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Do students improve their academic achievement when assigned to a growth mindset teacher? Evidence from Census Data in Chile using a Student Fixed Effect Design

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Do students improve their academic achievement when assigned to a growth mindset teacher? Evidence from Census Data in Chile using a Student Fixed Effect Design[1]

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Abstract

Growing evidence shows that a student's growth mindset (the belief that intelligence is malleable) can benefit their academic achievement. However, due to limited information, little is known about how a teachers' growth mindset affects their students' academic achievement. In this paper, we study the impact of teacher growth mindset on academic achievement for a nationwide sample of 8th and 10th grade students in Chile in 2017. Using a student fixed effect model that exploits data from two subject teachers for each student, we find that being assigned to a teacher with a growth mindset increases standardized test scores by approximately 0.02 standard deviations, with larger effects on students with high GPAs and particularly on students in low socioeconomic schools.

Keywords: growth mindset, fixed mindset, teachers, student academic achievement, fixed effect.

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Introduction

A prominent focus of research on education over the past 10 years has been the social and emotional development of students. In line with this, research focusing on the measurement, impact, and development of students' socioemotional skills has increased (Yeager et al., 2011; Taylor et al., 2017; MacCann et al., 2020). In particular, *growth mindset*—the belief that intelligence is malleable and can grow as opposed to being fixed (Dweck, 2012)—has gained special attention from educational foundations, nonprofit organizations, state governments, and school districts in the US and other countries (Farrington et al., 2012; Hough et al., 2017; West et al., 2018; Marsh et al., 2018; OECD, 2019). Several US school districts monitor students' mindsets through self-reported surveys, such as the CORE districts (a consortium of school districts in California), and both the federal government and educational foundations are investing in research to study the effect of different interventions to increase the prevalence of growth mindsets (Obama, 2014; National Science and Technology Council, 2015).[2]

Many studies have shown the importance of student growth mindset on academic development (Yeager et al., 2019; Alan et al., 2019; Paunesku et al., 2015; Blackwell et al., 2007). Although the literature has shown that a growth mindset intervention[3] directly applied to students can lead to an increase in their academic achievement (Yeager et al., 2019), there is little evidence on how a teacher's growth mindset can affect these results. Some studies have found that a teacher's mindset seems to shape their behaviors and plays an important role in their pedagogical thinking and practices (Rubie-Davies et al., 2011; Rattan et al.,

[2] Obama, Barack (2014) Weekly Address: Everyone Should Be Able to Afford Higher Education [video]; National Science and Technology Council (2015) Social and Behavioral Sciences Team. Annual Report.

[3] For a detailed discussion of growth mindset interventions see Yeager et al. (2016)

2012; Schmidt et al., 2015; Smith et al., 2018; Rissanen et al., 2019; DeLuca et al., 2019; Zeng et al., 2019); to the best of our knowledge, however, there is no research regarding its impact on student academic achievement. Moreover, the few studies that have explored the correlation between teacher mindset and student achievement have been based on small samples (Truax, 2018; Smith et al., 2018; Rissanen et al., 2019; Bostwick et al., 2020). And most studies have focused on other outcomes than academic achievement, such as writing and motivation (Truax, 2018; Rattan et al. 2012). Hence, there is no evidence showing that school teachers with growth mindsets benefit students' achievement more than teachers with fixed mindsets, or whether this potential benefit applies across different types of students. Assessing whether teachers with a growth mindset benefit their students' academic achievement more than teachers with a fixed mindset may help the design of policies relating to teacher selection, teacher education, and professional development and to increase the effectiveness of the educational system.

In this paper, we present evidence on a national scale on the impact that being assigned to a teacher with a growth mindset has on student academic achievement. In addition, we analyze how this impact differs across student groups and school socioeconomic characteristics, which may help us better understand the types of students that would gain most from teachers with a growth mindset. To evaluate this effect on student academic achievement, we use nationwide data for 8th and 10th grade students and their teachers in Chile, which includes standardized test scores in mathematics, Spanish, social science, and science, as well as student, teacher, and parent surveys. The teacher survey includes items to measure teacher growth mindset. In 2017, the survey was applied to all 8th and 10th grade teachers and two subject teachers per student responded to the questionnaires. This provided us with the

opportunity to estimate the effect of being assigned to a teacher with a growth mindset on students' academic achievement using a student fixed effect strategy. In the majority of schools in Chile, students have all their lessons in one classroom and teachers attend the classroom when required. Hence, students have the same peers for all subjects, only the subject teacher varies. Every student is evaluated in two subjects for which they have different teachers. This allows us to estimate the relationship between student academic achievement in a particular subject and the corresponding mindset of the teacher, controlling for each student's characteristics by adding student fixed effects. Furthermore, due to the size of our database, we can analyze which student subgroup most benefits from being assigned to a teacher with a growth mindset.

