**Achievement Gains and Social Inequality:
An Analysis of Brazilian School Districts, 2007-2017**

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An enduring unresolved issue in education is whether schools and school districts are more effective in raising student achievement when students are "segregated" into schools and classrooms that are more homogeneous socially and academically or when students learn in schools and classrooms that are more heterogeneous (Trevino et al, 2016; Gamoran and Nystrand, 1994); Willms, 2010)

In an important sense, the degree of social class or racial segregation is not an educational decision, but the structural product of the social, economic and political history of nations and national sub-regions. Countries characterized by greater social class (income) inequality are more likely to cluster their students into schools according to social class (Chiu and Khoo, 2005). Yet, even in more socially equal and unequal countries, there is considerable variation in school social class segregation (OECD, PISA, 2013, Volume 2, Part 5).

Social class or ethnic/racial segregation in and of itself may have socio-political implications for societies. Nevertheless, the more important educational issue may be whether such segregation involves unequal allocation of educational resources to different social class/ethnic groups, thereby unequally impacting their educational and social mobility opportunities.

It is difficult to separate the school segregation/classroom tracking issue from the unequal resources issue, since in most countries, states, provinces, and school districts whose students are lower social class or disadvantaged minority, or both, tend to spend less on them than do school districts with higher social class students. This usually translates into "better" teachers teaching in better resourced districts and has complicated estimates of teacher effects on student outcomes since the 1960s (Coleman et al, 1966). Even if lower-income districts/schools spend the same or somewhat more on their students, the conditions of work in these schools and districts are such that they tend to attract less qualified teachers and other personnel (Loeb and Page, 2000; Gamoran, 2010). Classroom tracking in the same school likely also results in unequal allocation of teacher quality (Gamoran, 2010).[1] Thus, in general (with exceptions) the research suggests that greater social class segregation in schools or greater ability/socio-economic classroom tracking within schools *tends to increase inequality of achievement gains* (see also Hanushek and Woessmann, 2006, using PIRLS and PISA data; Huang, 2009, using TIMSS data).

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[1] "Empirically it appears that instructional variation across tracks and groups at different levels is the more prominent reason for increases in achievement' gaps between tracks. A number of studies have concluded that students in high tracks encounter more challenging curricula, move at a faster pace, and are taught by more experienced teachers with better reputations, while students in low tracks encounter more fragmented, worksheet-oriented, and slower paced instruction provided by teachers with less experience or clout (Gamoran, 2010, p. 217)"

It is possible that even if social class grouping of students between or within schools results in greater inequality of achievement outcomes (Owens, 2018), such grouping may result in increased *average educational productivity* (higher achievement gains over time) in both low-income and high-income schools and for both low-achievement and high-achievement differentiated classrooms. More socially homogeneous schools, for example, could allow teachers and principals to focus on the most effective means of increasing achievement for these groups of students, therefore better engaging students and increasing their achievement levels more rapidly than in highly diverse, academically and socially heterogeneous schools. Inequality between higher and lower social class students could increase with greater social class segregated schools and classrooms, but the achievement levels of both groups could increase more than in more heterogeneous groupings.

To the contrary, it may be that peer effects from being in a lower social class/lower ability or higher social class/higher ability classroom or school and their concomitant impact on opportunity to learn might so negatively influence student learning in lower social class schools that negative peer effects overcome any positive educational productivity effects of homogeneous grouping. On net, then, it is also possible that homogeneous grouping results in overall neutral or even negative mean achievement increases for the student population overall.

In this study, we analyze these issues in an economically and socially unequal large developing country—Brazil. We examine gains in math and Portuguese test scores across school districts (municipalities) over a ten-year period—2007-2017. Specifically, we estimate whether such gains were larger or smaller in those districts where there was less initial (in 2007) social class segregation among schools in the district (variance in the average social class of students in schools) and where there were smaller *increases* in social class segregation among schools during that decade. We examine this relationship at the end of two levels of schooling, elementary and middle school (5^{th} and 9^{th} grade).

Thanks to recently developed data sets in the United States (Reardon et al, 2019), there is nascent research on learning gains across school districts in the U.S., focusing largely on explaining black-white and social class differences in test score gains due to differences in school resources across districts (Matheny et al, 2020). Brazil provides similarly rich data for delving into the relation between learning gains across school districts and how students are distributed across schools within those districts. The Brazilian educational statistics agency—the *Instituto Nacional de Estudos e Pesquisas Educacionais Anisio Texeira* (INEP)—surveys and tests essentially all public-school students in the 5^{th} and 9^{th} grade every two years. The name of this test is the *Prova Brasil,* and its results are comparable from test year to test year.

The Brazilian Education System

The Brazilian educational system is formally decentralized under the most recent Constitution of 1988, with states and municipalities exercising considerable control over educational policies regarding schools under their jurisdiction. There are 27 states and more than 5,000 municipalities in Brazil. Municipalities in every state are designated as the administrators of elementary schools. Municipalities and states administer middle schools in two separate school systems, so that throughout the country, many municipalities have both state and municipal-run middle schools present in the municipality. The proportion of middle schools under state jurisdiction varies from state to state, with some states, such as those in the Northeast region, in charge of only a small percentage of middle schools, and other states, such as those in the Amazon region and in the South, where the state administers more than 50% of middle schools. Secondary schools nationwide are essentially all under the administrative control of state governments.

Thus, in every state, students may pass from municipal-run primary schools to state-administered middle schools and then to state-administered secondary schools, or students may stay in municipal-run primary and middle schools but eventually study in state-administered secondary schools. The 1988 Constitution directs states and municipalities to "cooperate" in the delivery of schooling, but the coordination of education policies and the implementation of educational reforms vary greatly from state to state. Given this mandate, it makes sense to focus on municipalities as the core unit of analysis, since they play such an important role in setting educational policies in primary and middle schools, but we also need to take account of state fixed effects and, in the 9th grade, to control for the proportion of middle school students in the municipality attending state schools.

Three features of Brazil's decentralized education system figure importantly in our study. First, average student achievement scores in both mathematics and reading increased significantly across municipalities in 2007-2017. Fifth grade math scores in an average municipality rose 0.7 standard deviations (SDs), or 0.07 SDs annually. Fifth grade reading (Portuguese) scores increased 0.9 SDs, or 0.09 SDs annually. Ninth grade math scores increased 0.025 SDs annually, and ninth grade reading scores, 0.05 SDs annually.

A second important feature is that there has been large variation across the 5,000+ municipalities and across states (Carnoy et al, 2022) in student test score increases at both the 5th and 9th grades. Students in the lowest gaining quintile of municipalities in 5th grade mathematics, for example, increased their scores by 0.015 SDs annually, whereas students in the highest gaining quintile of municipalities increased their scores by 0.12 SDs annually, about eight times more rapidly. This is analogous to a similarly large variation in achievement gains among U.S. school districts (Matheny et al, 2020). In Brazil, there are also large differences among municipalities in the average student social class variation among schools *within* municipalities, and in the inequality of the distribution of test scores within municipalities at the 5th and 9th grades.

A third feature of this period in Brazil's educational evolution is that the social class achievement gap in both mathematics and Portuguese increased significantly among fifth graders in 2007-2017, but did not increase among 9th graders (Soares and Alves, 2013; Alves et al, 2016; Soares and Delgado, 2016; Soares et al, 2018; Carnoy et al, 2022). An important part of the increase in the 5th grade SES achievement gap among students can be explained by changes in the distribution of students attending *lower and higher SES schools within municipalities*, especially in the years 2007-2011. This suggests increased school segregation or variation in the "quality" of public schooling among higher and lower SES schools in those years (Carnoy et al, 2022).

The Present Study

In this context of change, our paper addresses the following important questions:

Is student social class segregation among schools within municipal school districts in the 5th grade (elementary school) and 9th grade (middle schools) significantly related to average student test score gains in municipalities over time—this during a period (2007-17) of considerable overall increases in student achievement gains in the country as a whole?

Is the impact of school social class segregation related to municipal school resources, such as teacher characteristics?

The results of our analysis in this paper suggest that the municipal-level student test score increases in the 5th grade are significantly *negatively* related to both initial (2007) average student *social class inequality* among schools in a municipality and to *growing inequality* in the distribution of average school social class (increasing school segregation) in 2007-17. This is generally *not* the case at the 9th grade, although in some of our estimates, municipalities characterized by *growing inequality* in the distribution of average school social class (increasing school segregation) made significantly smaller gains in 9th grade test scores than municipalities where the variation of school social class became more equal during this period.

We find, in addition, some evidence that both in 5th and 9th grade, school social class segregation in municipalities is positively correlated with the quality of teacher resources in the municipality, so that better educated municipal teachers teaching only in one school may override any negative relation between school social class segregation and municipal test score gains.

Furthermore, in both the 5th and 9th grade, these negative relationships between municipal test score gains and initial and growing social class inequality among schools within municipalities become statistically insignificant when we control for state fixed effects. This suggests that higher initial school social class inequality (in 2007) and increases in school social class inequality in this period tended to occur in municipalities located in states with relatively lower increases in test scores. Alternatively, it is possible that municipalities with higher school social class segregation and larger increases in school social class segregation that had lower test score gains were bunched in certain states, and municipalities where initial social class segregation was lower and declined over time and where students made larger increases in achievement scores were bunched in other states.

