives for High-Performing Teachers: Final Results from a Multisite Randomized Experiment. NCEE 2014-4003.” *National Center for Education Evaluation and Regional Assistance*. Retrieved June 1, 2015 (http://eric.ed.gov/?id=ED544269).

Goldhaber, Dan, Lesley Lavery, and Roddy Theobald. 2015. “Uneven Playing Field? Assessing the Teacher Quality Gap Between Advantaged and Disadvantaged Students.” *Educational Researcher* 44(5):293–307.

Guarino, Cassandra M., Mark D. Reckase, and Jeffrey M. Wooldridge. 2015. “Can Value-Added Measures of Teacher Performance Be Trusted?” *Education Finance and Policy* 10(1):117–56.

Hanushek, Eric A. and Steven G. Rivkin. 2010. “Generalizations about Using Value-Added Measures of Teacher Quality.” *American Economic Review* 100(2):267–71.

Horvat, Erin McNamara, Elliot B. Weininger, and Annette Lareau. 2003. “From Social Ties to Social Capital: Class Differences in the Relations Between Schools and Parent Networks.” *American Educational Research Journal* 40(2):319–51.

Irizarry, Yasmiyn. 2015. “Utilizing Multidimensional Measures of Race in Education Research The Case of Teacher Perceptions.” *Sociology of Race and Ethnicity* 1(4):564–83.

Irvine, Jacqueline Jordan. 1990. *Black Students and School Failure: Policies, Practices, and Prescriptions*. New York: Greenwood Press.

Isenberg, Eric et al. 2013. *Access to Effective Teaching for Disadvantaged Students*. Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Retrieved (http://ies.ed.gov/ncee/pubs/20144001/).

Isenberg, Eric et al. 2016. “Do Low-Income Students Have Equal Access to Effective Teachers? Evidence from 26 Districts (Final Report).” *Mathematica Policy Research*. Retrieved January 5, 2017 (https://www.mathematica-mpr.com/our-publications-and-findings/publications/do-low-income-students-have-equal-access-to-effective-teachers-evidence-from-26-districts).

Jennings, Jennifer L., David Deming, Christopher Jencks, Maya Lopuch, and Beth E. Schueler. 2015. “Do Differences in School Quality Matter More Than We Thought? New Evidence on Educational Opportunity in the Twenty-First Century.” *Sociology of Education* 88(1):56–82.

Jennings, Jennifer L. and Thomas A. DiPrete. 2010. “Teacher Effects on Social and Behavioral Skills in Early Elementary School.” *Sociology of Education* 83(2):135–59.

Kalogrides, Demetra, Susanna Loeb, and Tara Béteille. 2013. “Systematic Sorting: Teacher Characteristics and Class Assignments.” *Sociology of Education* 86(2):103–23.

Kane, Thomas J., Daniel F. McCaffrey, Trey Miller, and Douglas O. Staiger. 2013. *Have We Identified Effective Teachers? Validating Measures of Effective Teaching Using Random Assignment*. Bill and Melinda Gates Foundation. Retrieved (http://files.eric.ed.gov/fulltext/ED540959.pdf).

Kane, Thomas J. and Douglas O. Staiger. 2008. “Estimating Teacher Impacts on Student Achievement: An Experimental Evaluation.” *National Bureau of Economic Research Working Paper Series* No. 14607. Retrieved (http://www.nber.org/papers/w14607).

Kilgore, Susan B. and William W. Pendleton. 1993. “The Organizational Context of Learning: Framework for Understanding the Acquisition of Knowledge.” *Sociology of Education* 66(1):63–87.

Koedel, Cory, Kata Mihaly, and Jonah E. Rockoff. 2015. “Value-Added Modeling: A Review.” *Economics of Education Review* 47:180–95.

Konstantopoulos, Spyros. 2009. “Effects of Teachers on Minority and Disadvantaged Students’ Achievement in the Early Grades.” *The Elementary School Journal* 110(1):92–113.

Ladson-Billings, Gloria. 1995. “Toward a Theory of Culturally Relevant Pedagogy.” *American Educational Research Journal* 32(3):465–91.

Ladson-Billings, Gloria. 2006. “From the Achievement Gap to the Education Debt: Understanding Achievement in U.S. Schools.” *Educational Researcher* 35(7):3–12.

Lankford, H., S. Loeb, and J. Wyckoff. 2002. “Teacher Sorting and the Plight of Urban Schools: A Descriptive Analysis.” *Educational Evaluation and Policy Analysis* 24(1):37–62.

Lareau, Annette. 1989. *Home Advantage: Social Class and Parental Intervention in Elementary Education*. London; New York: Falmer Press.

Lareau, Annette and Erin McNamara Horvat. 1999. “Moments of Social Inclusion and Exclusion Race, Class, and Cultural Capital in Family-School Relationships.” *Sociology of Education* 72(1):37–53.

Lareau, Annette and Elliot B. Weininger. 2003. “Cultural Capital in Educational Research: A Critical Assessment.” *Theory and Society* 32:567–606.

Lauen, Douglas L. and Gary T. Henry. 2015. *The Distribution of Teachers in North Carolina, 2009-2013*. Consortium for Educational Research and Evaluation-North Carolina. Retrieved June 10, 2016 (http://cerenc.org/wp-content/uploads/2015/08/0-FINAL-Final-TQ-Distribution-report-8-6-15.pdf).

Lewis, Amanda E. and John B. Diamond. 2015. *Despite the Best Intentions: How Racial Inequality Thrives in Good Schools*. Oxford University Press.

Lucas, Samuel R. 2001. “Effectively Maintained Inequality: Education Transitions, Track Mobility, and Social Background Effects.” *American Journal of Sociology* 106(6):1642–90.

Lucas, Samuel R. and Mark Berends. 2007. “Race and Track Location in U.S. Public Schools.” *Research in Social Stratification and Mobility* 25(3):169–87.

Mansfield, Richard K. 2015. “Teacher Quality and Student Inequality.” *Journal of Labor Economics* 33(3):751–88.

