

PEER QUALITY AND HUMAN CAPITAL INVESTMENTS IN SECONDARY EDUCATION: AN UNINTENDED CONSEQUENCE OF SELECTIVE SCHOOLS' CONSTRUCTION

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RESUMO

Este artigo analisa o efeito dos pares sobre os resultados educacionais de estudantes do ensino médio. Para identificar a relação causal, utiliza-se uma variação exógena na qualidade dos estudantes das escolas regulares no Ceará, decorrente da expansão das escolas profissionalizantes. Escolas profissionalizantes realizam um processo seletivo dentre os estudantes do primário e com isso afetam a qualidade dos estudantes das escolas regulares. Os resultados sugerem que reduzir a proporção de pares com elevado desempenho afeta negativamente as notas em testes padronizados de matemática e português dos estudantes das escolas regulares. Além disso, a qualidade dos pares impacta sobre a evasão escolar e a taxa de repetência durante o ensino médio. Tais resultados parecem ser explicados pelo aumento da distração dos estudantes, diminuindo seu foco nos estudos.

Palavras-Chave: Efeito dos pares, efeito de equilíbrio geral, Ensino Médio

ABSTRACT

This paper investigates the effect of reducing peer quality on high-school students' outcomes. To identify the causal effect, we exploit an exogenous variation in peer quality caused by the construction of vocational schools. Vocational schools in Ceará, Brazil, perform an admission process and cherry-picking the high-achievers from middle schools, leaving the low-achiever's students to attend regular schools. Results suggest that the share of students attending vocational schools negatively affect the test scores in math and language from regular students. Moreover, we find that peer quality also affects the rate of drop-out and retention during secondary education. The potential mechanism that explains these findings is related to an increase in students' attention diversion.

Keywords: Peer effect, General equilibrium effect, Secondary education
JEL: I2, I28, I24

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1. Introduction

Social interactions are an important factor for several economic outcomes, as health (Fortin; Yazbeck, 2015), crime (Billings; Deming; Ross, 2016), job productivity (Georgeanas *et al.*, 2015, Falk; Ichino, 2006), and education (Sacerdote, 2014). However, the effect of peers in education, notably on secondary education, is fiercely debated. In part, the inconclusiveness is related to identification's problems as self-selecting (sorting), endogenous, and reflection bias (Manski, 1993, Angrist, 1994). To overcome these limitations, recent literature has followed a range of novel identification strategies.

In this paper, we estimate the effect of reducing the quality of peers at Brazilian's secondary schools. Since 2008, the state of Ceará, a Northeast state of Brazil, has expanded the number of vocational schools (*Escolas Profissionalizantes*) relative to regular schools. Unlike other schools in Brazil, the vocational schools in Ceará adopt an admission process that selects high-achievers from middle schools (*Ensino Fundamental II*). The selection process separates high from low-achievers, leaving low-achieving students to attend regular schools².

The construction of a vocational school significantly reduces the proportion of high abilities students attending regular schools. We exploit this variation to identify the impact of reducing the share of high-achievers on the regular students' outcomes. To measure peer quality impact, we consider municipal-by-cohort exposure to the proportion of students attending vocational schools. Increase the share of vocational students reduces the proportion of high-achievers in regular schools.

Theoretically, it is not clear what is the impact of reducing peer quality (Duflo, Dupas, and Kremer, 2011; Lazear, 2001). Unfortunately, empirical pieces of evidence are also controversial. Lavy, Paserman, and Schlosser (2012) estimate that the proportion of repeaters harms the academic achievements of peers. Carrell, Hoekstra, and Kuka (2018) find that the presence of disruptive students in elementary schools negatively affects long-run outcomes, as earnings and college attendance. However, Duflo, Dupas, and Kremer (2011) point out that homogeneous classrooms raise students' test scores, even with a large number of low-achieving students. In this case, the mechanism is explained by teachers' adjustment of pedagogical practice. We expect to shed light on this controversy providing robust empirical evidence.

This paper has two main contributions. First, it estimates the effect of reducing the peer quality on students' outcomes exploiting a plausible exogenous variation in the share of students that leave the regular schools in favor of vocational schools. As short-run outcomes variables, we consider student's test scores in math and language. Using a school-level version of the empirical strategy, we also assess the effect on long-run outcomes as student's drop-out and retention. Both outcomes are relevant to human capital accumulation and may affect the economic opportunities of the students in future.

Second, we extensively explore the potential mechanisms that explain the findings. Analogous to Lavy, Paserman, and Schlosser (2012), we empirically attempt to understand why the increase in the proportion of low achieving peers affects students' outcomes. We analyze several potential channels: student engagement, social skills, teacher pedagogical practices, interest in learning, students' well-being, and time allocation. These channels are related to main theories attempting to explain how peers affect his colleagues. There is no consensual evidence of which channels are more relevant and we expect that this paper helps with this issue.

Our identification approach explores two exogeneity events. First, we assume that the period and location of vocational school constructions are exogenous to students' outcomes. We

² In addition, vocational schools are preferred by parents and students in comparison to regular ones. Parents prefer vocational schools for two reasons. First, vocational school is full-time, contrary to the regulars, which is part-time. Therefore, parents can leave the students under the school's supervision during all workday. Second, vocational schools provide vocational skills, increasing the probability of students enters the labor market after the secondary. In some municipalities of Ceará, the supply of tertiary education is limited, then attending vocational schools can improve the economic opportunity.

test this assumption in several ways. Second, we measure the municipal's exposure to vocational school constructions using the share of students that attend those schools in each municipal-by-cohort. We assume that the choice of attending a vocational school does not depend on the remaining regular students. We discuss in detail the plausibility of this assumption. Under the validity of the identification strategy, we can access the causal effect of reducing peer quality in short and long-run student's outcomes. Our results are the Intention-to-Treat effects (ITT) because we can not guarantee that regular students will be affected by the students that enrolled in vocational schools. Thus, our results can be seen as a lower-bound treatment effect.

The results suggest that the share of students attending vocational schools negatively affects the academic achievements of regular students. The effect size is large and significant at the end of high school. This finding is robust to several model specifications, suggesting that is reliable. The magnitude of the impact on math is higher than in language test scores; however, the difference is small. Hence, the peer quality affect both cognitive skills – reading and mathematical skills – indicating that the effect on the total skills is larger.

Furthermore, low-achieving students in middle education are more affected than other students, supporting the evidence of nonlinear peer effects models. Interestingly, high-achievers math students in middle schools increase their performance in the presence of low peer quality students in secondary. This evidence has two main implications. First, it suggests the validity of weak monotonicity peers effect models', in which lower the quality of the peers, the bigger is the negative effect on students. Second, specifically for math, top-ranked students in the middle can yield better academic achievement in secondary education, despite the quality of the peers.