Results from other studies help us understand how inequality may have been related in this ten-year period to municipal achievement gains in our analysis. The first is that the growth of achievement inequality between the highest scoring quartile of students and the lowest scoring quartile was much greater in municipalities with higher levels of school social class segregation and increases in segregation. This was true both across states (no control for state fixed effects) and within states (controlling for state fixed effects). Thus, achievement inequality among students increased more in more school social class segregated municipalities (Carnoy et al, 2022).

One of our study's "sub-findings" is that municipalities with higher average social class students made larger gains in both 5th and 9th grade test scores in 2007-17 than municipalities with lower average social class students. In addition (and quite logically), municipalities that saw their average student social class rise in 2007-17 were much more likely to have larger test score gains. This was true across and within states.

A second "sub-finding" is that municipal *gains in average achievement* in 2007-2017 were significantly and positively related to both the initial level and the change in student *achievement inequality* in the municipality, suggesting that municipalities with higher overall achievement inequality (within and between schools) were more likely to have larger achievement gains. More achievement unequal municipalities therefore had larger average gains than less achievement unequal municipalities.

A third consistent "sub-finding" of our study is that municipalities with higher proportions of self-identified black (*preto*) students had lower increases in test scores even when controlling for a number of covariates, including the average SES level of the municipality and the degree of social class inequality among schools in the municipality and the increase in school social class inequality. This relationship is robust when we control for state fixed effects, implying that it reflects the differences among municipalities within as well as between states, and that, for blacks, attending schools in municipalities with a higher percentage of black students could reduce their test score gains.

A fourth "sub-finding" is that even controlling for these many socio-demographic characteristics of municipalities, certain municipal teacher resources—notably, the proportion of teachers teaching in primary school (5th grade) or middle school (9th grade) who have completed a higher education degree in the subject they are teaching (for primary teachers, this would refer to one of the subjects they are teaching)—are significantly related to the increase in average municipal test score in 2007-2017.

Data

We combined six survey years of student background information and academic performance in the *Prova Brasil* test to investigate the relationship between the inequality of student social class distribution among public schools in school districts (municipalities) and average student achievement gains across municipalities over ten years (2007-2017).

The data we use from *Prova Brasil*, spans the years 2007-2017. *Prova Brasil* is part of the Brazilian national assessment system, and its goal is to provide reliable measures on the quality of the public education system. The test is applied every two years. The data is publicly available from the National Institute for Educational Studies (INEP). There are mainly two data sets within the *Prova Brasil* survey that provide the information for our analysis: student survey data and test score data.

Student Survey Data

In *Prova Brasil*, INEP collects information about student characteristics, including their social and economic background. We use survey responses to build a yearly socioeconomic measure for all students in 5th and 9th grades.

There is a substantial literature outside and inside Brazil that focuses on the "best" measures of socio-economic background (for example, Alves and Soares, 2009; Cowen et al, 2012; Chudgar et al, 2014). There is no single best measure, and all are highly correlated. We used a construct of an index of a student's reported articles in the home and parent education items. We used nine (9) home articles—number of bedrooms; number of bathrooms; number of cars; number of computers; refrigerator; number of radios; number of television sets; DVD player; and washing machine—plus mother's and father's literacy, to construct this index. The index was constructed using the IRT method. This socioeconomic measure was aggregated and averaged at the school and municipal levels.

Because the surveys change from year to year, we applied item harmonization procedures to guarantee their comparability longitudinally. The harmonization process consisted of preserving only questions that appeared in all years and making sure they had the same number of possible answers. For instance, in 2007 the question "number of cars in the household" had four possible answers (None, 1, 2, 3 or more) while in 2013 there were five (None, 1, 2, 3, 4 or more). In this case, the last category in 2013 was grouped with the second to last category ("4 or more" became "3 or more") to match the structure of previous years. The other eight items went through similar harmonization processes. The pattern was mostly related to quantities, merging the top category to the one below. We removed some items that could be informative in identifying socioeconomic status because they did not appear in all surveys. A question about the number of vacuum cleaners in the household, for example, was available in the 2007 survey but not in following years.

Student Test Scores

Student scores are comparable over time since INEP adopted the item response theory (IRT) in *Prova Brasil*. INEP has consistently assessed students in 5th and 9th grade math and Portuguese. However, it is not possible to follow individual students over time as they move from the 5th to the 9th grade, since INEP does not provide student identity numbers. Neither is it possible to follow imaginary cohorts of students within schools from 5th to 9th grade, since a high percentage of students switch schools when they move from elementary education to middle schools. It is possible to identify schools, municipalities, and states and to follow changes in average test scores and average student characteristics over time at the school, municipal, and state levels. We are particularly interested in the latter two (municipalities and states) because this is where educational policies are made that are intended to impact student achievement gains.

Since this study aims at understanding average municipal (school district) test score gains across six test years of the data, we estimated average municipal test scores in math and Portuguese for the year 2007 and 2017 and normalized scores based on the 2007 parameters at the national level. In this sense, all test scores were measured in terms of 2007 standard deviations, which allowed us to estimate the 2017 normalized score with the 2007 normalized score.

Teacher Characteristics

Using publicly accessible data from the Instituto Nacional de Estudos e Pesquisas Nacionais (INEP),[2] we were able to compile five indicators of the quality of teaching resources for every municipality in our sample:

- The AFD teacher education index I: the proportion of teachers in each municipality with higher education completed and a degree in a program of study the same as the subject that the teacher teaches (Group 1 + Group 2).
- The AFD teacher education index II: the proportion of teachers in each municipality who did not complete a higher education degree (Group 5).
- The Esforco Docente IED index: the proportion of teachers in the municipality who teach one or more school sessions only ion one school (Level 1 + Level 2 + Level 3).
- The teacher regularity index (IRD): an index from 0-5 of the number of years in the previous five years that each teacher taught in basic education in that municipality averaged across all teachers in the municipality.
- The average salary paid to teachers in the municipality in primary school (5th grade) and middle school (9th grade).

Sample Restrictions

In a typical year, approximately 5 million students, 2.5 million in each grade, participate in the *Prova Brasil*. Our analytical sample includes all students that took both tests between 2007 and 2017. Nonresponse rates also vary due to changes in the test sample design.[3] With this exclusion we had a possible 25 million students in our dataset and 50 million test scores. Since our analysis also relied on student survey responses to construct the socioeconomic indicator, the sample was initially restricted to observations with non-missing values in the items used in the IRT-constructed SES index. For this reason, 34% to 50% of the observations were dropped, depending on the year, which reduced our sample, on average, from 4.2 to 2.5 million students per year. Note that the missing data rates in each of these sets of variables--student SES and student test scores--are not additive, since essentially all students without a recorded test score also had missing socioeconomic information.

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[2] https://www.gov.br/inep/pt-br/acesso-a-informacao/dados-abertos/indicadores-educacionais

[3] In 2007, INEP defined the eligibility criteria as urban schools with at least 20 students enrolled in each class of each grade. Two years later students in rural schools also participated and the minimum enrollment rule was reduced to 20 students in each grade (dropping the classroom requirement). This modification allowed for a larger number of schools to take the test, including those with a high nonresponse rate, which ultimately increased the percentage of missing test information in our sample from less than 0.5% in 2007 to about 20% of all students in 2009 and later.

Other data for municipality characteristics, such as population size, gross domestic product, and proportion of the population by ethnic group were taken from the *Instituto Brasileiro de Geografia e Estatística (IBGE)* Demographic Census.

A very high percentage of higher SES students attends private schools; private school students in Brazil with similar social class background as public-school students score somewhat higher on the *SAEB/Prova Brasil* test; and the percentage of students attending private schools in Brazil increased considerably in 2007-2017, especially in primary school (UNESCO STAT, 2022). Focusing only on public school students could therefore bias our estimates of the relationship between school social class variation and average municipal test score increases. However, to the extent that an increasing proportion of the increase in private school enrollment came from higher scoring students attending lower-SES schools, this could minimize potential bias, since that type of movement toward private schools could have reduced the variation in public school SES within a municipality and also reduced gains in public school achievement scores. It is also possible that lower-scoring, higher SES students left public schools in this period, which would have also reduced the variation in average public-school SES but increased public school achievement gains—this would imply that our estimates of the SES-achievement gain relation are biased upward.

Methodology

We use the following ordinary least-squares regression to investigate test score gains at the municipal level:

$$A_{jms.2017} = \beta_0 A_{jms2007} + \beta_1 var(SES_{jms2007}) + \beta_2 \Delta[var(SES_{jms})] + \beta_3 SES_{jms2007} + \beta_4 \Delta(SES_{jms}) + \beta_5 P_{ms} + \beta_6 R_{ms} + \beta_6 (R_{ms})^2 + \beta_7 PIB_{ms} + \beta_8 \Delta(PIB_{ms}) + \beta_9 var(A_{jms2007}) + \beta_{10} \Delta[var(A_{jms})] + \beta_{11} AFD_{ms} + \beta_{12} IRD_{ms} + \beta_{13} IED_{ms} + \beta_{14} TS_{ms} + \delta_s + \varepsilon_{jms} \quad (1)$$

where $A_{mst2017}$ represents the average mathematics or Portuguese scores of students in school *j,* municipality *m,* and state *s* and $A_{jms2007}$ is the same variable measured in 2007. Controlling for $A_{jms2007}$ makes $A_{mst2017}$ into a quasi-gain score for municipality m between 2007 and 2017. SES_{im2007} is the average SES in school j, municipality m, and state s. Our variables of interest are the initial variance in SES among schools in municipality m in state s in 2007, which represents the degree of inequality in the average SES of students among schools in a municipality and the change (Δ) in that inequality between 2007 and 2017. Our coefficients of interest are β_1 and β_2.