McCaffrey, Daniel F., J. R. Lockwood, Daniel M. Koretz, and Laura S. Hamilton. 2003. *Evaluating Value-Added Models for Teacher Accountability. Monograph*. RAND Corporation. Retrieved (http://www.eric.ed.gov/ERICWebPortal/detail?accno=ED529961).

McKown, Clark and Rhona S. Weinstein. 2008. “Teacher Expectations, Classroom Context, and the Achievement Gap.” *Journal of School Psychology* 46(3):235–61.

Morris, Edward W. 2005. “‘Tuck in That Shirt!’ Race, Class, Gender, and Discipline in an Urban School.” *Sociological Perspectives* 48(1):25–48.

Nye, Barbara, Spyros Konstantopoulos, and Larry V. Hedges. 2004. “How Large Are Teacher Effects?” *Educational Evaluation and Policy Analysis* 26(3):237–57.

Penner, Emily K. 2016. “Teaching for All? Teach For America’s Effects Across the Distribution of Student Achievement.” *Journal of Research on Educational Effectiveness* 9(3):259–82.

Pianta, Robert C., Jay Belsky, Renate Houts, Fred Morrison, and The National Institute of Child Health and Human Development (NICHD) Early Child Care Research Network. 2007. “Opportunities to Learn in America’s Elementary Classrooms.” *Science* 315(5820):1795–96.

Raudenbush, Stephen W. 2004. “What Are Value-Added Models Estimating and What Does This Imply for Statistical Practice?” *Journal of Educational and Behavioral Statistics* 121–129.

Raudenbush, Stephen W. and Robert D. Eschmann. 2015. “Does Schooling Increase or Reduce Social Inequality?” *Annual Review of Sociology* 41(1):443–70.

Raudenbush, Stephen W. and J. Douglas Willms. 1995. “The Estimation of School Effects.” *Journal of Educational and Behavioral Statistics* 20(4):307–35.

Ready, Douglas D. and David L. Wright. 2011. “Accuracy and Inaccuracy in Teachers’ Perceptions of Young Children’s Cognitive Abilities: The Role of Child Background and Classroom Context.” *American Educational Research Journal* 48(2):335–60.

Reardon, Sean F. 2011. “The Widening Academic Achievement Gap Between the Rich and the Poor: New Evidence and Possible Explanations.” Pp. 90–115 in *Whither Opportunity? Rising Inequality, Schools, and Children’s Life Chances*, edited by G. J. Duncan and R. J. Murnane. New York: Russell Sage Foundation.

Reardon, Sean F. and Claudia Galindo. 2009. “The Hispanic-White Achievement Gap in Math and Reading in the Elementary Grades.” *American Educational Research Journal* 46(3):853–91.

Rivkin, Steven G., Eric A. Hanushek, and John F. Kain. 2005. “Teachers, Schools, and Academic Achievement.” *Econometrica* 73(2):417–58.

Robinson, Keith and Angel L. Harris. 2014. *The Broken Compass: Parental Involvement with Children’s Education*. Retrieved October 13, 2016 (http://site.ebrary.com/id/10823661).

Roscigno, Vincent J. and James W. Ainsworth. 1999. “Race, Cultural Capital, and Educational Resources: Persistent Inequalities and Achievement Returns.” *Sociology of Education* 72(3):158–78.

Rothstein, J. 2010. “Teacher Quality in Educational Production: Tracking, Decay, and Student Achievement.” *Quarterly Journal of Economics* 125(1):175–214.

Sorensen, Aage. 1970. “Organizational Differentiation Of Students And Educational Opportunity.” *Sociology of Education* 43(4):355–76.

Sorensen, Aage B. 1989. “Schools and the Distribution of Educational Opportunities.” *Research in the Sociology of Education and Socialization* 8:3–26.

Sorensen, Aage B. and Maureen T. Hallinan. 1977. “Reconceptualization of School Effects.” *Sociology of Education* 50(4):273–89.

Stanovich, Keith E. 1986. “Matthew Effects in Reading: Some Consequences of Individual Differences in the Acquisition of Literacy.” *Reading Research Quarterly* 21(4):360–407.

Tach, Laura Marie and George Farkas. 2006. “Learning-Related Behaviors, Cognitive Skills, and Ability Grouping When Schooling Begins.” *Social Science Research* 35(4):1048–79.

Valenzuela, Angela. 1999. *Subtractive Schooling: U.S.-Mexican Youth and the Politics of Caring*. Albany: State University of New York Press.

Wang, Jia. 1998. “Opportunity to Learn: The Impacts and Policy Implications.” *Educational Evaluation and Policy Analysis* 20(3):137–56.

Tables and Figures

Table 1. Estimates of Interactions between Teacher Effectiveness, Economic Background, and Prior Achievement as Predictors of Mathematics Achievement

	Mathematics			Reading		
	(1)	(2)	(3)	(4)	(5)	(6)
Teacher Effectiveness (TE)	0.130*	0.132*	0.135*	0.057*	0.059*	0.061*
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)
EDS	-0.064*	-0.064*	-0.065*	-0.078*	-0.078*	-0.079*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
EDS * TE	0.001	-0.002	-0.002	-0.001	-0.005*	-0.006*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
TE * Prior Achievement(a)		-0.005*	-0.015*		-0.005*	-0.011*
		(0.001)	(0.001)		(0.001)	(0.001)
EDS * TE * Prior Achievement			0.019*			0.010*
			(0.002)			(0.002)
Prior Achievement	0.663*	0.663*	0.666*	0.608*	0.608*	0.602*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
EDS * Prior Achievement			-0.004*			0.012*
			(0.002)			(0.002)

* p<.05

(a) Prior Achievement reflects same-subject standardized test score in the previous year.

EDS = Economically Disadvantaged

Note: The outcome variable is achievement, standardized to have a mean of 0 and standard deviation of 1 within grade and year. Standard errors, displayed in parentheses, are adjusted for clustering within schools. All models also control for student characteristics measured in the prior year (gender, race/ethnicity, economic disadvantage, Limited English Proficiency, gifted designation, retained, achievement in the alternate subject), classroom aggregate characteristics (proportion nonwhite, proportion economically disadvantaged, and mean prior achievement in mathematics and reading), and grade-by-year fixed effects.