In addition, we report that a concentration of low-achieving students raises the rate of drop-out and retention during secondary education. The impact on drop-out is more prominent to large municipalities. Small municipalities have modest labor market opportunities; hence, stay out of the school may not be a great option. Similar evidence of long-run effect of peers are reporting by Carrell, Hoekstra, and Kuka (2018), Gould, Lavy, and Paserman (2009), Bifulco, Fletcher, and Ross (2011), Bifulco *et al* (2014), Anelli and Peri (2017). The results are submitted several robustness' checks, and we conclude that our estimates are unlikely to be biased.

A concern is the vocational school constructions potentially also affect the teacher labor markets by attracting better teachers from regular schools. We test this possibility and do not find evidence of teacher labor market changes related to vocational school expansion. The share of students attending vocational schools do not affect teacher turnover, teacher adequation, the average class size, neither school management complexity³.

We then move to understand the channels that explain the underlying effects. There are at least two theories for why low achievement student might harm their peers. First, the classroom composition can affect social interactions or having network externalities (Lazear (2001); Lavy and Schlosser (2011)). Second, a raise of low abilities students can change teacher pedagogical practices (Duflo, Dupas, and Kremer (2011), Lavy, Paserman, and Schlosser (2012)). We investigate both hypotheses.

First, we examine if the marginal low-achieving student affects the students' engagement, students' expectations, classroom noise level, relationship between teacher and students, relationship among students, and time allocation. We find that reducing the peer quality impact on the outside classroom noise level and raise the time of internet usage by the student, a measure of how students allocate her time. Our finding suggests that the main channel through which low-achieving student affect their peers are by diverting student's attention. Reducing peer quality appears to be related to negative network externalities, as the "bad apple" theory of Lazear (2001).

Second, we test if the share of students attending vocational schools' impacts on student perception about teacher practices. We do not find evidence that regular students perceive

³ In the appendix, we present the definition of these educational measures.

changes in teacher pedagogical practices or diverting teacher attention to struggling students, as Lavy, Paserman, and Schlosser (2012). Therefore, teachers' pedagogical practices do not appear to be affected by an increase in the proportion of low-achiever's students.

This paper is related to three strands of literature. First, we contribute the literature about the importance of classroom composition for student outcomes as Lazear (2001), Duflo et al (2011), Lavy et al (2012), Imberman et al (2012), Carrell et al (2018), Shiltz et al (2019), Bossavie (2020), and others. By using a quasi-experimental approach, we cope with the main econometric challenges in peer effect estimation, allowing obtain reliable estimations of the educational social interactions' effect. In addition, our measure of share of low-achievers does not depend on specific students' aspects, as repeaters (Lavy et al (2012)) or disrupt contemporaneous behavior and learning (Carrell et al (2010, 2018)) that may cause difficulty in interpretation of the effects. Second, a few papers study how education policies might have general equilibrium effects on student outcomes (Duflo (2004), Bianchi (2020), Gilraine et al (2018)). This paper complements this literature by showing how the expansions of vocational schools could have unintended spillover effects on students of different schools. Third, this paper sheds light on the channels through the social interactions impact students. A few papers study these mechanisms, especially in secondary schools (Lavy et al (2012)). We add to these studies by evidencing that the main channel of peer effect is related to diverting student attention.

2. Backgrounds

2.1 Vocational schools in Ceará, Brazil

The state of Ceará is located in the Northeast of Brazil, one of the poorest regions in the country. Ceará's per-capita GDP is nearly USD 5,500, which is smaller than the average per-capita GDP in Brazil (close to USD 9,800). The state's population is approximately 9 million, and the Human Development Index (HDI) is 0.68, close to Brazil, 0.69⁴.

Secondary education in Ceará is divided into three main categories: regular schools, vocational schools, and indigenous schools⁵. Regular schools are part-time schools and teach the standard secondary nationwide curriculum, providing skills to students that aim to apply to higher education at the end of secondary. Indigenous schools teach only a specific indigenous curriculum and represent a small share of secondary school in Ceará, nearly 1%.

Since 2008, the government of Ceará has expanded the number of vocational schools. In 2017, there existed 120 vocational schools in Ceará, representing nearly 17% of the secondary education in the state. Vocational schools have remarkable differences comparing with regular ones. First, vocational schools have a full-time program and two different curriculums. In the part-time, students learn standard nationwide curriculum, similar to regular counterparts. In the other part-time, students learn practical knowledge and occupation-specific skills that directly map into entering a particular occupation in the labor market.

Second, vocational schools in Ceará perform an admission process to enroll students. The admission process cherry-picks the high-achievers to attend vocational schools, reducing the proportion of high-achievers at the regular students during secondary education. In general, vocational students have better socioeconomic characteristics, greater grades, and higher levels of non-cognitive aspects, like persistence, than regular students.

During the implementation process of vocational schools, we observe variation in the exposure of students over time and geographical areas. The government smoothly scaled up the program across years and municipalities. Figure 1 shows the municipality evolving of vocational schools along the time between 2010 to 2017.

⁴ To put in perspective, Ceará's GDP is similar to countries like Nicaragua, Mozambique, and Albania.

⁵ There exist a fourth school category since 2018, the full-time schools. However, our data span until 2017.