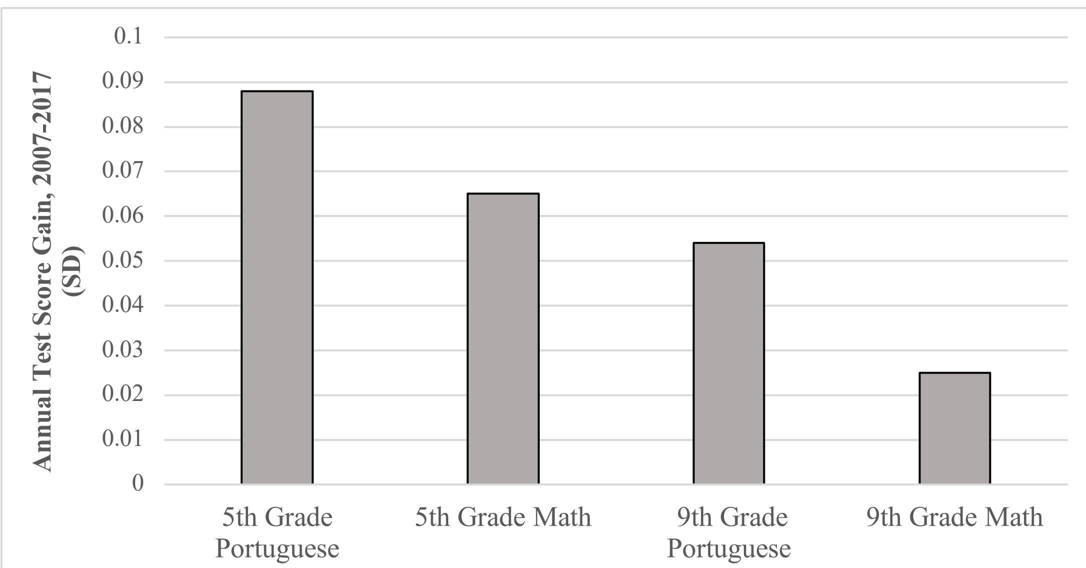
In the regression, we add several covariates to test their impact on our estimates of the relation between SES inequality and increase in student achievement at the municipal level. P_{ms} is a control for the population size of the municipality, R_{ms} is the proportion of black students in the schools of the municipality, PIB_{ms} is the gross national product per capita in the municipality, and $var(A_{jms2007})$ is the variation in average student test score among schools in municipality *m* in state s. The variables AFD_{ms}, IRD_{ms}, IED_{ms}, and TS_{ms} are the school resource indicators described earlier, where we include either *AFD I* or *II* in the regression. We also included state fixed effects (δ_s). Standard errors (ε_{jms}) are clustered at the municipality level (which is roughly equivalent to a school district in the U.S.).

Results

Variation in Trends Among Municipalities

We found that in the period 2007-2017, mathematics scores increased annually in the average municipality by 0.065 standard deviations for 5th grade students and only 0.025 standard deviations for 9th grade students. The increase in Portuguese (reading) scores was greater: 0.088 standard deviations annually in 5th grade and 0.054 standard deviations in 9th grade (see Figure 1). These very large test score gains in 5th grade and the considerably smaller gains in 9th grade are average trends, but there is considerable variation among municipalities/school districts in these trends. Figure 2 shows test score gains for the lowest gaining 20% of municipalities and the highest gaining 20% of municipalities for each grade and each subject within grade. There is a spread of more than 0.1 SD difference in annual gain for both Portuguese and math gains between the lowest and highest 20% gaining municipalities, which resulted in a difference of more than a standard deviation increase in test score difference over the ten-year period. In 9th grade, the average difference in annual gain between these two groups of municipalities was somewhat smaller, at 0.09 SD, but this still resulted in a 0.9 SD increase in test score difference at the end of 10 years.

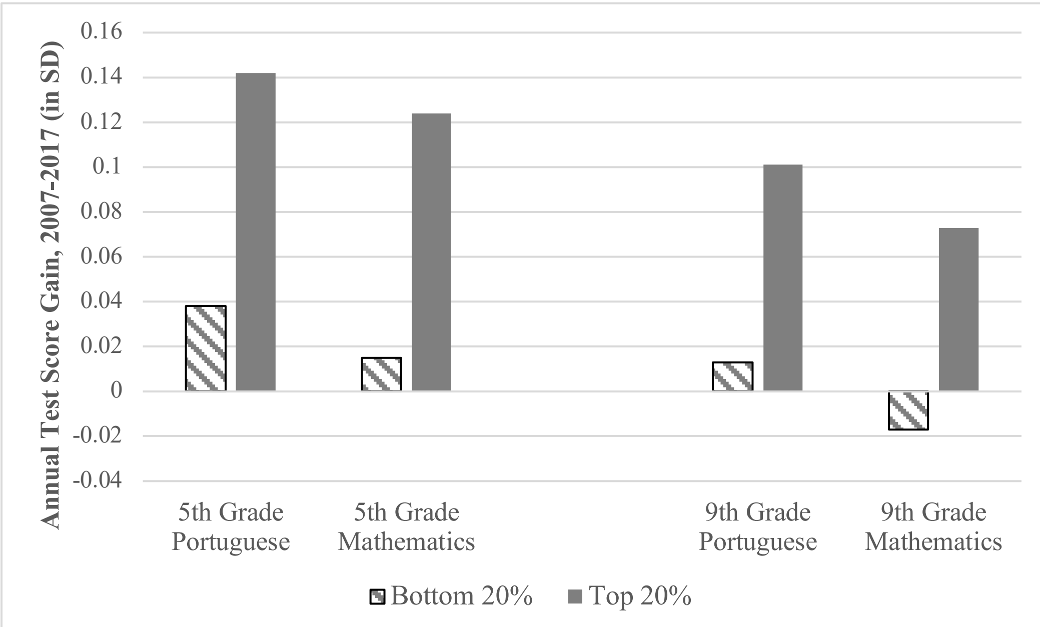
Figure 1. Brazil: Average Annual Municipal (School District) Test Score Gains (in SD), 2007-20017, by Subject and Grade.



Source: *Prova Brasil* microdata, authors' calculations.

The variation in test score increases was also great for both 5th grade and 9th grade students among the largest (in student enrollment) twenty municipalities/school districts in Brazil (Table 1). For example, average 5th grade math test scores in Manaus increased at a rate of 0.11 SDs/year, whereas the increased at the much lower rate of 0.03 SDs/year in Campo Grande.

Figure 2. Brazil: Average Annual Municipal (School District) Test Score Gains (in SD), 2007-2017, by Subject and Grade for Lowest and Highest 20% Gaining Municipalities.



Source: *Prova Brasil* microdata, authors' calculations.

Table 1. Brazil: Average Annual Test Score Gains (in SD), 2007-2017, by Grade and Subject, Twenty Largest School Enrollment Municipalities.

Fifth Grade				**Ninth Grade**			
Municipio	*Portuguese*	*Municipio*	*Math*	*Municipio*	*Portuguese*	*Municipio*	*Math*
Teresina (PI)	0.133	Teresina (PI)	0.132	Teresina (PI)	0.104	Teresina (PI)	0.084
Fortaleza (CE)	0.123	Manaus (AM)	0.108	Fortaleza (CE)	0.086	Recife (PE)	0.052
Manaus (AM)	0.122	Guarulhos (SP)	0.105	Recife (PE)	0.081	Fortaleza (CE)	0.045
Guarulhos (SP)	0.122	São Paulo (SP)	0.099	Manaus (AM)	0.077	Rio de Janeiro (RJ)	0.043
São Paulo (SP)	0.114	Fortaleza (CE)	0.096	Maceió (AL)	0.071	Manaus (AM)	0.041
São Bernardo do C. (SP)	0.109	Campinas (SP)	0.094	Guarulhos (SP)	0.069	Guarulhos (SP)	0.035
Campinas (SP)	0.103	São Bernardo do C. (SP)	0.092	Rio de Janeiro (RJ)	0.059	Belo Horizonte (MG)	0.034
Belo Horizonte (MG)	0.100	Belo Horizonte (MG)	0.076	São Bernardo do C. (SP)	0.059	Maceió (AL)	0.034
Salvador (BA)	0.093	Rio de Janeiro (RJ)	0.072	Belo Horizonte (MG)	0.059	Duque de Caxias (RJ)	0.029
Recife (PE)	0.091	Salvador (BA)	0.071	Curitiba (PR)	0.055	Porto Alegre (RGS)	0.028
Maceió (AL)	0.091	Maceió (AL)	0.071	Duque de Caxias (RJ)	0.054	São Bernardo do C. (SP)	0.025
Rio de Janeiro (RJ)	0.084	Recife (PE)	0.069	Porto Alegre (RGS)	0.052	Curitiba (PR)	0.025
Curitiba (PR)	0.083	Curitiba (PR)	0.065	Campinas (SP)	0.050	Campinas (SP)	0.021
Belém (PA)	0.075	Belém (PA)	0.053	São Gonçalo (RJ)	0.049	São Paulo (SP)	0.016
Porto Alegre (RGS)	0.071	Brasília (DF)	0.047	São Paulo (SP)	0.046	São Gonçalo (RJ)	0.016
Brasília (DF)	0.067	Duque de Caxias (RJ)	0.046	Brasília (DF)	0.041	Nova Iguaçu (RJ)	0.012
Duque de Caxias (RJ)	0.065	Porto Alegre (RGS)	0.045	Belém (PA)	0.035	Brasília (DF)	0.010
São Gonçalo (RJ)	0.064	Nova Iguaçu (RJ)	0.039	Salvador (BA)	0.034	Salvador (BA)	0.009
Nova Iguaçu (RJ)	0.059	São Gonçalo (RJ)	0.036	Campo Grande (MS)	0.033	Belém (PA)	-0.001
Campo Grande (MS)	0.054	Campo Grande (MS)	0.027	Nova Iguaçu (RJ)	0.033	Campo Grande (MS)	-0.002