Our analyses indicate that being assigned to a teacher with a growth mindset increases the standardized test scores of students by approximately 0.02 standard deviations, with larger effects on students in low socioeconomic schools and students with a high grade point average (GPA). The difference in effects between schools with the highest percentage of low-income students and those with the lowest percentage of low-income students is 0.053 standard deviations, and this result is statistically significant at the 1% level. The difference between students with a high GPA and a low GPA is 0.016 standard deviations, and it is statistically significant at the 5% level. These effect sizes are meaningful and in the range found in other studies that focus on student academic achievement. For example, Ladd and Sorensen (2017) find similar effect sizes in the difference between a teacher with one year's experience and one with no experience. Being taught by a teacher with one year's teaching experience raises students' reading achievement by about 0.02 standard deviations more than being taught by a teacher with no experience. In math, the difference in reading achievement

is about 0.07 standard deviations. A second example is Paredes (2014), which studies the effect of teacher gender on student academic achievement for 8th grade students in Chile. The paper shows that being assigned to a female teacher increases female student academic achievement by 0.03 standard deviations, with no effect for male students.

We also explore two possible mechanisms for how a teacher's growth mindset may impact on student academic achievement. Because of data limitations we do this through correlational analyses. First, we find that teacher growth mindset has a positive and significant correlation with pedagogical practices identified with better teaching. Second, we find that a teacher's mindset does not have a significant correlation with the mindset of the teacher's students. Thus, our results suggest that one mechanism through which a teacher's growth mindset impacts student academic achievement may be through improved teaching rather than by improving their students' mindsets. However, because the mechanisms presented are correlations they should be taken with caution.

The findings of our study contribute to several strands of literature. First, this study adds to the scarce literature on teacher growth mindset and the impact it has on student development. Previous literature has studied teacher mindset through noncausal analysis, using small samples, or by measuring different outcomes than student academic achievement. For instance, using qualitative evidence, Truax (2018) shows that when a teacher gives a growth mindset feedback students report increased motivation for writing. Rattan et al. (2012) show experimentally that teachers with a growth mindset not only hold higher expectations for students and give more appropriate feedback to students in math but also that students reported higher motivation and higher expectations for their own performance. However, they only explore this phenomenon among tertiary-level teachers. Yeager and Walton (2011)

suggest that training teachers in social-psychological topics may maximize the impact of psychological interventions on students and generate long-lasting benefits.

Considering these studies, we complement this knowledge by bringing quasi-experimental evidence on the positive impact of being assigned to a teacher with a growth mindset on student academic achievement in standardized tests. The mindset instrument applied in the survey data used in this study is adapted from a growth mindset instrument developed by Farrington et al. (2012). This same instrument is used in other student surveys in the US to measure student growth mindset (Loeb et al., 2012; Hough et al, 2017).[4] Although our study is just a first step in assessing the effects of being assigned to a teacher with a growth mindset on a national level, the findings provide initial evidence that it may be beneficial to monitor the prevalence of a growth mindset among teachers, especially in low socioeconomic schools.

Second, we contribute to the education policy literature that estimates teacher effects on student development. More specifically, different studies have used the same methodology that we use to measure the effect of teachers on academic achievement. For instance, Egalite et al. (2015) study the effect of same-race teachers on student academic achievement and find a small but significant positive effect when Black and White students are assigned to race-congruent teachers in reading. In a similar line of research, using a classroom fixed-effects strategy, Egalite and Kisida (2018) find that students assigned to a teacher with similar demographic characteristics have a positive effect on their academic perceptions and

[4] The items of the mindset instrument developed by Farrington et al. (2012) only partially overlaps with the instrument used in other mindset studies (Dweck, 1999; Paunesku et al., 2015; Claro et al., 2016; Yeager et al., 2019). It is important to take into account the instrument used before comparing results across studies (Hwang, Reyes, Eccles, 2019).

attitudes. Additionally, using panel data and both teacher and student fixed effects, Rockoff (2004) finds large and statistically significant effects showing that teacher quality increases reading and math test scores and that teaching experience has statistically significant positive effects on reading test scores. Rivkin et al. (2005) show that teachers have powerful effects on reading and math achievement; however, little of the variation in teacher quality is explained by observable features. In this sense, we show that a teacher's mindset is another factor that helps to improve their students' academic achievements.

Finally, this study contributes to the literature that explores the heterogeneous effects of a growth mindset. Previous studies have found that growth mindsets in students have a larger relationship with achievement for low-income students (Claro et al., 2016; Claro & Loeb, 2019) and students with lower grades (Paunesku et al, 2015; Yeager et al, 2019). We complement this literature by studying the heterogeneous effects of teacher growth mindset on student academic achievement. We show that, consistent with the literature, teacher growth mindset has a larger effect on lower-income students. In contrast to the existing literature, however, we find that students with higher grades benefit more from being assigned to a teacher with a growth mindset than those with lower grades. In fact, students with lower grades do not appear to benefit from being assigned to a teacher with a growth mindset. We also report heterogeneity depending on a student's gender, mindset, and school subject.