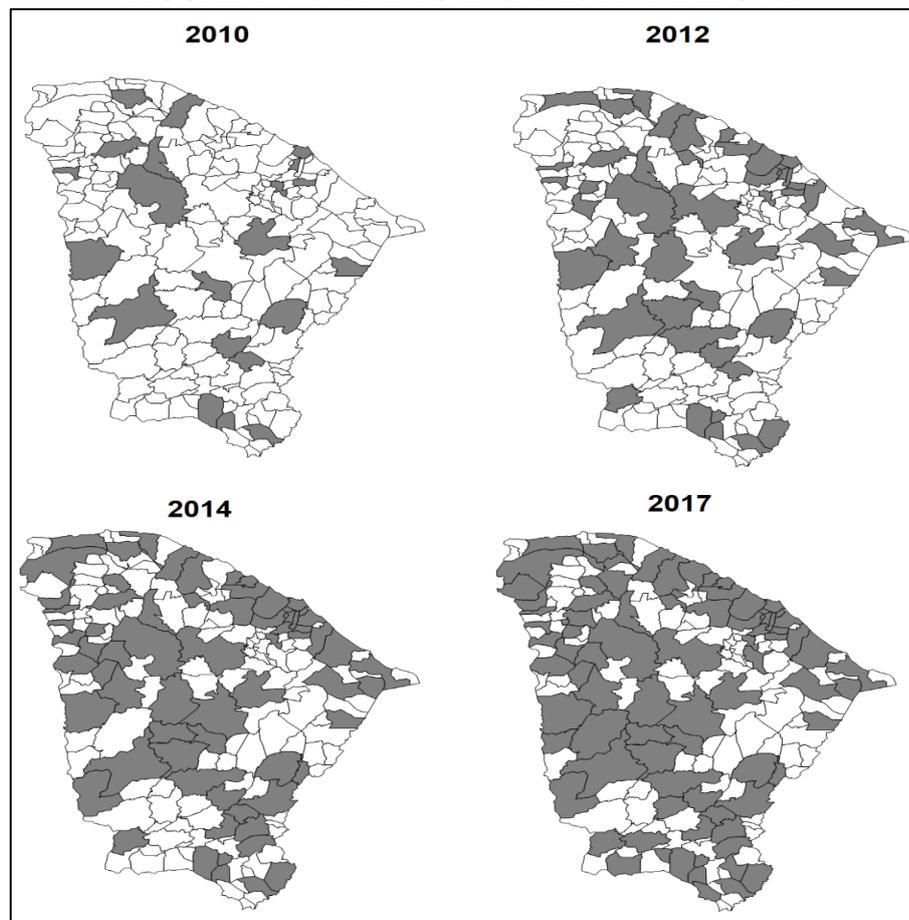
Vocational school is usually preferred by parents and students. The Ceará's state has a small offer of public higher education. Students that attend regular secondary education and do not apply to public universities have few opportunities to enter the labor market. Vocational schools aimed to raise the opportunities for students by providing them occupation-specific skills, allowing enter the labor market just after the secondary.

2.1.1 Admission Process

A special characteristic of vocational schools in Ceará, differently from other public schools in Brazil, is the admission process to cherry-pick the high-achieving students from middle education. To be enrolled in a vocational school, students should apply, at the end of the middle education (9^a grade), in a selection process performed individually by each school. The school ranks the applicants using the average high-stake grades overall 6th to 9th, and the top-ranked students are invited to enroll in the vocational school.

The admission process differentiates vocational from regular students in at least two aspects. First, vocational students show intrinsic motivation to study in these schools because they have to apply to compete for a slot. Demotivated students do not apply and do not participate in the selection process. Second, the admission process selects students based on high-stakes performances over the last three academic years. Therefore, vocational students have higher grades and also sustained their performance for a long time in comparison with other students. This aspect is associated with persistence and grit (Duckworth et al., (2009)).

FIGURE 1: Vocational School construction in Ceará



Notes: Figure 1 presents the variation in time and geographic location of the expansion of vocational schools in Ceará's state, Brazil. The first vocational school was introduced in 2008 and in 2017 there exists 120 schools in Ceará, representing 17% of all secondary schools.

3. Data and Descriptive Statistics

3.1 Data Sources

This paper requires considerable data sources. First, we create the share of students attending vocational schools in each municipality of Ceará's state from the annual School Census, a survey of every school in Brazil, conducted by the Ministry of Education. We consider only students that attended public middle education before enroll in high-schools, excluding students from private schools. The School Census data also allows measuring some school quality indicators, as the proportion of teachers with higher education and the average number of students per classroom.

To measure test scores in math and language, we consider the administrative data from SPAECE⁶, a state test applied by Ceará's Department of Education. The SPAECE data span from 2008 to 2017 and include individual test scores for students in the 9th grade of the middle and 3th grade of high-school (9 and 12 grades). The data contains 550.867 students at the end of secondary (12 grade), where nearly 93% of students attend regular schools.

The Ceará's Department of Education also applies, during the SPAECE, a contextual survey to students that allows construct student demographic and socioeconomic characteristics. In some cases, we were not able to match student test scores to student's survey data because of misreporting. We test different specifications of empirical strategy to cope with this missing information⁷.

The contextual survey also provides several information about student engagement, perception about teacher practices, school climate, and time allocation. We use this information to understand the potential mechanisms of the peer effect.

Finally, we consider as long-run outcomes the rate of school drop-out and the rate of retention during high school. These variables are constructed from the Ministry of Education at the school level. Both variables represent the percentual of students that dropped out or repeated during one of the three years of secondary schools.

3.2 Descriptive Statistics

Based on the admission process, we posit that students attending vocational schools have better performance in comparison with regular students. Figure 2 displays the distribution of test scores in math and language at the ending of grade 9, before they enter in high-school. The scores are standardized to have mean zero and standard deviation one. As suggested by this graph, vocational students outperform regular students in math and language test scores. This evidences that regular students have low-abilities compared with vocational students before they attend vocational schools.

Table 1 summarizes the characteristics of regular and vocational students. We consider test scores and many other demographics and socioeconomical aspects as the proportion of female, age, race, mother's education, and the share of students that the family attends the *Bolsa Família* Program⁸. Vocational students' average score is 27.32 and 13.21 points higher than regular students, in math and language respectively⁹. Regular students are represented by a smaller proportion of girls and white students. In turn, vocational students are younger, their mothers are more educated, and they live in families that have a lower proportion of parents

⁶ *Sistema Permanente de Avaliação da Educação Básica do Ceará* (SPAECE).

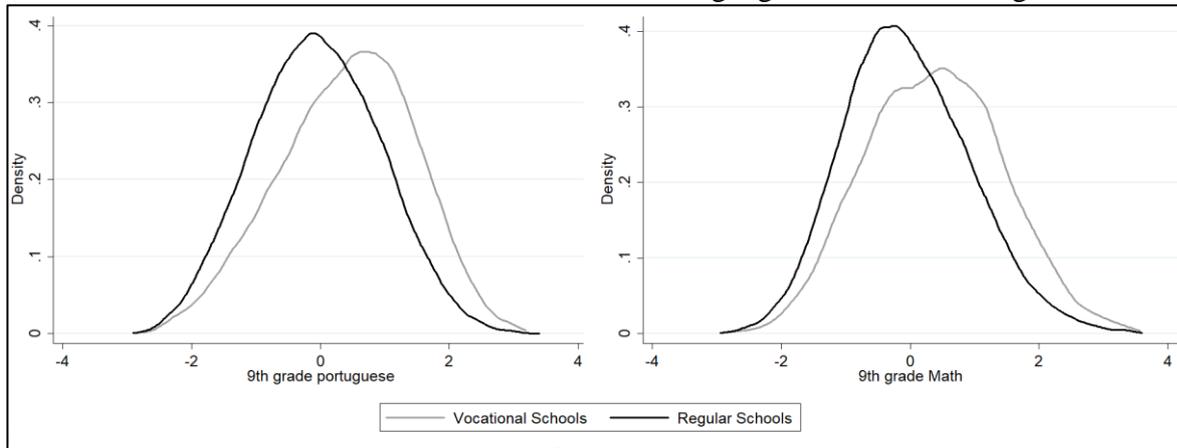
⁷ The SPAECE dataset has few sample restrictions. First, in some years, the SPAECE was not realized on a census basis. We eliminate these years because we do not know how were the sampling design. Second, the misreports restrict the sample to nearly 20% of the 550.867. In the online appendix, we test if the missing data affect the results, however, we found no evidence in this regard. More details in online appendix A1, available by email contact to authors.