Source: *Prova Brasil* microdata, authors' calculations.

Indeed, municipalities such as Teresina, Fortaleza, Manaus, and Guarulhos, had consistently large gains across subjects and grades during this period, and students in municipalities such as Campo Grande and Nova Iguaçu increased their scores at a much lower rate across subjects and grades.

The concentration of highest and lowest gaining municipalities is not random across states. More than 30% of students in the lowest 20% gaining municipalities on the 5th grade *Prova Brasil* test are concentrated in two states, Bahia and Maranhao, although only 13% of 5th graders attended school in these states in 2007. At the same time, 32% of students in the highest gaining municipalities on the 5th grade test are in two other states, Ceará and Minas Gerais, which only have 15% of all 5th grade students in 2007.

The Distribution of Municipality Gains Across Average Municipality Student Social Class

Test score gains in 2007-2017 on the mathematics and Portuguese test vary greatly within groups of municipalities of low- and high-average student social class. Figure 3 and Figure 4 shows the distribution of the gain on the 5th grade mathematics test (in points) and 5th grade Portuguese scores of all municipalities in our sample by the average social class in 2007 of students in the 5th grade in each municipality (measured in standard deviations from the average social class of 5th grade students in Brazil).

Figure 3. Brazil: Distribution of Municipality Fifth Grade Mathematics Test Score Gains 2007-2017 by Municipality Average Fifth Grade Student Social Class

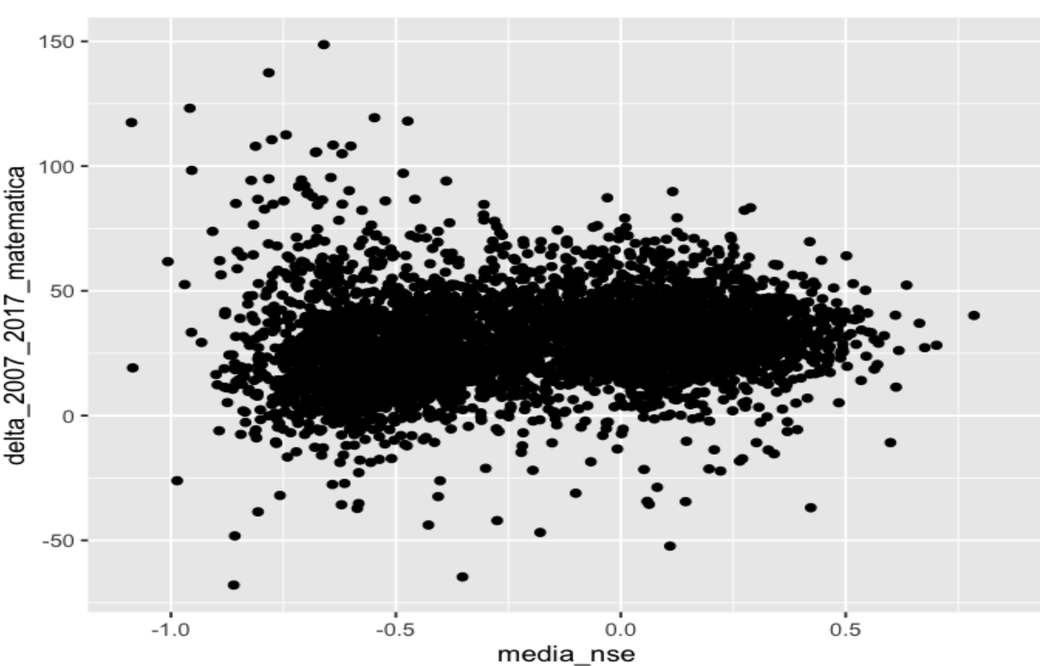
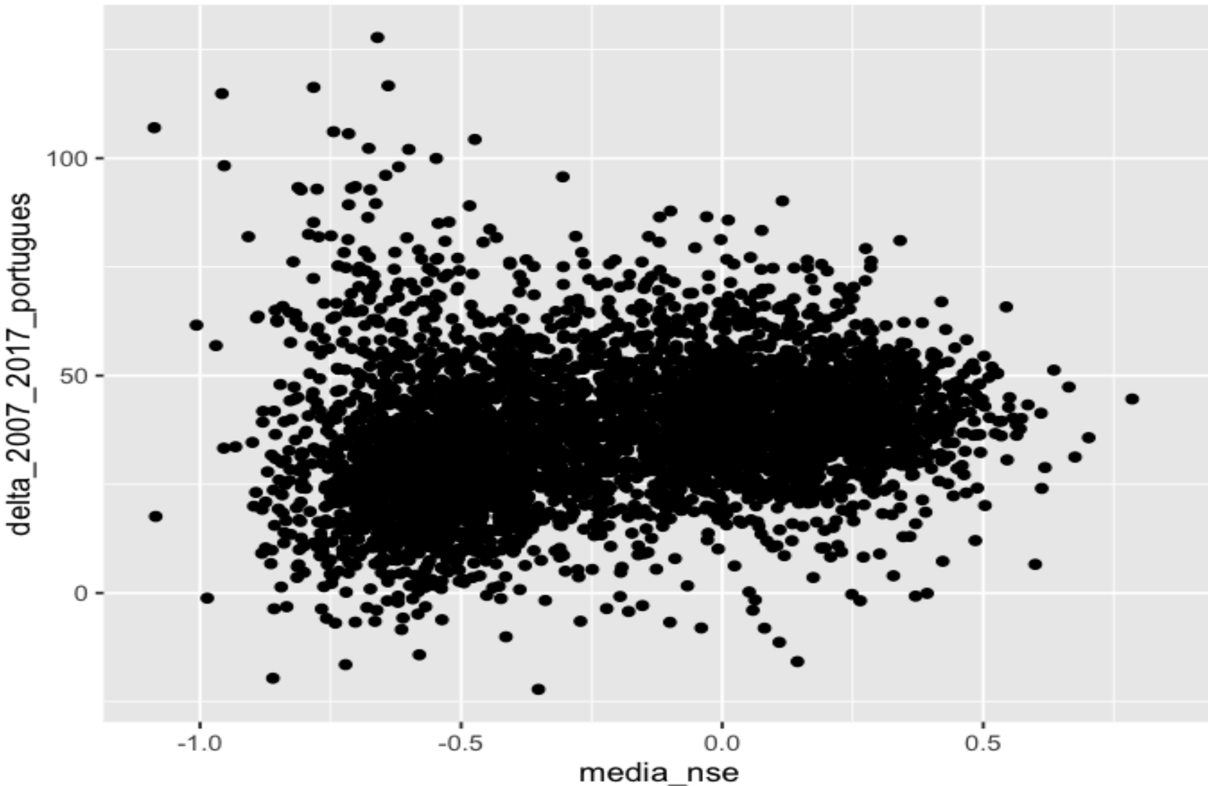


Figure 4. Brazil: Distribution of Municipality Fifth Grade Portuguese Test Score Gains 2007-2017 by Municipality Average Fifth Grade Student Social Class



The figures show a positive relation between municipality achievement gains and average student social class, and the relationship is stronger for language than for mathematics. As we have noted, this implies that lower social class municipalities are likely to have made lower gains in these ten years than higher social class municipalities. That said, the variation in gains is much greater among low social class municipalities than among high social class municipalities in both mathematics and language. There are a considerable number of low SES municipalities that made very high gains in achievement in each test—higher than even the highest gaining high social class municipalities.

School Segregation (Inequality in SES among Schools) within Municipalities and Average Municipal Student Test Score Gains

Our focus in this paper is on the possible role of social class inequality on Brazilian public school districts' (municipalities') "capacity" to improve students' performance on the *Prova Brasil* national test. We showed in the previous section that there is considerable variation in the average gains in student performance across municipalities/school districts. Is greater social class segregation across public schools within municipalities negatively related to those municipal gains in average test scores?