Table 2. Estimates of Interactions between Teacher Effectiveness, Racial Background, and Prior Achievement as Predictors of Mathematics Achievement

	Mathematics			Reading		
	(1)	(2)	(3)	(4)	(5)	(6)
Teacher Effectiveness (TE)	0.134*	0.136*	0.137*	0.059*	0.061*	0.062*
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)
Black	-0.068*	-0.068*	-0.071*	-0.068*	-0.068*	-0.068*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Black * TE	-0.008*	-0.013*	-0.009*	-0.005*	-0.010*	-0.009*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Black * Prior Achievement(a)			-0.007*			0.002
			(0.002)			(0.002)
Black * TE * Prior Achievement			0.018*			0.009*
			(0.002)			(0.002)
Hispanic	0.053*	0.053*	0.053*	0.003	0.003	0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Hispanic * TE	-0.002	-0.005*	-0.006*	-0.008*	-0.013*	-0.011*
	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)
Hispanic * Prior Achievement			-0.000			0.007*
			(0.002)			(0.003)
Hispanic * TE * Prior Achievement			0.010*			0.010*
			(0.002)			(0.002)
Mathematics Prior Achievement	0.663*	0.663*	0.665*	0.608*	0.608*	0.607*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Teacher Effectiveness * Prior Achievement		-0.006*	-0.012*		-0.006*	-0.010*
		(0.001)	(0.001)		(0.001)	(0.001)

* p<.05

(a) Prior Achievement reflects same-subject standardized test score in the previous year.

Note: The outcome variable is achievement, standardized to have a mean of 0 and standard deviation of 1 within grade and year. Standard errors, displayed in parentheses, are adjusted for clustering within schools. All models also control for student characteristics measured in the prior year (gender, race/ethnicity, economic disadvantage, Limited English Proficiency, gifted designation, retained, achievement in the alternate subject), classroom aggregate characteristics (proportion nonwhite, proportion economically disadvantaged, and mean prior achievement in mathematics and reading), and grade-by-year fixed effects.

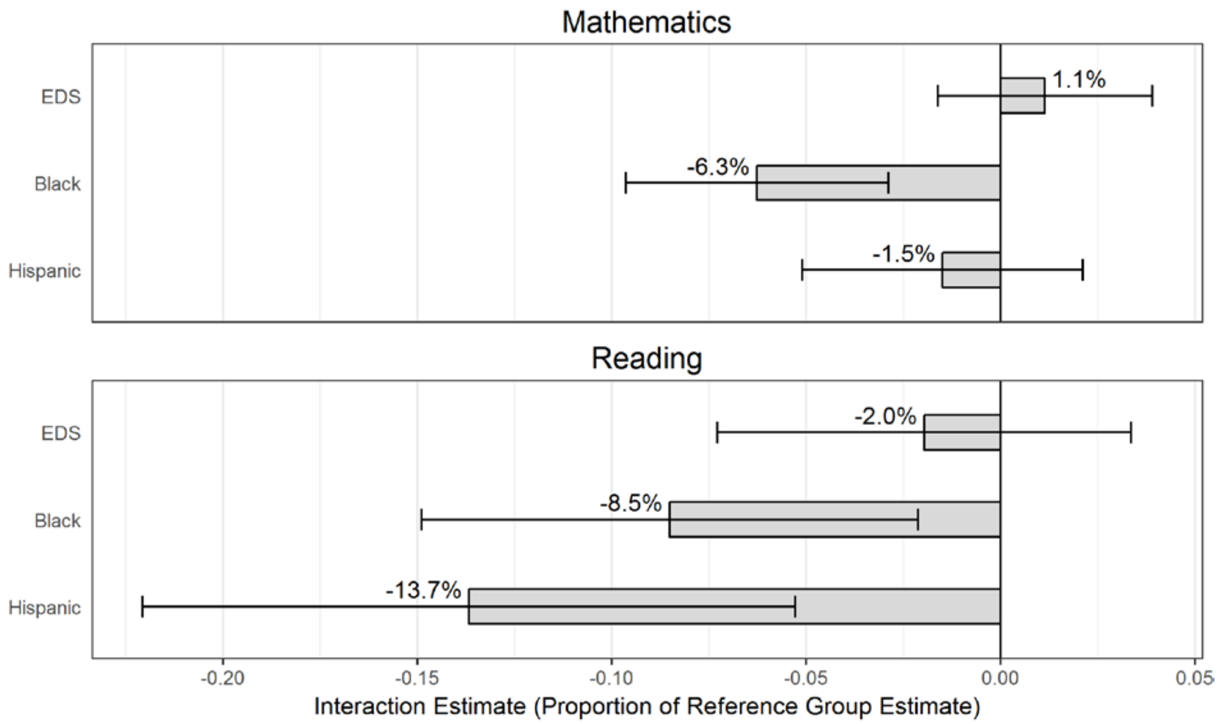
Table 3. Implied Contributions to Achievement Gaps

	Mathematics			Reading		
	EDS	Black	Hispanic	EDS	Black	Hispanic
Raw Achievement Difference	0.731	0.792	0.536	-0.763	-0.760	-0.717
Conditional Achievement Difference	0.150	0.147	0.067	-0.183	-0.179	-0.132
Contribution to Gaps						
Differential Exposure to TE	0.006	-0.001	0.003	0.002	-0.003	-0.002
% Raw Gap	*3.8*	*0.1*	*0.6*	*0.3*	*-0.4*	*-0.3*
% Cond. Gap	*0.8*	*0.7*	*4.8*	*1.2*	*-1.7*	*-1.6*
Differential TE Slope	-0.003	0.0170	0.0040	0.002	0.0102	0.016
% Raw Gap	*-0.4*	*2.1*	*0.7*	*0.3*	*1.3*	*2.3*
% Cond. Gap	*-2.0*	*11.5*	*5.9*	*1.2*	*5.7*	*12.4*
Differential TE Exposure and Slope	-0.003	0.0159	0.0073	0.0037	0.0069	0.0139
% Raw Gap	*-0.4*	*2.1*	*0.7*	*0.3*	*1.3*	*1.6*
% Cond. Gap	*-2.0*	*11.5*	*5.9*	*1.2*	*5.7*	*12.4*