⁸ The *Bolsa Família* program is a nationwide conditional cash-transfer program in Brazil. The program provides cash payments to poor households if their children (ages 6 to 15) are enrolled in school, see Glewwe and Kassouf (2012).

⁹ The distribution of the SPAECE test has a mean 250 and a standard deviation of 50 points.

attending the cash-transfer program. These results suggest that vocational students have high cognitive skills and better socioeconomic conditions than regular students.

FIGURE 2: Distribution of math and language test scores in 9th grades



Notes: Figure 2 presents the distribution of math and language test scores in 9th grades for students that in the next year will attend regular (black) and vocational (gray) schools. It shows that vocational students have better performance in both subjects before enroll in secondary education.

We are interested in the causal effect of high achieving peers on students left behind in regular education. Hence, the treatment group is composed of regular students exposed to vocational schools. Table 2, reported in appendix, compares treated and untreated students, i.e. the regular students that were not expose to vocational school construction.

Treated and untreated students are very similar. There is no statistical difference among scores in math and language at the end of middle education, grade 9. Treated students outperform untreated students on language scores at the ending of secondary. Untreated students are represented by a large share of black and brown and are younger than treatment group. In turn, the treated students are less poor, and their mothers have more years of instruction.

In short, treated and untreated students has similar characteristics and we expect that the exposure to vocational schools is the only factor that differentiates short and long-run educational outcomes between the two groups.

TABLE 1: Descriptive statistics comparing vocational and regular students

Variables	Vocational Students		Regular Students		Difference
	Average	SD	Average	SD	
Test Scores Math 9 ^o grade	255.74	47.94	228.42	45.71	27.32***
Test Scores Portuguese 9 ^o grade	249.88	48.61	236.67	44.67	13.21***
Girls	0.57	0.49	0.55	0.49	0.02***
Black	0.11	0.31	0.14	0.35	-0.03***
Brown	0.11	0.31	0.12	0.33	-0.01
White	0.17	0.38	0.08	0.28	0.09***
Age	14.59	1.60	15.34	2.80	-0.75***
Mother education	2.94	1.07	2.85	1.07	0.09***
Attend Bolsa Familia	0.72	0.44	0.74	0.43	-0.02**

Note: Table 1 presents the descriptive statistics of vocational and regular students' factors. The last column shows the difference about the variables' averages. The stars represent the rejection of the null hypothesis of equal mean based on a test t. Significance levels: 1% ***, 5% **, 10% *.

4. Empirical Strategy

To overcome the usual problems of selection and sorting associated with the estimation of peer effects, we rely on exogenous variation in timing and location of vocational school construction. We also access the intensity of vocational school construction's exposure by using the share of students that, in some municipality and cohort, attend vocational school.

Our benchmark specification is the following

$$y_{ismt} = \beta + \gamma Share_voc_{mt} + \delta' X_{ismt} + \alpha' X_{smt} + \tau_t + \pi_s + \varepsilon_{ismt} \quad (1)$$

Where y_{ismt} is the achievement for student i , on the school s , in municipality m , on year t ; $Share_voc_{mt}$ is the share of students attending vocational schools in municipality m in year t . π_s is a school effect, τ_t is a time effect, X_{ismt} is a vector of students controls that includes gender, race, age, mother's education, an indicator that a family is a recipient of a conditional cash transfer program (CCT), 9th grades test scores in math and language, polynomials third-order of these test scores, an indicator that student usage public transportation to go to school. X_{smt} is a vector of school covariates that includes the proportion of teachers with tertiary education and average class size. When presenting our estimates, we show different combinations of these covariates. ε_{ismt} is the error term. Standard errors are clustered at the school level.

Our parameter of interest is γ , which measures the effect of the regular students being exposed to an increase of the proportion of high-achievers attending vocational schools. We assume that the rise of the share of students attending vocational schools implies a reduction of the quality of peers in the regular schools, measured by the proportion of low-achiever's students.

To control for potential confounding factors, we include in all specifications school and time fixed effects. However, one may be concerned that there are time-varying unobserved factors that are also correlated with the proportion of low-achieving students at school level. Therefore, we also estimate a model adding a full set of school-specific linear time trends to (1).

We also consider a school-level version of (1) that is used to estimate the effect of increase the share of low achieving students on the rate of student drop-out and retention. These variables have high opportunity costs for the students suggesting that the peer quality can have a persistent effect.

We estimate the following equation

$$y_{smt} = \beta_0 + \mu Share_voc_{mt} + \vartheta' X_{smt} + \tau_t + \pi_s + \varepsilon_{smt} \quad (2)$$

Where y_{smt} is the proportion of repeaters or students that dropped out the regular school s in the year t in the municipality m . Important, we consider these variables for all high school grades (10, 11, and 12 grades). In the Online Appendix, we estimate the same specification for the three grades of high-school separately.

To control for school potential confounding variables, we include specific school controls, X_{smt} , and school fixed effect. X_{smt} contains the proportion of teachers with tertiary education and average class size. Therefore, we also consider a model that includes school interacted with time fixed effects to capture time-varying school-specific unobservable factors.

4.1 The validity of the identification strategy

The validity of identification strategy depends on two key assumptions: (1) time and location of vocational school construction are exogenous to regular students, (2) the share of students attending vocational schools is unrelated to regular students' unobservable factors.

The first assumption is not validated if the decision about the time and location where constructed a vocational school is related to students' unobservable characteristics. To assess this

possibility, we regress a logit panel model where the dependent variable is the time and location of vocational schools against a vector of controls that includes average students age, proportion of girls, racial shares, and average previous test scores in language and math for 9th and 12th grades. The results do not suggest that the decision to construct a vocational school is reasonably associated with these factors¹⁰. The demographic factors are not significant and the estimates for average grades present contradictory implications. For example, the results indicate that vocational school constructions are correlated to municipalities with higher average language test scores and lower test scores in math.

In turn, the share of students attending vocational schools are unrelated with regular students' unobservable factors is plausible assumption because the decision to be enrolled in a vocational school is taken before the secondary education. Thus, students accepted to enroll in vocational school do not previously know the quality of future peers.