Table 2 presents the means and standard deviations of the variables shown in Equation (1), and Tables 3 and 4 present stepwise regression models predicting overall trends for 5th graders by subject tested in the relation between initial (2007) social class variation among schools in a municipality as well as the *change* in 2007-2017 in social class variation among schools in a municipality and the gain in average municipal test score. The dependent variable in all regressions is the average municipal test score in 2017 in Portuguese (reading) or mathematics in either Grade 5 or 9. Further, in all regressions we control for the baseline test score in 2007 to estimate a version of a municipal *gain score* as discussed in the methodology section.

Further, our models include additional sets of covariates with and without state fixed effects. For example, Model 1 presents the regression results for test score gains over time as they relate to our main variables of interest without controls for other covariates. Our proxy for school segregation—the initial level of variance in school SES within the municipality—and the change in this variation during the ten years are both negatively and statistically significantly related to average municipal test score gains. Thus, without controls for any other covariates, it appears that public school students in 5th grade in municipalities characterized by greater social class segregation among schools made significantly lower Portuguese reading and mathematics gains in the ten years 2007-2017.

Model 2 presents the regression results for the relation between our main variables of interest and test score gains, controlling for average student SES in the municipality in 2007and the change in average student SES in 2007-2017. Model 2 also includes controls for the population of the municipality, municipal GDP per capita in 2010, and the change in municipal GDP per capita in 2010-2017. We know that average student SES and GDP per capita are correlated with average test score and possibly with test score gain. Including the average student SES and GDP/capita variables is meant to control for possible effects of their correlation with test score gain on our relation of interest between the degree of school social class segregation and test score gain. The regression results indicate that the coefficients of municipal school social class segregation and increases in municipal school SES segregation are greatly reduced but remain statistically significant when we control for the student social class and GDP/capita covariates. Since the coefficients of student SES, increase in student SES and GDP/capita are positive, this suggests that higher student SES/higher GDP/capita municipalities and those increasing their SES more rapidly are also those both making greater test score gains in both math and Portuguese (see Carnoy et al, 2022) *and* are also those municipalities with higher initial levels of school SES segregation and greater increases in school SES segregation during the 10 years, 2007-2017.

Table 2. Brazil: Means and Standard Deviations of Variables in Regression Estimates

	Fifth Grade		**Ninth Grade**	
Variable	*Mean*	*SD*	*Mean*	*SD*
Municipal Portuguese Score, 2007	-0.083	0.392	-0.070	0.327
Municipal Mathematics Score, 2007	-0.472	0.372	-0.331	0.330
Municipal Portuguese Score, 2017	0.800	0.523	0.493	0.383
Municipal Mathematics Score, 2017	0.367	0.501	0.238	0.387
Variation School SES in Municipality, 2007	0.246	0.118	0.267	0.133
Change in Variation of School SES, 2007-17	-0.004	0.140	-0.021	0.153
Municipal Student SES, 2007	-0.418	0.390	-0.427	0.468
Municipal Student SES, 2017	-0.072	0.392	-0.088	0.438
% *Pretos* in Municipality, 2007	0.109	0.066	0.111	0.073
Population of Municipality, 20??	46,150	246,552	47,844	252,026
GDP per capita, 2010	12,721	15,643	12,943	15,607
GDP per capita, 2017	21,970	21,616	22,387	21,857
% Teachers in Municipality w/Subject University Degree, 2017	0.544	0.256	0.615	0.239
% Teachers in Municipality w/o University Degree	0.318	0.267	0.247	0.234
% Teachers Teaching in Only One School, 2017	0.750	0.141	0.486	0.209
Monthly Teacher Salary, 2017	3,432	1,166	3,450	1,180
Index of Teacher Regularity in 2013-2017	2.941	0.398	2.935	0.395

Source: INEP, *Prova Brasil* and *Censo Escolar* microdata, authors' calculations.

Table 3. Brazil: Municipal Average 5th Grade Portuguese Scores, 2017 as Function of Average Municipal 5th Grade Math Scores, 2007, SES Inequality among Schools within Municipality, 2007, and Growth in SES Inequality among Schools within Municipality, 2007-2017.

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
Mean Municipality 5th Grade Port. Score 2007	1.006***	0.482***	0.415***	0.423***	0.599***	0.336***	0.322***
	[0.016]	[0.121]	[0.021	[0.021]	[0.019]	[0.018]	[0.019]
Variance School SES in Municipality 2007	-0.239***	-0.098*	-0.170***	-0.200***	0.045	-0.020	-0.019
	[0.069]	[0.060]	[0.056]	[0.058]	[0.055]	[0.049]	[0.041]
Change in Var School SES in Municipality 2007-17	-0.358***	-0.109**	-0.182***	-0.223***	-0.056	-0.063	-0.014
	[0.057]	[0.050]	[0.047]	[0.048]	[0.046]	[0.041]	[0.041]
Mean Municipal Student SES 2007		0.610***	0.465***	0.446***		0.583***	0.543***
		[0.027]	[0.026]	[0.027]		[0.030]	[0.031]
Change in Mean Municipal Student SES 2007-17		0.979***	0.803***	0.786***		0.637***	0.593***
		[0.036]	[0.034]	[0.035]		[0.035]	[0.036]
% *Pretos* in Municipality 2007			-3.336***	-3.345***		-2.812***	-2.810***
			[0.248]	[0.248]		[0.216]	[0.217]
% *Pretos* in Municipality Squared			4.187***	4.309***		3.831***	3.730***
			[0.716]	[0.717]		[0.618]	[0.630]
Variance in Portuguese Scores in Municipality 2007				0.031*		0.074***	0.063***
				[0.019]		[0.016]	[0.016]
Change in Variance in Portuguese Scores 2007-17				0.064***		0.064***	0.054***
				[0.014]		[0.012]	[0.012]
% Better Educated Teachers in Municipality							-0.224***
							[0.026]
% Teachers Teaching in Single School							0.102***
							[0.039]
Regularity of Teaching Index							0.005
							[0.012]
Average Teacher Salary (in 10^3 Rs/month)							-0.007
							[0.004]
Intercept	0.934***	0.638***	0.948***	0.907***	1.083***	0.676***	0.673***
	[0.018]	[0.121]	[0.114]	[0.115]	[0.019]	[0.098]	[0.110]
N	3599	3599	3599	3591	3599	3591	3474
Adjusted R-squared	0.544	0.653	0.698	0.699	0.735	0.801	0.805
Control Variables							
Population of Municipality	NO	YES	YES	YES	NO	YES	YES
GDP/capita and change in GDP/capita	NO	YES	YES	YES	NO	YES	YES
State fixed effects	NO	NO	NO	NO	YES	YES	YES

Source: INEP, *Prova Brasil* and *Censo Escolar* microdata, authors' calculations. Note: *** = p<.001; ** = p<.01; * = p<.05.

Table 4. Brazil: Municipal Average 5th Grade Math Scores, 2017 as a Function of Average Municipal 5th Grade Math Scores, 2007, SES Inequality among Schools within Municipality, 2007, and Growth in SES Inequality among Schools within Municipality, 2007-2017.

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
Mean Municipal 9th Grade Math Score 2007	1.006***	0.402***	0.415***	0.421***	0.599***	0.334***	0.320***
	[0.016]	[0.022]	[0.021]	[0.021]	[0.019]	[0.018]	[0.019]
Variance School SES in Municipality 2007	-0.227***	-0.093*	-0.162***	-0.194***	0.043	-0.015	0.001
	[0.065]	[0.057]	[0.053]	[0.055]	[0.052]	[0.047]	[0.047]
Change in Var. School SES in Municipality 2007-17	-0.340***	-0.104**	-0.173***	-0.215***	-0.053	-0.059	-0.016
	[0.054]	[0.048]	[0.045]	[0.046]	[0.044]	[0.039]	[0.039]
Mean Municipal Student SES 2007		0.579***	0.442***	0.417***		0.550***	0.511***
		[0.026]	[0.025]	[0.026]		[0.029]	[0.029]
Change in Mean Municipal Student SES 2007-17		0.930***	0.763***	0.737***		0.600***	0.555***
		[0.034]	[0.032]	[0.033]		[0.033]	[0.034]
% *Pretos* in Municipality 2007			-3.169***	-3.155***		-2.651***	-2.645***
			[0.236]	[0.236]		[0.205]	[0.206]
% *Pretos* in Municipality Squared			3.978***	4.104***		3.636***	3.528***
			[0.681]	[0.681]		[0.587]	[0.597]
Variance in Math Scores in Municipality 2007				0.054***		0.086***	0.081***
				0.019]		[0.016]	[0.016]
Change in Variance in Math Scores 2007-17				0.086***		0.083***	0.076***
				[0.015]		[0.013]	[0.013]
% Teachers w/o University Degree in Municipality							-0.215***
							[0.025]
% Teachers Teaching in Single School							0.104***
							[0.037]
Regularity of Teaching Index							0.004
							[0.011]
Average Teacher Salary (in 10^3 Rs/month)							-0.006
							[0.004]
Intercept	0.890***	0.402***	0.671***	0.620***	0.872***	0.373***	0.354***
	[0.019]	[0.116]	[0.109]	[0.109]	[0.018]	[0.094]	[0.105]
N	3599	3599	3599	3591	3599	3591	3474
Adjusted R-squared	0.544	0.653	0.698	0.700	0.735	0.802	0.806
Control Variables							
Population of Municipality	NO	YES	YES	YES	NO	YES	YES
GDP/capita and change in GDP/capita	NO	YES	YES	YES	NO	YES	YES
State fixed effects	NO	NO	NO	NO	YES	YES	YES

Source: INEP, *Prova Brasil* and *Censo Escolar* microdata, authors' calculations. Note: *** = p<.001; ** = p<.01; * = p<.05.