EDS = Economically Disadvantaged; TE = Teacher Effectiveness

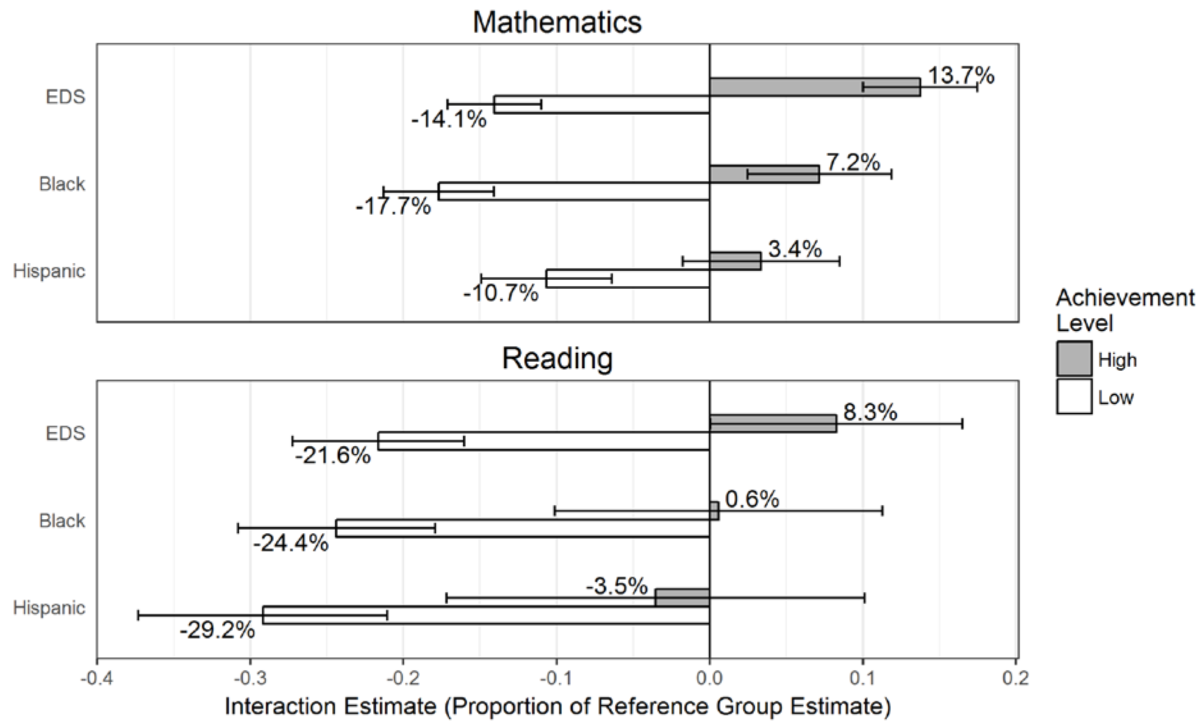
Notes: For achievement differences, the reference group for economically disadvantaged students is non-economically disadvantaged; and the reference group for Black and Hispanic students is White students. Achievement differences are in standardized units (standard deviation of 1 within grades and years). The conditional achievement difference is the gap controlling for achievement in the prior year. See supplementary materials for details of the calculations of the contribution to differences.

Figure 1. Estimated Interactions between Social Background and Assignment to a More Effective Teacher on Achievement



EDS = Economically disadvantaged
Notes: Estimates based on the Models 1 and 4 reported in Tables 1 and 2. Percentages report the size of the estimated interaction between teacher effectiveness and background as a share of the reference group (Non-economically disadvantaged students or White) teacher effectiveness effect. Error bars show the 95% confidence intervals for each ratio accounting for uncertainty in the numerator and denominator.

Figure 2. Estimated Interactions between Social Background and Assignment to a More Effective Teacher on Achievement High-and Low-Achieving Students



EDS = Economically disadvantaged

Notes: High (Low) Achievement = 1 standard deviation above (below) the mean. Estimates based on the Models 3 and 6 in Tables 1 and 2. Percentages report the size of the estimated interaction between teacher effectiveness and background as a share of the reference group (Non-economically disadvantaged students or White) teacher effectiveness effect. Error bars show the 95% confidence intervals for each ratio accounting for uncertainty in the numerator and denominator.

Appendix

Table A1. Characteristics for Main Analytic and Alternate Samples

		Mathematics				Reading			
	All	Main	EN	BW	BA	Main	EN	BW	BA
Students	1981463	1572936	1290820	820743	254460	1537673	1256127	794971	216375
Proportion of all Students	1	0.794	0.651	0.414	0.128	0.776	0.634	0.401	0.109
Schools	1976	1580	1543	1315	299	1559	1522	1295	274
Districts	219	210	192	164	99	209	192	167	107
Female	0.490	0.494	0.494	0.494	0.493	0.494	0.494	0.495	0.494
American Indian	0.015	0.014	0.014	0.011	0.013	0.014	0.014	0.011	0.013
Asian	0.025	0.024	0.023	0.025	0.028	0.025	0.023	0.025	0.028
Black	0.266	0.256	0.237	0.302	0.281	0.256	0.237	0.300	0.273
Hispanic	0.122	0.122	0.116	0.123	0.122	0.122	0.116	0.123	0.119
White	0.532	0.545	0.570	0.496	0.518	0.544	0.571	0.496	0.529
Multiracial	0.040	0.039	0.040	0.043	0.038	0.039	0.040	0.044	0.038
Economically Disadvantaged	0.516	0.518	0.510	0.525	0.549	0.516	0.507	0.522	0.545
Mathematics Achievement	0.000	0.025	0.037	0.004	0.019	0.027	0.038	0.005	0.006
Standard Deviation	1.000	0.991	0.978	0.991	0.998	0.991	0.977	0.991	0.990
Reading Achievement	0.000	0.018	0.031	0.000	-0.004	0.023	0.037	0.007	-0.005
Standard Deviation	1.000	0.993	0.979	0.989	0.998	0.992	0.977	0.987	0.991
Teachers		17868	12259	7034	3435	17958	12274	7005	3042
Years of Experience		11.3	11.6	11.6	11.4	11.3	11.6	11.7	11.2
Standard Deviation		8.6	8.5	8.5	8.8	8.7	8.6	8.7	8.7
At least 2 Years Experience		0.857	0.876	0.879	0.853	0.857	0.875	0.879	0.845
Mean Effectiveness		0.011	0.026	0.025	0.064	0.002	0.003	0.019	0.038
Standard Deviation		0.981	0.953	0.938	0.980	0.962	0.911	0.880	0.983
Mean Reliability		0.910	0.925	0.934	0.908	0.813	0.837	0.856	0.806
Standard Deviation		0.070	0.057	0.049	0.070	0.123	0.107	0.094	0.125