A potential threat to this assumption is the students' capacity to anticipate the quality of future peers in high school based on the quality of current peers in middle schools. We consider this possibility unlikely for two reasons. First, students probably change the school during the transition from middle to secondary education because the number of middle schools is much higher than secondary education¹¹. Second, many students dropped out during the transition to middle to secondary education¹². Both reasons affect the capacity to predict the quality of the peers on secondary.

The contributions of Manski (1993) has evidenced the fundamental problem of selection into peer groups which can contaminate peer effect estimates. First, students may self-select themselves into peer groups based on certain unobserved factors, called correlated effects. Second, peers may influence each other simultaneously, known as reflection problem. Third, it is difficult to distinguish between peer effects due to peers' achievement, endogenous effects, and peer effects due to peers' background, contextual peer effects.

Our empirical strategy overcomes the first and second fundamental problems. The construction of the vocational school has a municipal level impact, i.e. which is not school-specific. This minimizes the self-selection process, especially the exposure of the regular students to high-achievers. In addition, the inclusion of school fixed effects accounts for the most obvious source of student sorting between schools.

A concern is the possibility of student's migration when vocational schools are constructed. We test whether the vocational school construction affects the municipal students' characteristics, like the proportion of girls, the racial shares, age, the proportion of families attending the conditional cash-transfer program, and mother's education. If the vocational school construction produces a relevant migration process, especially from high-achievers, we expect that municipal students' demographics will be affected. Table 2 presents the estimates. All models consider municipal and time fixed effects. We do not find evidence that vocational schools construction impact on these students' characteristics, except to students that report using Public Transport.

¹⁰ The results of these estimates are not reported in this paper by concision; however, it is available under the authors' contact by emails.

¹¹ Particularly in Ceará, there existed 717 secondary schools and 4326 middle schools in 2017.

¹² The rate of school progression from middle to secondary education is 86%.

Table 2: Change in the students' characteristics

	Age	Girls	Black	Brown
	(1)	(2)	(3)	(4)
Treatment	0.256	-0.022	0.001	0.024
	(0.219)	(0.015)	(0.011)	(0.021)
	Public Transport	CCT	Mother Education	
	(5)	(6)	(7)	
Treatment	0.141**	0.103	-0.256	
	(0.052)	(0.078)	(0.202)	

Notes: Table 2 presents the impact of vocational school construction on municipal students' factors. It evidences that only the proportion of students using public transport is significantly affect by the vocational school program. Each estimation includes municipal and time fixed effects. Significance levels: 1% ***, 5% **, 10% *.

5. Results

5.1 Effects on test scores

Tables 3 and 4 report the effect of the proportion of vocational students on high school achievement of regular students in math and language, respectively. We transform SPAECE's test scores into standardized z-scores to facilitate the interpretation of the results. We consider six specifications in which the differences stem from the additional covariates. The presence of missing data in the sample reduces the sample size as more covariates are incorporated.

Column 1 presents the average treatment effect and standard deviation of the outcome variables for regular students considering only additive school and time fixed effects. This sample has nearly half a million students at the end of high-school, spanning from 2008 to 2017. The columns 2-5 include additional controls. Column 2 considers regular controls as gender, age, racial status, and an indicator of the use of public transport. Column 3 adds 9th test scores in math and language to control for previous skills. Column 4 adds as control an indicator for students' families that receive conditional cash-transfer (CCT) and mother's education. Finally, Column 5 includes the third-order polynomials for math and language 9th test scores. Column 6 considers the same specification of column 5, however, it adds the school-by-time fixed effects which controls for potential time-varying unobservable factors.

Results show that all estimates are negative and statistically significant. This suggests that the share of students attending vocational school reduce the performance of students from regular schools. The estimates do not change in magnitude in different specifications, except for Column 3, which includes previous students' test scores. This result can be associated with the sample reduction. However, in more restrictive samples, as Columns 4, 5, and 6 the magnitude of initial specifications is restored.

The average effect size is -0.38σ for language and -0.40σ for math considering three years of exposure to low-achievers peers. The impact of reducing peer quality affects mathematical and reading skills, suggesting that the global effect on student ability can be larger¹³. To put these estimates into perspective, considering that, in 2017, 17% of secondary students in Ceará are enrolled in a vocational school, then the average effect is near -0.06σ for math and language.

¹³ In Online Appendix, we present the estimation on the sum test scores. The point estimate is -0.79σ for our preferred specification similar to column 5 in both tables.

Table 3: Estimates of the proportion of vocational students on math achievement of regular school

Math	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.410*** (0.065)	-0.347*** (0.076)	-0.165* (0.093)	-0.419*** (0.131)	-0.444*** (0.128)	-0.498*** (0.049)
School fixed effects	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y
Regular control		Y	Y	Y	Y	Y
Prior test scores			Y	Y	Y	Y
Additional control				Y	Y	Y
Non Linearities					Y	Y
School-time fixed effects						Y
N. obs.	502.920	364.260	167.499	96.176	96.176	96.176

Notes: Table 3 reports the effect of share of vocational students on math test scores of regular students. The five specification change according to the number of covariates in each model. The specifications (1) to (5) contains school and time fixed effect. The column (6) presents results for the school-by-time fixed effects. The standard errors are estimated clustering by school. Significance levels: 1% ***, 5% **, 10% *.

These results evidence that peer quality is relevant to students' achievements. Specifically, our results indicate that peer quality matters to test scores at the end of secondary education in Brazil. Although the effect size is not large, we can compare it with other studies. Jackson (2014) analyzes the effect of teacher quality on high-school students in North Carolina State, US. The impact of a decrease by one standard deviation the teacher quality is 0.06, similar to our estimates. Then, to put in perspective, the effect of reducing peer quality is equivalent to reducing teachers' value-added by one standard deviation, according to estimates from Jackson et al (2014).

Table 4: Estimates of the proportion of vocational students on language achievement of regular school

Language	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.490*** (0.061)	-0.379*** (0.066)	-0.258** (0.085)	-0.330** (0.118)	-0.337** (0.116)	-0.359*** (0.048)
School fixed effects	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y
Regular control		Y	Y	Y	Y	Y
Prior test scores			Y	Y	Y	Y
Additional control				Y	Y	Y
Non Linearities					Y	Y
School-time fixed effects						Y
N. obs.	502.920	364.260	167.499	96.176	96.176	96.176

Notes: Table 4 reports the effect of share of vocational students on math test scores of regular students. The five specification change according to the number of covariates in each model. The specifications (1) to (5) contains school and time fixed effect. The column (6) presents results for the school-by-time fixed effects. The standard errors are estimated clustering by school. Significance levels: 1% ***, 5% **, 10% *.