Thus, Model 2 indicates that there are two "opposing" forces at work in higher SES municipalities/school districts. The first is that higher student SES/higher per capita GDP municipalities tend to have increased their average test scores more than lower student SES/lower per capita GDP municipalities. The second is that higher SES and higher growth in SES districts are characterized by greater social class segregation and increases in SES segregation among public schools within the municipalities, which tends to reduce average municipal test score gains over time.

In Models 3 and 4, we add covariates for the percentage of black students (*pretos*) in the municipality (as a quadratic) and the initial 2007 variance in the municipality of 5th grade student achievement on the test (either Portuguese or math) and the change in that variance in 2007-2017. These covariates are also related significantly to test score gains (we will discuss these relations in greater detail below) and they are somewhat correlated with our variables of interest in their relation to test score gains. Nevertheless, Model 4 suggests that even with all these covariates included, greater initial public school social class segregation in a municipality and greater growth of public-school social class segregation is related negatively to increases over time in average municipal 5th grade test scores. Thus, greater inequality in the way higher and lower social class students are distributed among schools in a municipality appears to have a negative influence on a municipality's test score growth.

In Model 5, we add state fixed effects (controls for the individual state dummy variables with Sao Paulo state as the reference state) to our original Model 1, which tests the relationship between variance of school social class and test score gains. The coefficients of both variables in school social class in the municipality and changes of school social class in the municipality in 2007-17 are not statistically significantly different from zero when we control for state fixed effects, even when no other covariates are included. Thus, *within* states, we observe no significant relation between school social class segregation or the change in school SES segregation between schools within municipalities and test score increases. This suggests that higher initial school social class inequality and increases in school social class inequality in this period tended to occur in municipalities located in states with relatively lower increases in test scores, and that vice-versa, lower initial school social class inequality and lower increases in school social class inequality in this period tended to occur in municipalities located in states with relatively higher increases in test scores.

In Model 6 we include the covariates of Model 4 and add state fixed effects. Other than the variance of school social class and change in variance of school social class within municipality, the coefficients of the covariates of Model 4 remain statistically significant, suggesting that their relation to gains in test scores over the ten years is statistically significant *within* states.

In Model 7 we add indicators of the quality of municipal teacher resources, including teacher average salaries.

The regression results for students in 9th grade—the end of middle school—are displayed in Table 5 and 6. The main difference between the 5th and 9th grade results is that the relation between school SES inequality and gains in 9th grade test scores, although negative, is not statistically significantly different from zero once we control for student social class differences between municipalities, even when between state variation is included (no state fixed effects).

Nevertheless, the models predict that those municipalities characterized by increases in school SES inequality over the ten years would likely have lower increases in both Portuguese and math scores in 2007-2017 if we did not control for state fixed effects. As was the case for 5th graders, once we include state fixed effects neither initial school SES inequality nor changes in inequality are significantly related to average municipal test score gains for 9th graders.

Table 5. Brazil: Municipal Average 9th Grade Portuguese Scores, 2017 as a Function of Average Municipal 9th Grade Portuguese Scores, 2007, SES Inequality among Schools within Municipality, 2007, and Growth in SES Inequality among Schools within Municipality, 2007-2017.

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
Mean Municipal 9th Grade Portuguese Score 2007	0.805***	0.501***	0.472***	0.471***	0.648***	0.457***	0.449***
	[0.015]	[0.021]	[0.021]	[0.021]	[.018]	[0.020]	[0.020]
Variance School SES in Municipality 2007	-0.227***	-0.054	-0.052	-0.072	-0.007	0.018	0.030
	[0.053]	[0.049]	0.047	[0.048]	[0.044]	[0.041]	[0.042]
Change in Var School SES in Municipality 2007-17	-0.271***	-0.068	-0.077*	-0.099**	-0.020	0.003	0.015
	[0.046]	[0.042]	[0.041]	[0.041]	[0.038]	[0.036]	[0.036]
Mean Municipal Student SES 2007		0.261***	0.219***	0.211***		0.345***	0.322***
		[[0.021]	[0.020]	[0.021]		[0.025]	[0.025]
Change in Mean Municipal Student SES 2007-17		0.573***	0.551***	0.545***		0.471***	0.452***
		[0.031]	[0.030]	[0.030]		[0.030]	[0.030]
% *Pretos* in Municipality 2007			-1.158***	-1.156***		-1.488***	-1.564***
			[0.171]	[0.171]		[0.165]	[0.168]
% *Pretos* in Municipality Squared			0.523***	0.553***		1.327***	1.589***
			[0.038]	[0.438]		[0.396]	[0.407]
Variance in Math Scores in Municipality 2007				0.029*		0.051***	0.054***
				[0.016]		[0.014]	[0.014]
Change in Variance in Math Scores 2007-17				0.050***		0.056***	0.057***
				[0.013]		[0.011]	[0.011]
% Teachers w/o University Degree in Municipality							-0.107***
							[0.025]
% Teachers Teaching in Single School							0.045
							[0.039]
Regularity of Teaching Index							0.005
							[0.004]
Average Teacher Salary (in 10^3 Rs/month)							0.003
							[0.004]
Intercept	0.610***	-0.037	0.023	0.003	0.634***	0.301***	0.334***
	[0.015]	[0.111]	[0.107]	[0.107]	[0.157]	[0.094]	[0.107]
N	3058	3058	3058	3050	3058	3050	2954
Adjusted R-squared	0.466	0.556	0.587	0.587	0.656	0.715	0.715
Control Variables							
Population of Municipality	NO	YES	YES	YES	NO	YES	YES
GDP/capita and change in GDP/capita	NO	YES	YES	YES	NO	YES	YES
State fixed effects	NO	NO	NO	NO	YES	YES	YES

Source: *Prova Brasil* and *Censo Escolar* microdata, authors' calculations. Note: *** = p<.001; ** = p<.01; * = p<.05.

Table 6. Brazil: Municipal Average 9th Grade Math Scores, 2017 as a Function of Average Municipal 9th Grade Math Scores, 2007, SES Inequality among Schools within Municipality, 2007, and Growth in SES Inequality among Schools within Municipality, 2007-2017.

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
Mean Municipal 5th Grade Portuguese Score 2007	0.805***	0.0501***	0.472***	0.468***	0.648***	0.457***	0.452***
	[0.016]	[0.021]	[0.021	[0.021]	[0.018]	[0.020]	[0.020]
Variance School SES in Municipality 2007	-0.228***	-0.055	-0.053	-0.072	-0.007	0.030	0.048
	[0.053]	[0.049]	[0.047]	[0.048]	[0.044]	[0.041]	[0.042]
Change in Var School SES in Municipality 2007-17	-0.273***	-0.069	-0.078*	-0.105***	-0.020	0.006	0.018
	[0.046]	[0.043]	[0.041]	[0.042]	[0.039]	[0.036]	[0.036]
Mean Municipal Student SES 2007		0.263***	0.220***	0.213***		0.348***	0.326***
		[0.021]	[0.021]	[0.021]		[0.025]	[0.026]
Change in Mean Municipal Student SES 2007-17		0.578***	0.555***	0.543***		0.472***	0.453***
		[0.031]	[0.030]	[0.030]		[0.0309]	[0.030]
% *Pretos* in Municipality 2007			-1.165***	-1.138***		-1.480***	-1.542***
			[0.173]	[0.173]		[0.166]	[0.169]
% *Pretos* in Municipality Squared			0.519	0.502		1.285***	1.484***
			[0.441]	[0.441]		[0.399]	[0.410]
Variance in Math Scores in Municipality 2007				0.043***		0.042***	0.042***
				[0.016]		[0.013]	[0.137]
Change in Variance in Math Scores 2007-17				0.067***		0.056***	0.058***
				[0.013]		[0.011]	[0.011]
% Teachers w/o University Degree in Municipality							-0.122***
							[0.027]
% Teachers Teaching in Single School							-0.021
							[0.029]
Regularity of Teaching Index							0.006
							[0.012]
Average Teacher Salary (in 10^3 Rs/month)							0.003
							[0.004]
Intercept	0.564***	-0.167	-0.114	-0.134	0.548***	0.172*	0.185
	[0.016]	[0.112]	[0.108]	[0.108]	[0.016]	[0.095]	[0.104]
N	3059	3059	3059	3051	3059	3051	2955
Adjusted R-squared	0.466	0.557	0.587	0.589	0.656	0.715	0.715
Control Variables							
Population of Municipality	NO	YES	YES	YES	NO	YES	YES
GDP/capita and change in GDP/capita	NO	YES	YES	YES	NO	YES	YES
State fixed effects	NO	NO	NO	NO	YES	YES	YES

Source: INEP, *Prova Brasil* and *Censo Escolar* microdata, authors' calculations. Note: *** = p<.001; ** = p<.01; * = p<.05.