All = All students; Main = Analytic sample reported in text; EN Subsample of teachers with at least 10 poor and nonpoor students; BW = Subsample of teachers with at least 10 Black and White students; BA = “Balanced Assignment” schools in which prior achievement is not predictive of classroom placement within grade-years cells.

Table A2. Teacher Effectiveness Gaps by Economic and Racial Background for Alternate Measures of Teacher Effectiveness

	Mathematics			Reading		
Teacher Effectiveness Specification	EDS	BW	HW	EDS	BW	HW
All Controls	-0.042*	0.007	-0.025	-0.025*	0.056*	0.042*
	(0.010)	(0.014)	(0.015)	(0.009)	(0.013)	(0.012)
Individual Controls Only	-0.100*	-0.058*	-0.051*	-0.174*	-0.100*	-0.113*
	(0.011)	(0.015)	(0.015)	(0.011)	(0.015)	(0.014)
Prior Achievement Only	-0.180*	-0.167*	-0.104*	-0.308*	-0.282*	-0.276*
	(0.012)	(0.015)	(0.015)	(0.013)	(0.016)	(0.017)

* $p < 0.05$
EDS = Economically disadvantaged student (versus not); BW = Black (versus White); HW = Hispanic (versus White)
Note: Estimates reflected difference in teacher effectiveness for students from different groups. As in the main text, teacher effectiveness estimates have been standardized to have a mean of 0 and standard deviation of 1 in the population of teachers. Standard errors, displayed in parentheses, are adjusted for clustering within schools.

Table A3. Teacher Effectiveness-Social Background Interaction Estimates for Alternate Effectiveness Measure Specifications

	EDS		Black-White		Hispanic-White	
	Est	SE	Est	SE	Est	SE
Mathematics						
Main(a)	0.011	0.014	-0.063	0.017	-0.015	0.018
Alternate Effectiveness Covariates						
Individual Controls Only	0.005	0.013	-0.063	0.017	-0.018	0.018
Prior Achievement Only	-0.003	0.013	-0.053	0.018	-0.024	0.017
Subgroup Specific Effectiveness						
Teachers of Poor and Non-poor Students	0.033	0.014				
Background-specific TE	0.014	0.016				
Teachers of Black and White Students			-0.045	0.018		
Race-specific TE			-0.143	0.020		
Reading						
Main(b)	-0.020	0.027	-0.085	0.033	-0.137	0.043
Alternate Effectiveness Covariates						
Individual Controls Only	-0.034	0.025	-0.095	0.031	-0.141	0.040
Prior Achievement Only	-0.039	0.025	-0.100	0.030	-0.143	0.039
Subgroup Specific Effectiveness						
Teachers of Poor and Non-poor Students	0.008	0.028				
Background-specific TE	0.039	0.043				
Teachers of Black and White Students			-0.080	0.036		
Race-specific TE			-0.272	0.043		

EDS = Economically disadvantaged student (versus not); TE = Teacher effectiveness
Note: All interaction estimates reported as a proportion of the estimated benefit for the reference group (non-economically disadvantaged or White).
(a) Estimates correspond to Model 1 in Tables 1 and 2 (and Figure 1) of the main text.
(b) Estimates correspond to Model 4 in Tables 1 and 2 (and Figure 1) in the main text.
Est = Estimated interaction with teacher effectiveness, expressed as proportion of estimated benefit for advantaged group; SE = Standard Error, accounting for uncertainty in numerator and denominator (adjusted for clustering of observations within schools).

Table A4. Teacher Effectiveness-Social Background Interaction Estimates for Alternate Outcome Model Specifications

	EDS		Black-White		Hispanic-White	
	Est	SE	Est	SE	Est	SE
Mathematics						
Main(a)	0.011	0.014	-0.063	0.017	-0.015	0.018
School Fixed Effects	0.024	0.016	-0.049	0.021	-0.002	0.021
Alternate Covariates						
Achievement Only(c)	0.024	0.013	-0.058	0.015	-0.020	0.016
Individual Characteristics Only(c)	0.010	0.014	-0.065	0.017	-0.016	0.018
With Teacher Judgments (d)	0.010	0.014	-0.063	0.018	-0.009	0.018
With Classroom-TE Interactions (d)	0.018	0.014	-0.053	0.017	-0.002	0.018
Schools with Balanced Classroom Assignments						
Balanced Assignments Subsample	0.066	0.039	-0.064	0.045	0.046	0.045
Effectiveness Based Only on Subsample	0.070	0.037	-0.047	0.047	0.069	0.045
Reading						
Main(a)	-0.020	0.027	-0.085	0.033	-0.137	0.042
School Fixed Effects	-0.017	0.035	-0.091	0.042	-0.156	0.057
Alternate Covariates						
Achievement Only(c)	-0.017	0.026	-0.084	0.027	-0.152	0.038
Individual Characteristics Only(c)	-0.031	0.026	-0.097	0.032	-0.144	0.041
With Teacher Judgments (d)	-0.052	0.026	-0.111	0.031	-0.141	0.04
With Classroom-TE Interactions (d)	-0.015	0.027	-0.078	0.033	-0.126	0.043
Schools with Balanced Classroom Assignments						
Balanced on Ach. And Demographics	-0.024	0.065	-0.128	0.083	-0.005	0.096
Measures Based Only on Subsample	-0.032	0.064	-0.132	0.086	-0.043	0.097

EDS = Economically disadvantaged student (versus not); TE = Teacher effectiveness

Note: All interaction estimates reported as a proportion of the estimated benefit for the reference group (non-economically disadvantaged or White).