5.1.1 Heterogenous effects on test scores

There exist a fiercely debate about the presence of non-linearity of peer effect models. For example, the monotonicity model posits that lower the quality of the peers the bigger is the

negative effect on students. We test the presence of non-linear effects on regular students due to an increase in the share of students attending vocational schools.

We verify the effect of being exposed to large peer quality reduction on regular students considering the educational status in 9th grade. The Ceará's Department of Education classifies the students in the 9th grade in four levels according to performance in test scores: Very Critic, Critic, Intermediate, and Adequate¹⁴.

We estimate our preferred specification that includes all variables similar to Column 5 of Tables 3 and 4. To assess the heterogeneous effect, we interact the variable $Share_voc_{mt}$ with each of the educational levels, measured in 9th grade. Table 5 presents the heterogeneous effect estimates on math and language test scores.

Students at a Very Critic level are most negatively affected in both math and language. This suggests the validity of the monotonicity model, i.e., worsen peers lower the test scores of their peers. This pattern is clearer for language test scores, in which all educational levels are harmed by having peers less able. The magnitude of the effect decreases according to the educational level raise, except for the Critic level, indicating the presence of weak monotonicity (IMBERMAN et al., 2012)).

Specifically for math, students at the Adequate level benefit if more students attend vocational school. This indicates the presence of the invidious model, which posits that a student's performance increase by having less able peers. In short, the monotonicity property is verified for language and is less obvious for math.

Table 5: Heterogeneous effect of reducing peer quality on test scores

<u>Panel A: Math</u>	Very Critic	Critic	Intermediate	Adequate
Treatment	-0.471*** (0.108)	0.071 (0.087)	0.159 (0.108)	0.873*** (0.231)
<u>Panel B: Language</u>	Very Critic	Critic	Intermediate	Adequate
Treatment	-0.593*** (0.134)	-0.283*** (0.115)	-0.439*** (0.123)	-0.354*** (0.116)

Notes: Table 5 reports the heterogeneous effect of share of vocational students on language and math test scores of regular students, considering the educational level achieved by students at 9th grade. The specification includes covariates in each model. All specification contains school and time fixed effect. The standard errors are estimated clustering by school. Significance levels: 1% ***, 5% **, 10% *.

5.2 Effect on student's drop-out and retention

There are relatively few pieces of evidence of the long-run educational consequences of peers. Carrell, Hoekstra, and Kuka (2018), Anali and Peri (2017), and Bifulco et al (2014) are exceptions. We attempt to assess the long-run effect of reducing peer quality by estimating the impact on the rate of student dropout and the rate of student retention. Both variables have long-run consequences for secondary students.

We consider a school-level specification where the dependent variables are the rate of students' drop-out – i.e. the proportion of students that dropped out the school in each cohort - and the rate of students' retention – i.e. the ratio of students who remains in the same grade in each year. The specifications include school controls as the average class size and the proportion of teachers with tertiary. We also include school and time fixed effects.

¹⁴ This approach is more suitable to testing nonlinear models using our data. The standard approach is based on quartile specifications as Imberman et al (2012) or Hoxby and Weingarth (2006). Our sample has many missing values in 9th-grade, which prevents obtaining the actual ranking of the student in 9th grade.

Student drop-out is related to labor market opportunities (Atkin, 2016; Charles et al, 2018; Carrillo, 2020). The effect of reducing peer quality on student drop-out should be greater in places with better opportunities to enter in labor markets because students, face a negative incentive, can search for other opportunities outside the school. In places with few labor opportunities, we expect that the peer quality has a lower effect on students' drop-out. To verify this possibility, we also estimate a model considering only municipalities with less than 150 thousand inhabitants, called here small municipalities.

Table 6 reports the estimates of the proportion of students attending vocational schools on those outcomes. The column 1 refers to the impact on school dropout considering all municipalities of Ceará, and column 2 presents the effect on school dropout just for small municipalities. Column 3 refers to the impact on school retention for all municipalities, and column 4 shows the effect on just small municipalities.

The results suggest that reducing peer quality increase the likelihood of school drop-out in 5.3 percentual points, considering all municipalities (Column 1). On average, 11,4% of secondary students dropped out in secondary education in Ceará. Thus, the estimate represents an increase almost of 50% on the rate of school drop-out in average. Therefore, the impact of peer on student drop-out is large, suggesting that peer quality matters for longer-run outcomes.

Nonetheless, in column 2, the effect of reducing peer quality is not significant, although it is positive. Small municipalities of Ceará show few economic opportunities for students to enter the job market and students may prefer to stay in school than to drop out of it. Together, the results suggest that peer quality can affect the student's decision to drop out the school, however, the economic opportunities also should play an important role in student decision.

In turn, the effect of reducing peer quality affect significantly the rate of school retention, even in small municipalities. In the columns 3 and 4, the impact of the share of students attending vocational school on regular school retention is 3.2 percentual points considering all municipalities and 2.9 percentual points considering just the small's one. On average, the rate of school retention is 7.08% in secondary education in Ceará. This represents a raise of 35% in the school retention considering all municipalities.

Table 6: Effect on the rate of school drop-out and retention

	School drop-out		School Retention	
	All municipalities	Small municipalities	All municipalities	Small municipalities
Treatment	5.380** (2.353)	1.050 (2.377)	3.250** (1.467)	2.956* (1.517)
Mean	11.4%	9.3%	7.1%	6.7%
N. of municipals	184	181	184	181
N. of schools	555	395	556	391

Notes: Table 6 reports the impact of share of vocational students on language and math test scores of regular students, considering the educational level achieved by students at 9th grade. The specification includes covariates in each model. All specification contains school and time fixed effect. The standard errors are estimated clustering by school. Significance levels: 1% ***, 5% **, 10% *.

In short, we conclude that reducing peer quality has relevant consequences for students' outcomes in both the short and long-run. It is also interesting to note that the construction of vocational school generated an unintended effect on students that were not directly affected by these schools. This highlights the importance of public policy design.

6. Robustness

We conduct several robustness tests to verify if the estimates are robust. First, to check if the estimates capture a spurious correlation among the share of students attending the vocational school and the regular students' outcomes, we realize a falsification test using placebo regression. In short, we verify if the share of vocational students in the municipality m , in the year t affects the students' outcomes of regular students in the same municipality, in the year $t - 1$. If the estimates are significant, then potentially the treatment effects are driven by short-run trends.

Table 7 reports the placebo test estimations. We show no significant effect on the share of vocational students on previous regular students' test scores. The exception is the column (1) for language test scores. This specification does not include any covariates. The inclusion of the control variables eliminates the significance, suggesting that the validity of the estimates is conditioning to covariates in such a case.