How is Race Related to Average Municipal Test Score Gains?

An average municipality in our sample has 11% of students in 5th and 9th grade who identify as "black"/African-Brazilian (*preto*), and 85% of these municipalities have between 4% and 18% *preto* students. However, in the 5th grade data, there are 50 municipalities in the state of Bahia that have more than 30% black students (Table 6). Such identification is a complex issue in Brazil, because a high percentage of individuals identify as *pardo,* or mixed race, and the line between these groups is not well-defined. The same individual may identify as one or the other on different surveys (Telles and Lim, 1998; Bailey et al, 2013; Loveman et al, 2013). On average, however, those who self-identify as *preto* score lower on tests than *pardos*, whites, and Brazilians who identify as Asians. Students who identify as *preto* are also more likely to live in families in which parents have less education and with less income and less wealth—thus lower SES—and often live in spatially segregated poorer sections of the municipality.

Table 7. Brazil: The 20% of Municipalities in Fifth Grade Sample with Highest Percent of Black Students in Municipality, by State, 2007

State	*Number of Highest 20 % Black Student Districts in State*	*% of All Highest 20 % Black Districts in Brazil*	*Number of Municipalities in State*	*Highest 20% Black Districts as % of all Municipalities in State*
Alagoas (AL)	23	3.20%	102	22.55%
Amazonas (AM)	5	0.70%	62	8.06%
Amapá (AP)	7	0.97%	16	43.75%
Bahia (BA)	244	33.98%	417	58.51%
Ceará (CE)	5	0.70%	184	2.72%
Espírito Santo (ES)	2	0.28%	78	2.56%
Goiás (GO)	10	1.39%	246	4.07%
Maranhão (MA)	71	9.89%	217	32.72%
Minas Gerais (MG)	44	6.13%	853	5.16%
Mato Grosso (MT)	13	1.81%	141	9.22%
Para (PA)	22	3.06%	144	15.28%
Paraiba (PB)	28	3.90%	223	12.56%
Pernambuco (PE)	47	6.55%	184	25.54%
Piaui (PI)	48	6.69%	224	21.43%
Rio de Janeiro (RJ)	51	7.10%	92	55.43%
Rio Grande do Norte (RN)	31	4.32%	169	18.34%
Rondônia (RO)	2	0.28%	52	3.85%
Roraima (RR)	3	0.42%	15	20.00%
Rio Grande do Sul (RS)	10	1.39%	497	2.01%
Santa Catarina (SC)	2	0.28%	295	0.68%
Sergipe (SE)	30	4.18%	75	40.00%
San Paulo (SP)	1	0.14%	645	0.16%
Tocantins (TO)	17	2.37%	139	12.23%

Source: *Prova Brasil* microdata, authors' calculations.

Since our analysis focuses on how municipal test score gains are related to social class inequality among schools in the municipality, the proportion of black students in a municipality is a control variable—not the main objective of our research. Nevertheless, it is important to understand how the proportion of black students relates to municipalities' test score gains. Before turning to the estimated relation in our regression analysis, when other variables, especially municipal social class and social class segregation among schools, are controlled for, we show the "raw" distribution of achievement gains on the mathematics and Portuguese tests by the proportion of *preto* 5th grade students in the municipality (Figures 5 and 6). These suggest that the gain scores for municipalities with more than 15% *pretos* are distinctly lower than in municipalities with less than 10% *pretos*. There is also more variation in test score gains among municipalities with under 10% *pretos* and much less variation in achievement gains among municipalities with high (>25%) *pretos.*

Figure 5. Brazil: Distribution of Municipality Fifth Grade Mathematics Test Score Gains 2007-2017 by Average Municipality Fifth Grade Percentage of Preto Students

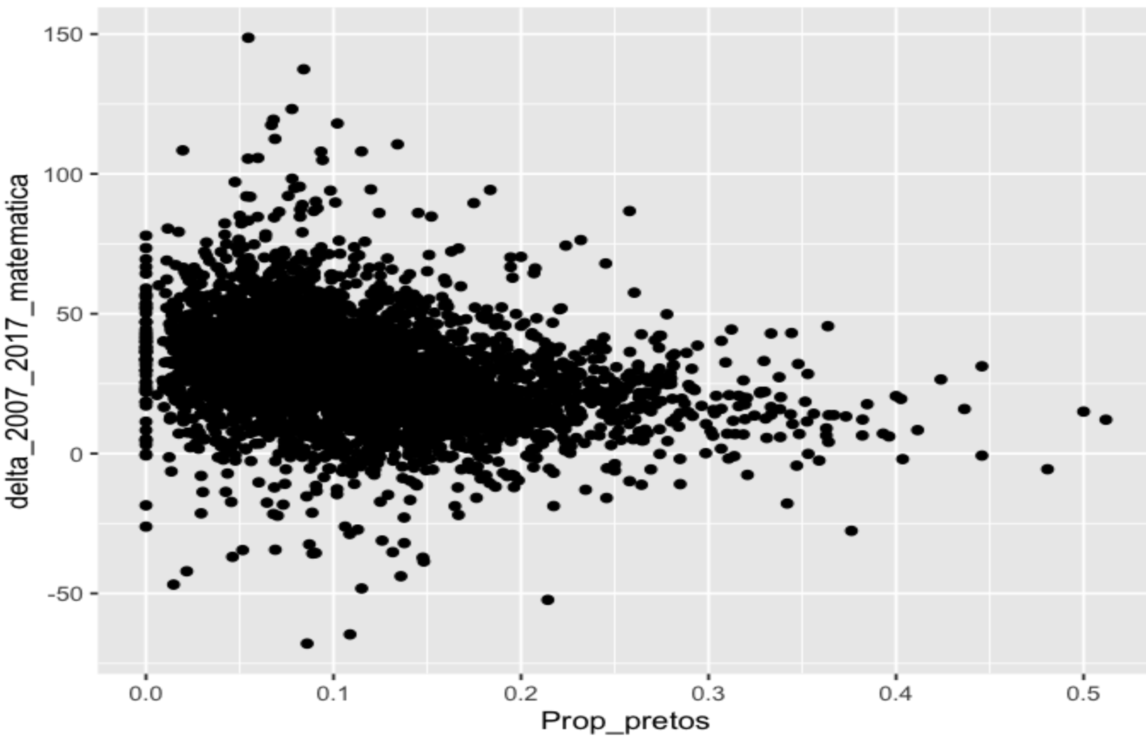
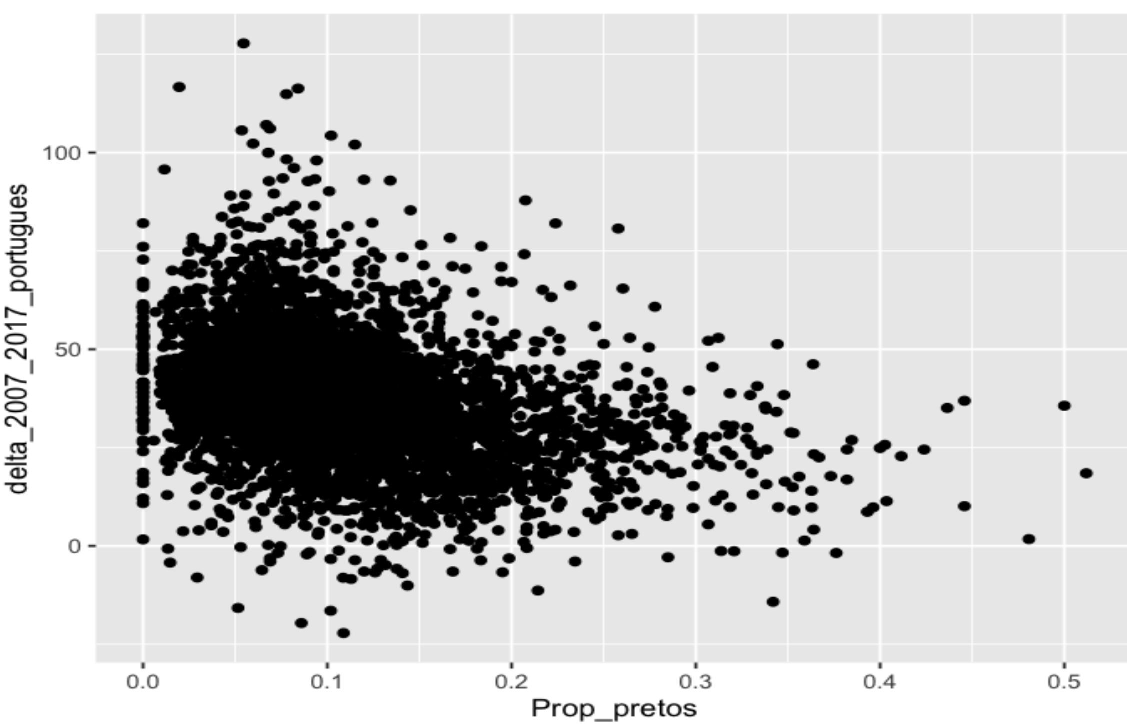