(a) Estimates correspond to Model 1 in Tables 1 and 2 (and Figure 1) of the main text.

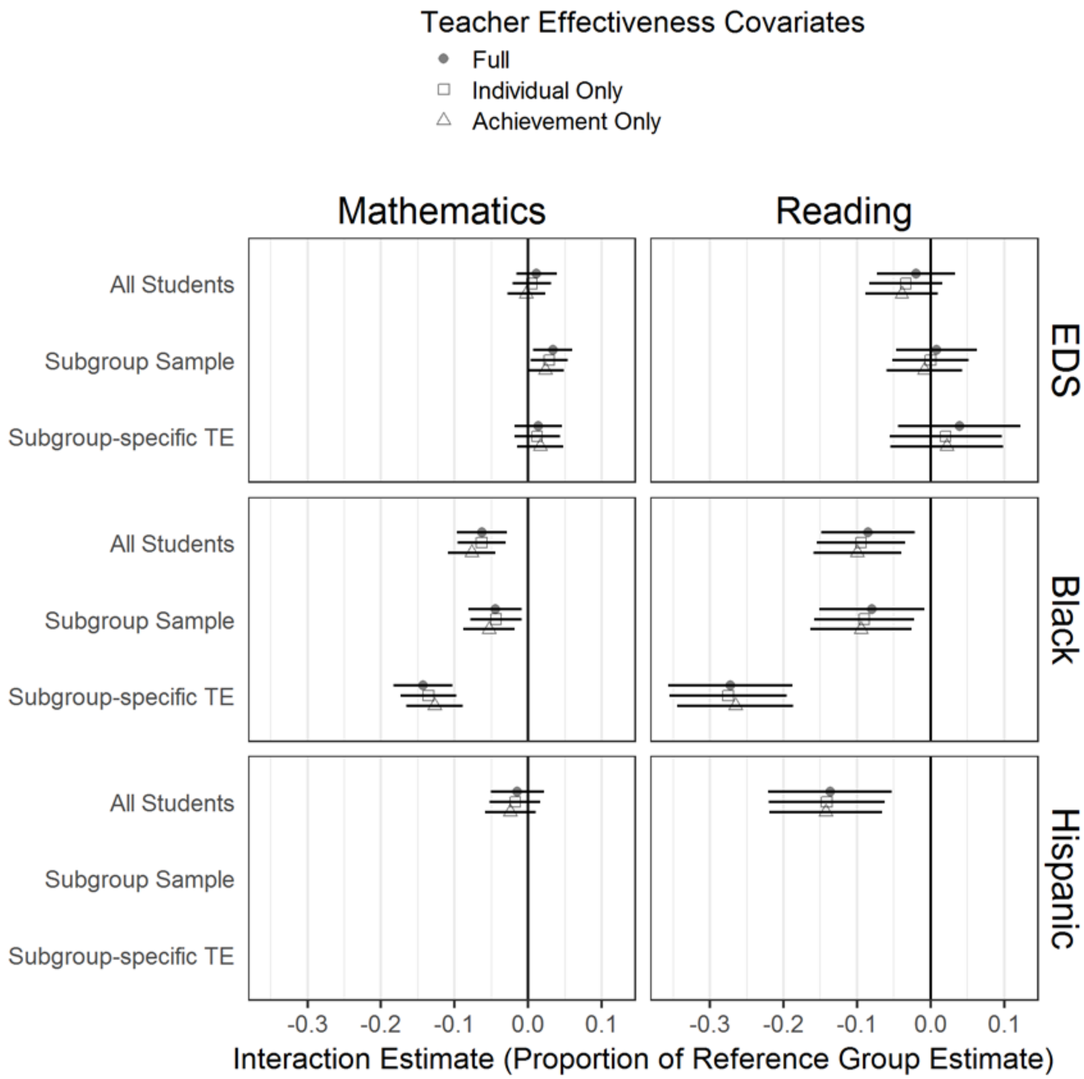
(b) Estimates correspond to Model 4 in Tables 1 and 2 (and Figure 1) in the main text.

(c) Covariates removed from the primary specification.

(d) Covariates added to the primary specification.