Next, we test if the results depend on the measure of vocational school's exposure. We do not expect that distinct measures of the vocational school's intensity yield contrasting estimates. We consider two alternative measures of vocational school's exposure. First, it is a binary variable indicating the year that some municipality received the first vocational school. In this case, the model is interpreted as a standard difference-in-difference estimation. Second, we define the proportion of vocational schools for each municipal-by-year. Table # shows the results for both alternatives measures. Although some estimates are not significant, the signal of the parameters is negative, suggesting that the vocational school's exposure can negatively affect the students' outcomes.

Table 7: Falsification test

<u>Math</u>	(1)	(2)	(3)	(4)	(5)
Placebo Effect	-0.024 (0.016)	-0.007 (0.014)	0.029 (0.030)	0.038 (0.029)	0.041 (0.029)
<u>Language</u>	(1)	(2)	(3)	(4)	(5)
Placebo Effect	-0.033** (0.014)	-0.022 (0.031)	-0.022 (0.027)	-0.010 (0.031)	-0.008 (0.031)
No control	Y				
Regular control		Y	Y	Y	Y
Prior test scores			Y	Y	Y
Additional control				Y	Y
Non Linearities					Y

Notes: Table 7 reports falsification test. It tests if the share of vocational students in the municipality m , in the year t affects the students' outcomes of regular students in the same municipality, in the year $t - 1$. All specification contains school and time fixed effect. The standard errors are estimated clustering by school. Significance levels: 1% ***, 5% **, 10% *.

Finally, we test if the learning incentives depend on local economic opportunities. Big municipalities yield distinct local labor market incentives in comparison with small ones, potentially affecting students' effort. To test this possibility, we also estimate a model that ignores municipalities with more than 150 thousand inhabitants.

Table 9 present the estimates that including school-by-time fixed effects for math and language test scores. Comparing the results with the columns (5) of tables 3 and 4, small municipalities do not appear to cause a heterogeneous effect on the main results.

Table 8: Alternative measures to vocational school exposure

	Math Scores				Language Scores			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Binary Treatment	-0.087*** (0.013)	-0.075*** (0.020)	-0.086*** (0.029)	-0.087*** (0.029)	-0.072*** (0.010)	-0.106*** (0.018)	-0.041 (0.028)	-0.040 (0.028)
School Treatment	-0.216*** (0.079)	-0.041 (0.091)	-0.207 (0.128)	-0.205 (0.127)	-0.164*** (0.067)	-0.011 (.084)	-0.216* (0.131)	-0.216* (0.131)
No control	Y				Y			
Regular control		Y	Y	Y		Y	Y	Y
Additional control			Y	Y			Y	Y
Non Linearities				Y				Y
N. obs.	507.648	368.932	97.433	96.933	507.648	368.932	97.433	96.933

Notes: Table 8 reports similar estimation of tables 3 and 4, however with alternative measures vocational school exposure. Binary treatment represents an indicator variable with one to municipalities m that receive a vocational school in time t , and School Treatment represent the share of vocational school in relation to regular ones. All specification contains school and time fixed effect. The standard errors are estimated clustering by school. Significance levels: 1% ***, 5% **, 10% *.

Table 9: Effect of the share of vocational students on small municipalities

Small municipalities	
Math	Language
-0.454*** (0.137)	-0.404*** (0.124)

Notes: Table 9 reports similar estimation of tables 3 and 4, however, considering only small municipalities. All specification contains school and time fixed effect. The standard errors are estimated clustering by school. Significance levels: 1% ***, 5% **, 10% *.

7. Mechanisms

Few papers address empirically the channels that explain the peer effects on education, exceptions are Duflo, Dupas, and Kremer (2011), and Lavy, Paserman, and Schlosser (2012). From a theoretical point of view, two concurrent theories attempt to predict the mechanisms of peer effect. First, reducing peer quality can affect classroom behavior, impacting student's effort to learning as in Lazear (2001). In turn, Duflo, Dupas, and Kremer (2011) argue that student composition can change teacher pedagogical practices, and thus affecting the quality of learning. Interestingly, theories predict contradictory effects for the importance of peers in secondary education.

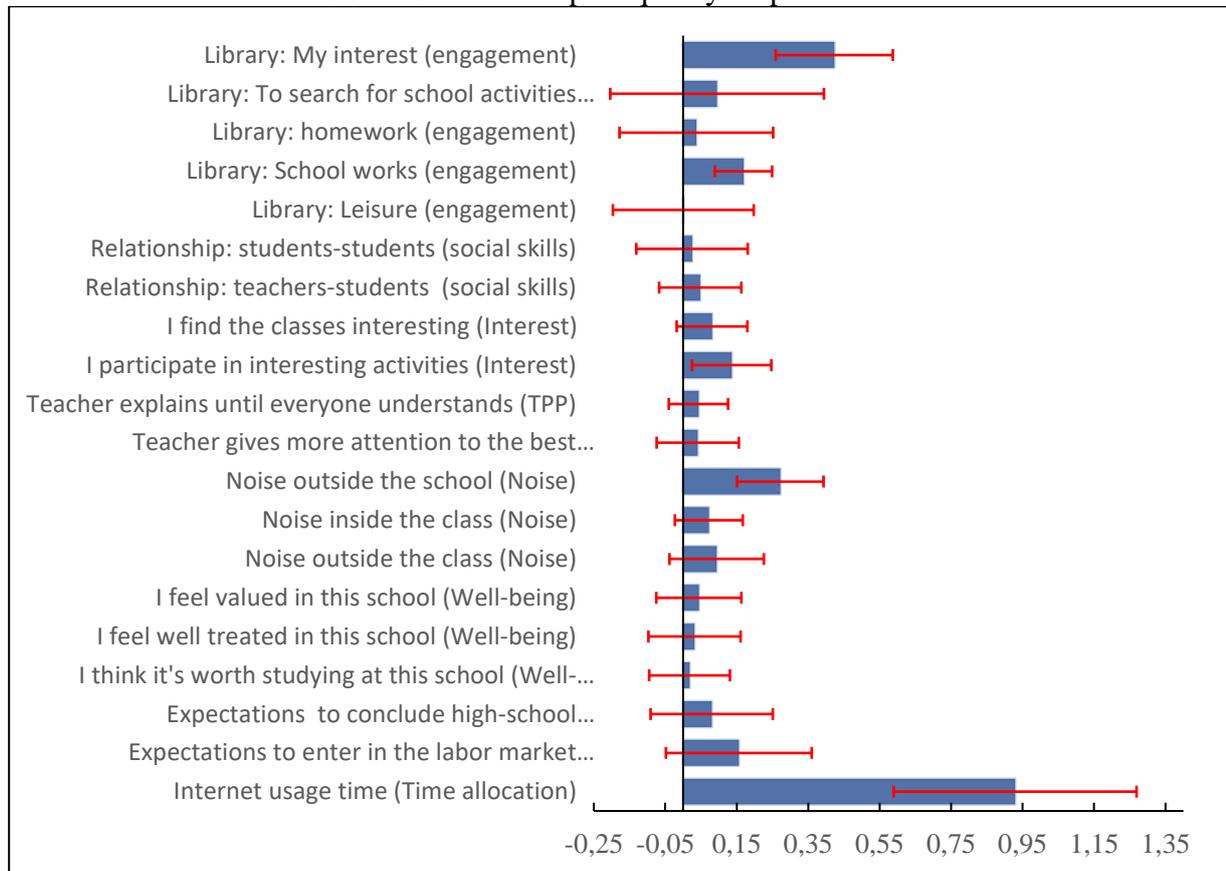
This paper contributes to this discussion by assessing the channels of peer effects in an exploratory way. Using the contextual survey of SPAECE, we select 20 items referring to the following categories: student engagement, social skills, interest in learning, school well-being, noise at school, expectations, and time allocation. We test the effect of the proportion of students attending vocational school on these indicators¹⁵.