Figure 6. Brazil: Distribution of Municipality Fifth Grade Portuguese Test Score Gains 2007-2017 by Average Municipality Fifth Grade Percentage of Preto Students



Turning to the regression models, the estimates show that the proportion of *pretos* in a municipality is significantly and negatively related to test score gains even when we control for other demographic variables, and that although about one-half of all the municipalities with the highest 20% of black students in the 5th grade sample are in three low test score gain states—Bahia, Maranhao, and Sergipe (Table 6)—the coefficient of *preto* proportion is significant even when we control for state fixed effects. For example, in our Model 5 estimate (including state fixed effects) for municipal 5th grade mathematics gains (Table 3), students in a municipality with a standard deviation higher than the mean percentage of black students (17.5% blacks in the municipality rather than the mean 10.9%) would be predicted to score 0.16 SD *lower* on the 2017 *Prova Brasil* math test relative to their 2007 test score than students in a municipality *in the same state* with the mean percentage of black students, controlling for all the other covariates in that estimate. In 9th grade math (Table 5), for students attending schools in municipalities with one SD higher percentage of pretos (18.5% rather than the mean 11.2%), the predicted math score in 2017 would be 0.10 SD lower than in municipalities in the same state with the average percentage of *pretos*—a smaller, but still significantly lower gain.

What does the negative relation of a higher municipal proportion of black students to achievement gains signify? In our estimates, Model 3 is the one in which we add the percent *preto* covariate to our estimates. For 5th grade average municipal student achievement gains (Tables 2 and 3), comparing Model 2 and Model 3 coefficients for the variance and change in variance of school SES suggests that the higher the percent *pretos* in a municipality, the weaker the relation between both the variance and change in variance of school SES to test score gains. This, in turn, suggests that the negative relation of more black students in a municipality to increases in average municipal student achievement over time does not result from increased school SES segregation in municipalities with higher proportions of black students in schools. Neither are achievement inequality and the change in achievement inequality in a municipality significantly correlated with the percentage of *pretos* in a municipality. The estimates for 9th grade are similar in that the relation between percentage of blacks in the municipality and average municipal test score increases also does not seem to be related either to variation in school SES or variance in municipal student achievement.

These "observables," which are likely to be correlated both with the percentage of black students in a municipality and with increases in average municipal test scores, do not explain away the negative significant relation between these two variables. We therefore probably need to look elsewhere to understand what is behind this relation. It is possible that municipalities with higher percentages of black students may be more poorly managed, perhaps because they are faced with "unobserved" multiple challenges besides students' academic achievement. Alternatively, there may be less political pressure to improve student achievement in higher concentration black municipalities because of historical discrimination against blacks in Brazil. Digging deeper into these possibilities should be an important topic for further research.

How is Test Score Inequality Related to Average Municipal Test Score Gains?

The regression estimates in Tables 2 and 3 (Model 4 and 5) show that municipalities with greater 5th grade test score inequality and greater growth in test score inequality are likely to have had larger gains in both Portuguese and math achievement in 2007-2017. The results are similar in the estimates of average municipal test score gains for students in 9th grade. Thus, although greater initial school social class inequality and increases in SES inequality in the municipality over time were negatively related to increases in municipal achievement gains in those ten years, greater initial variation in test scores and increases in test score inequality over time were both positively related to municipal test score gains. This is the case when several covariates are controlled for in the estimates and it is the case across states as well as within states (state fixed effects).

Municipal Test Score Gains and Teacher Characteristics

Our focus in this paper is on how the social class and racial characteristics of school districts (municipalities) in Brazil correlate with student achievement gains across districts. Nevertheless, it is also interesting to consider how municipalities' teacher resources fit into the relationship between municipal student/school social demographics and student gains. Our five municipal teacher resource indicators, as expected, correlate with our two variables of interest—municipalities' school social class segregation and growth of school social class segregation. For example, when we include AFD II (the percent of teachers in the municipality without a university degree) and the three other teacher indicators in the Model 2 regressions of Tables 2 and 3 (these results are not shown because of space considerations), the coefficients of school social class segregation and the growth in segregation are reduced by two-thirds, and, for mathematics, the school social class segregation variable is no longer statistically significant at a 5% level of significance. The teacher indicators are also somewhat correlated with average school social class and the proportion of *pretos* in the municipality, as would be expected.

In Model 7 of Tables 2 to 5, we show the estimated relation of our teacher indicators to average 5th and 9th grade municipal student achievement gains controlling for all our socio-demographic variables and for state fixed effects. We show only the result for AFD II—the percent of teachers *without* a university degree. Surprisingly, two of our teacher indicators—AFD II and the percent of teachers who teach all their classes at one school are significantly related to municipal test score gains in 5th grade even with all our controls for socio-demographic variables, including our school social class segregation and growth of segregation variables and state fixed effects, and in 9th grade, with all socio-demographic controls and state fixed effects, AFD II, the proportion of teachers without a university degree is, as in 5th grade, significantly (negatively) related to average municipal student test score gains. The results for AFD I are similar, except positive.

Thus, the average proportion of teachers in a municipality without university degrees is robustly and negatively related to municipal test score gains even within states, and the proportion of teachers with university degrees in fields of study conforming to the subjects they teach is robustly and positively related to average municipal student test score gains. It is interesting to note that the relationship is stronger on the negative side—that is, *reducing* the proportion of teachers without degrees in a municipality is more strongly related to positive achievement gains than increasing the proportion of teachers with university degrees relevant to the subject they teach.

Discussion and Conclusions

Brazilian students in 5th and 9th grade made large test score gains in Portuguese in the decade 2007-2017 and lower, but still considerable, gains in math in 5th grade. Not surprisingly, there was large variation in these gains across different municipalities. Even in 9th grade math, where overall gains were relatively small (0.25 SD in ten years), students in the highest 20% gaining municipalities increased their scores by 0.7 SD.

Our estimates are correlational, not causal, but they do suggest that greater social class inequality across schools—an indicator of social class segregation within a municipality—does tend to have a *negative* influence on a municipality's increase in 5th grade scores, and not 9th grade scores. However, once we control for how this relation varies across states, we find that in neither grade nor subject is this relation statistically significant. This suggests that if there is such a relation between school social class segregation within municipalities (as measured by the variation in the average social class in schools) and municipal test score gains, it is a phenomenon that is dominated by state differences rather than municipal variation within states.

Thus, we conclude that neither how students of higher and lower social classes are distributed among schools in different municipalities *within* the same state nor whether this distribution increased over the ten years was related to municipal test score gains during this period, even though differences among states in these two variables did seem to affect municipal test score gains in Brazil as a whole, especially in 5th grade.

This suggests that there may be something about higher school social class segregation and increases in school social class segregation that contributes to lower municipal test gains in states that have lower test score gains but not in states characterized by higher test score gains. If we analyze the percentage of municipalities in each state that fall into the lowest scoring 20% and highest scoring 20% of municipalities in the country compared to the percentage of municipalities in the same state that fall into the highest and lowest 20% of municipalities according to the variation in school social class, we don't find a clear relationship between the two patterns. Remember that we have only analyzed these relationships in the public-school sector. It is possible that in some states with high school social class segregation, public resources are distributed to those schools in a way that does not result in much lower academic gains to the lower social class school, whereas in other states, resources are distributed more unequally among schools with higher and lower social class students. Greater school social class segregation in a state such as Parana, which tends to be a high gainer on the 5th grade tests and also tends to be characterized by higher school social class segregation, may not mean the same thing as in Bahia, a state characterized by both low test score gains and greater social class variation among schools in its municipalities.

We also found that in both 5th and 9th grades, municipalities with initially (in 2007) higher social class students made larger gains in test scores than municipalities with lower social class students and that the same is true for municipalities with greater variation in test scores among their students. We note that much of that variation in test scores is within schools in each municipality. This is the case when we control for state fixed effects, so these positive relationships with test score gains are mainly the result of within state differences among municipal gains.

The mystery of the significant negative relation even within states for the percentage of self-reported blacks in a municipality and municipal test score gains is perhaps the most important to solve with further research. Our finding that lower social class municipalities made smaller gains in this period in both 5th and 9th grade math and Portuguese test scores is surprising enough—it may reflect worse management or inadequate teacher resources to meet the greater needs of lower social class municipalities. However, to learn that on top of those lower gains, municipalities with a higher percent of *pretos* do even worse, suggests some deep-seated racial problems in Brazilian education that go beyond social class disadvantages in improving student learnings.

Finally, we found evidence that reducing the percentage of teachers in a municipality without university degrees and increasing the percentage of teachers with university degrees related to the subjects they teach in school are positively related to average municipal achievement gains in math and Portuguese in both 5th and 9th grades. This suggests that teacher knowledge is important for improving school performance in municipalities within states for average municipal socio-demographic conditions. Further research needs to be done that examines how these teacher resource indicators are related to different social class and race groups.

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