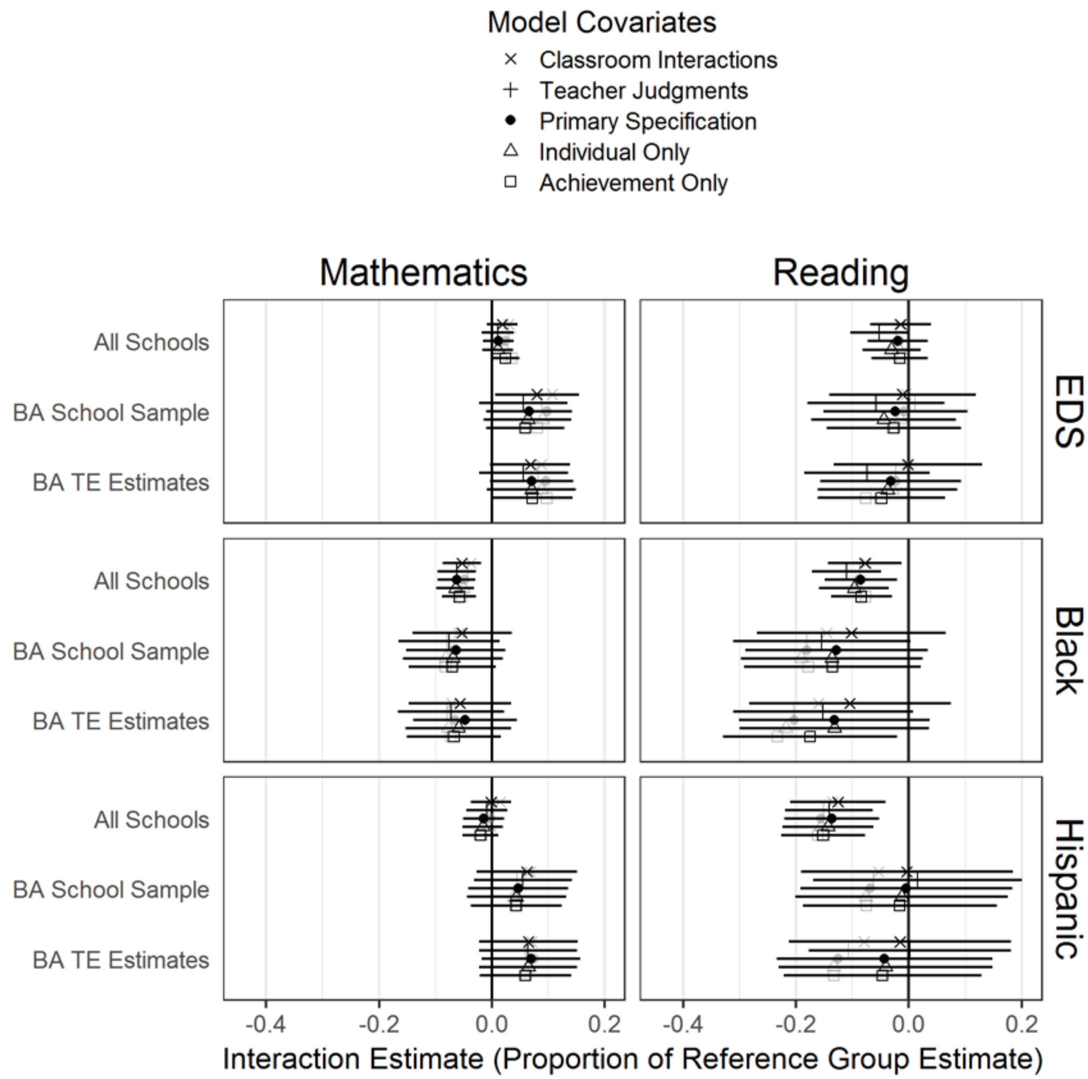
Est = Estimated interaction with teacher effectiveness, expressed as proportion of estimated benefit for advantaged group; SE = Standard Error, accounting for uncertainty in numerator and denominator (adjusted for clustering of observations within schools).

Figure A1. Interaction Estimates for Alternate Teacher Effectiveness Measure Specifications



EDS = Economically disadvantaged student; TE = Teacher effectiveness
Notes: "Full" covariates with the "All Students" sample correspond to the main specification reported in Models 1 and 4 of Tables 1 and 2. "Subgroup Sample" includes all teachers observed with at least 10 students in the focal and reference group in other years. "Subgroup-specific TE" employs teachers effectiveness measures calculated separately within group (among the subgroup sample of teachers). "Ind. Only" covariates omit classroom and school aggregate characteristics. "Ach. Only" covariates additionally omit all individual characteristics except for prior achievement.

Figure A2. Interaction Estimates for Alternate Model Specifications



BA = Balanced assignment; TE = Teacher Effectiveness
Note: Black (gray) shapes represent estimates without (with) school fixed effects. The "Primary Specification" covariates with the "All Schools" sample correspond to the main specification reported in Models 1 and 4 of Tables 1 and 2. The "BA School Sample" limits to schools with balanced classroom assignments in terms of prior achievement, race/ethnicity, and economic disadvantage. The "BA TE Estimates" calculates teacher effectiveness solely within this subsample. Covariate specifications alter the control variables of the model in Equation 2 of the text: "Individual Only" omits classroom characteristics, "Achievement Only" additionally omits all covariates except prior achievement, "Teacher Judgements" add to the primary specification indicators of previous teachers' judgment of students' academic proficiency, adn "Classroom Interactions" add to the primary specification interactions between teacher effectiveness and classroom aggregate characteristics.

Supplement.

Explanation of Calculation of Portion of Social Background Gaps due to Teacher Effectiveness Benefits

Calculations of the implications of teacher effectiveness are based on the primary outcome models (Equation 2 in the text; estimated reported in Models 1 and 4 of Tables 1 and 2). These interaction models specify distinct linear relationships between the teacher effectiveness of a students' teacher and academic outcome for different student groups. Based on these relationships, we can make predictions about mean group achievement under different allocation of teacher effectiveness or different benefits of effectiveness. Taking Black (B) students as an example, holding all other control variables at their reference points (mean prior achievement, etc.), expected achievement is given by:

$$\bar{Y}_B = intercept_B + slope_B(\overline{TE}_B) \quad \text{(A: observed)}$$

The intercept is a function of the overall model intercept and the main effect for Black students ($\hat{\beta}_2$ in Equation 2); the slope is the sum of the main effectiveness estimate and the background interaction ($\hat{\beta}_1 + \hat{\beta}_3$). To calculate achievement under a scenario with equal exposure to teacher effectiveness between groups, we can substitute the mean teacher effectiveness for White (W) students:

$$\bar{Y}_B = intercept_B + slope_B(\overline{TE}_W) \quad \text{(B: equal exposure)}$$

The difference between this scenario and observed can be interpreted as the influence of differential exposure.

Using a comparable procedure, we can calculate mean achievement under the hypothetical scenario that Black students experience the teacher effectiveness slope as White students.

$$\bar{Y}_B = intercept'_B + slope_W(\overline{TE}_B) \quad \text{(C: equal slopes)}$$

Here we must also specify the value of the shifted intercept in the hypothetical "equal slopes" scenario. If the effectiveness values exhibited ratio properties with a meaningful value of 0, we could constrain achievement in the hypothetical scenario to be equal to observed at this point. In the absence of a meaningful 0, I make the assumption that the equal slopes and observed expectations would be similar at -2 standard deviations, representing an especially ineffective teacher. This implies that the shifted intercept is $intercept_B + 2(slope_W - slope_B)$.