We consider a model that includes covariates as the age, gender, race, an indicator if the student's family attends a conditional cash-transfer program, and mother's education. Also, we include time and school fixed effects to control for time-varying and time-invariant unobservable factors. Figure # displays the estimates for each item. In parenthesis is the categories' names. For example, "*Library: My interest (engagement)*" refers to the question "*I go to the library to my*

¹⁵ Although the contextual survey of the SPAECE to be applied in all year of the sample, there are substantial difference among the items across the years. Therefore, we consider only the cohorts 2010-2013 and 2011-2014. To detailed information about this sample, see the Online Appendix available by email to the authors.

own interest” and is related to school engagement. All items are standardized, then the estimates represent standard deviations.

FIGURE 3: Effect of peer quality on potential mechanisms.



Notes: Figure 3 presents the impact of the share of vocational students on several variables that explains the mechanisms of why the reduction of peer quality affect students’ outcomes. We regress each variable against additive school and fixed effects and the share of vocational students. The standard errors are estimated clustering by school level.

Only four variables present significant effects: going to the library by my interest, going to the library because of school works, the noise outside the school, and internet usage. The last two variables suggesting that peer quality affects student attention. The share of students attending vocational school affects the student time spending on the internet, i.e., reducing peer quality changes the student's time allocation. Another relevant factor is the noise outside the school, which is negatively affected by the share of vocational students. Both results suggest that reducing peer quality diverting the student focus on learning.

Interestingly, our results contrast with Duflo, Dupas, and Kremer (2011), and Lavy, Paserman, and Schlosser (2012) because we do not support the notion that a high proportion of low-achieving students induce teachers to modify their pedagogy and their personalized attention to better students. Students do not perceive that teacher diverting her attention to specific students.

8. Conclusion

This paper investigates if peer composition affects secondary students’ outcomes. To identify the causal effects, we exploit the variation of vocational schools in time and location across municipals of Ceará from 2008 to 2017. Vocational schools in Ceará realize an admission process to cherry-pick the high-achievers from primary education. This selective process reduces the share of high-achievers in regular secondary schools.

We find that regular students exposed to vocational school construction decrease their performance in math and language test scores. The effect is large, significant and presents small variations in different specification, suggesting that the estimates are reliable.

In addition, we also test the effect of peer composition on the rate of school drop-out and the rate of retention during secondary education using a school-level version of the empirical strategy. Our results indicate that reducing the peer quality increase the rate of students that drop-out the school (this result is restricted to large municipalities) and the rate of repeaters. We realize a battery of robustness' checks and we conclude that our estimates are unlikely to be biased.

Moreover, we are interested to understand the underlying mechanisms that explain the results. Using a contextual survey applied to students, we test different potential channels: student engagement, social skills, teachers' pedagogical practices, student's well-being, school and classroom noise, and student's time allocation.

The vocational school exposure affects student time allocation and outside school noise. Specifically, the share of students attending vocational schools increases the time spending by regular students on the internet. Therefore, we conclude that the mechanism that explains our results is the students' diversion, following the "bad apple" theory of Lazear (2001).

Finally, this paper contributes to literature investigating the unintended effect of some policies. In our case, the construction of selective public schools changes the composition of regular schools, reducing the quality of their peers. The effect harms the regular students affecting short and long-run outcomes. Policy-makers should account for this spillover effect when evaluating the overall impact of the vocational school expansion in Ceará.

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Appendix

Table A1. Descriptive statistics

Variables	Treated		Untreated		Difference
	Average	SD	Average	SD	
<i>Test Scores</i>					
Test Scores Math 9°	236.80	44.50	236.70	44.83	0,10
Test Scores Portuguese 9°	229.00	45.75	227.72	45.50	1,28
Test Scores Math 3°	259.24	49.08	258.72	49.82	0,52
Test Scores Portuguese 3°	258.07	47.08	251.48	46.79	6,59*
<i>Race</i>					
Black	0.223	0.416	0.130	0.336	0,09*
Brown	0.125	0.331	0.081	0.274	0,04*
White	0.206	0.404	0.134	0.341	0,07*
Other	0.443	0.496	0.653	0.475	0,21*
<i>Mother education</i>					
Incomplete Primary	0.023	0.150	0.012	0.109	0,01*
Primary	0.169	0.289	0.093	0.216	0,07*
Secondary	0.055	0.228	0.031	0.174	0,11*
Higher	0.019	0.139	0.011	0.106	0,008
<i>Others</i>					
Conditional Cash-Transfer	0.754	0.430	0.742	0.437	0,01
Public Transport	0.290	0.453	0.510	0.499	-0,22
Girl	0.551	0.497	0.566	0.495	0,01

Table A2: Definitions of teacher and school quality measures

Variable	Definition
Average student by class	Total of students in each class divided by the total of students in each school.
Average class-hours by schools	Average class-hour in each school during the secondary.
Teacher overwork	Refers to the number of tasks that a teacher needs to perform his profession.
Teacher adequacy	High adequacy occurs when teacher teaches exactly what he/she was trained to teach. Example: Math teacher that teach Chemistry represent a low adequacy.
Proportion of teachers with tertiary education	Total of teachers with tertiary education divided by the total o teachers in each school.
Teacher turnover	Refers to the amount of turnover by school.
School managment complexity	School with management complexity have a large number of students and many stages of education.