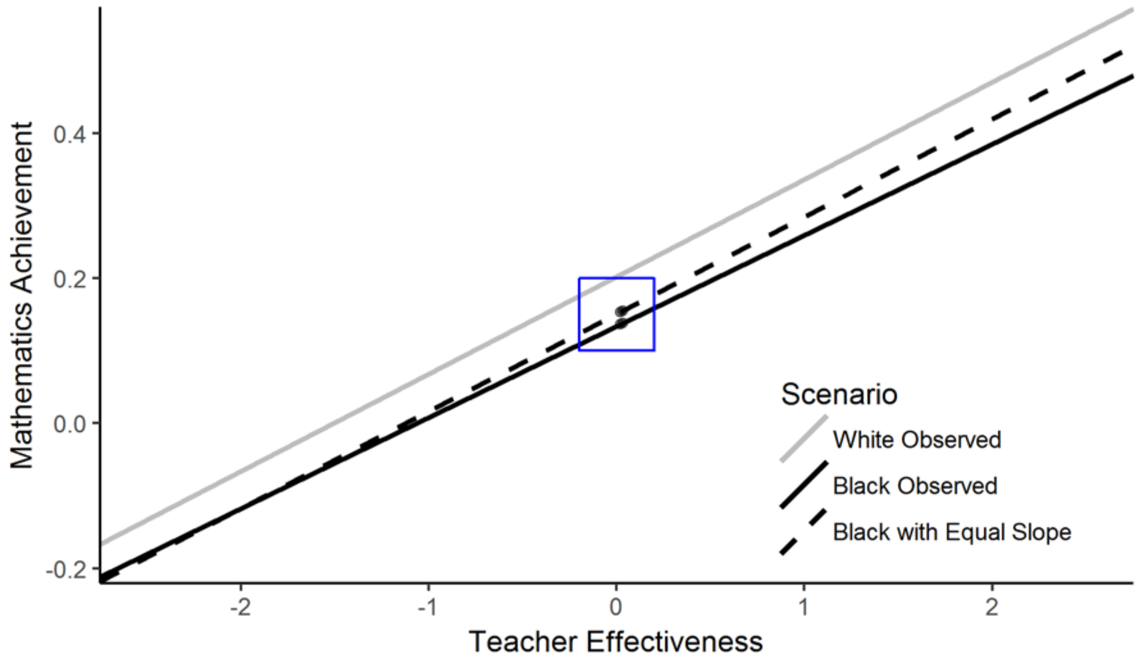
Finally, a scenario with both equal exposure and equal slopes is given by:

$$\bar{Y}_B = intercept'_B + slope_W(\overline{TE}_W) \quad \text{(D: equal exposure and slopes)}$$

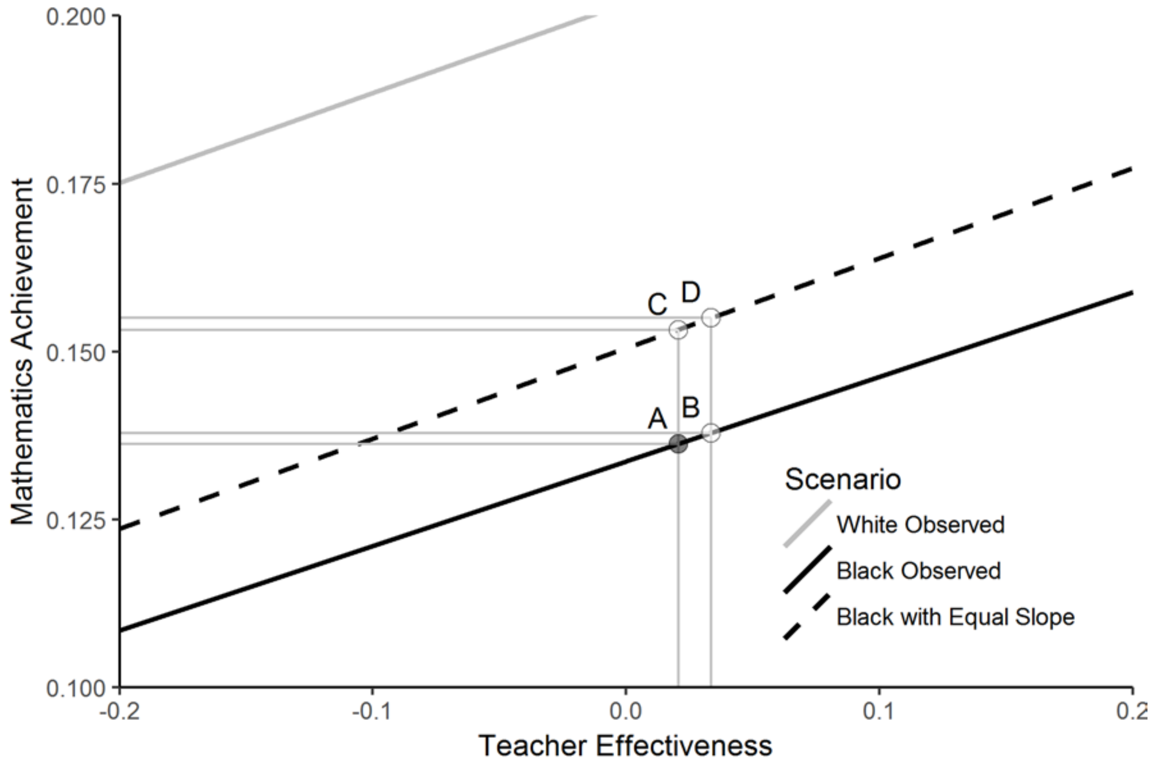
The difference between point (A) and this implied mean achievement to (A) r is a measure of the joint influence of differential teacher access and benefits.

Figure S1 demonstrates these values graphically for the case of Black and White students in Mathematics, and Panel B provides detail on the four key values (A-D) described here.

Figure S1. Expected Achievement by Teacher Effectiveness
A. Overall with Detail Section Highlighted



B. Detail for Mean Effectiveness



Note: Points A-D are explained in the supplemental text. A and C are placed at the level of mean teacher effectiveness for Black students. B and D are placed at the level of mean teacher effectiveness for White students.