Data

This study uses a nationwide dataset collected by Chile's System for Measuring the Quality of Education (known by its Spanish acronym, SIMCE). In 2017, students from the 8th grade were evaluated in mathematics, Spanish, and science, and students from the 10th grade were

evaluated in mathematics, Spanish, and social sciences. The dataset includes 222,567 students from the 8th grade and 210,444 students from the 10th grade, representing 94.1% and 92.3% of students in each grade, respectively.

In addition to the test scores, the SIMCE data includes results from student, teacher, and parent questionnaires.[5] As part of this system of standardized testing, Chilean students from the 4th, 6th, 8th and 10th grades are tested in a range of subjects. Some grades and subjects are evaluated every year and others in alternate years. In 2017, students from the 8th grade were evaluated in mathematics, Spanish, and science, and students from the 10th grade were evaluated in mathematics, Spanish, and social sciences. Additionally, two teachers were surveyed corresponding to each student that took the standardized test. For students in the 8th grade the teachers for math and science were selected, and for 10th grade students the teachers for Spanish and social science were chosen. In total, 29,625 teachers were surveyed in 2017 (Agencia de Calidad de la Educación, 2018).

The teacher questionnaire results include information about a teacher's characteristics and credentials, such as gender, type of certification, experience as a teacher, and years at the current school. In addition, teachers are asked about the malleability of intelligence using four items that measure their beliefs about intelligence and learning.[6] Adapted from Dweck (1999) by Farrington et al. (2013), these items offer 4 alternatives on a likert-type scale

[5] More details on the SIMCE tests can be found at https://www.agenciaeducacion.cl/evaluaciones/que-es-el-simce/

[6] Teachers are asked to rate how much they agree with each of the following four statements on a 4-point Likert-type Scale: (1) "My intelligence is something that I can't change very much"; (2) "Challenging myself won't make me any smarter"; (3) "There are some things I am not capable of learning"; (4) "If I am not naturally smart in a subject, I will never do well in it". See Figure A1 for the distribution of these questions.

ranging from strongly agree to strongly disagree. In the 2017 teacher survey, 92% of teachers answered the four questions.

To create a mindset score, we equally averaged the ratings of the four items. (The internal consistency analysis indicated that all four survey measures were internally consistent with Cronbach's alpha scores of 0.772). Then, we classified each score as either growth mindset or fixed mindset following Claro et al. (2016): teachers who disagreed or strongly disagreed with the statements suggesting that intelligence cannot be changed were categorized as having a growth mindset (Figure A2 shows the distribution of this mindset score).[7] Teachers were also asked about the expectations they had for their students' educational attainment: They were asked what they thought was the highest educational level that the majority of their students in the class would achieve. The teachers who answered that most of their students will complete either a professional institute, college, or graduate degree were considered to be teachers with high expectations.

The student questionnaire provides information regarding perceptions of teachers' classroom practices and about the student's own mindset. The parent questionnaire provides information on family income and mother's education, among other factors.

In addition to the variables found in the SIMCE 2017 database, we also use administrative information on students' past test scores and students' GPAs for the previous year (2016) for math, science, social science, and Spanish. Therefore, we can control for previous GPA in

[7] Teachers with an average equal to or higher than three were classified as teachers with a growth mindset; the rest were classified as having a fixed mindset. We used the same criteria for classifying the mindset of students. As a robustness check for the results, we constructed a second measure of mindset. This new measure is equal to one only if teachers *strongly disagree* with the statements suggesting that intelligence cannot be changed.

our model. We also incorporate past standardized test scores for the 8th-grade cohort because these students were evaluated in the same subjects (math and science) in 2013, when they were in the 4th grade.[8]

Our final sample includes 292,960 students, which equates to 63% of students in 8th and 10th grades in 2017 (and 68% of students evaluated by the SIMCE in these grades). The final number of teachers included in our sample was 24,636, which equates to 83% of the total number who answered the teacher survey. The rest of the students and teachers were omitted due to missing information, such as teacher mindset, student tests scores, gender or previous GPA.

The descriptive statistics for the characteristics included in our sample are presented in Table 1. Panel A in Table 1 presents the student characteristics and Panel B presents the teacher characteristics. The students' 2017 SIMCE test scores and past test scores presented in Panel A in Table 1 were standardized by subject to a mean of 0 and a standard deviation of 1. Past GPA scores were standardized by classroom and subject to a mean of 0 and a standard deviation of 1. The percentage of students with a growth mindset in our sample is 42% with a standard deviation of 0.49. Students are divided evenly by gender. Students in the 8th grade make up 54% of the sample and 33% belong to the lowest family income group.

Regarding the teachers in our sample, most of them are women (63%), they average 12 years teaching experience with almost 8 years of experience at their current school. In general, they obtained their teaching certificate at a university (95% versus 2% of teachers without

[8] Unfortunately, we do not have past scores for students who were in 10th grade in 2017.

certificate and 3% who obtained their certificate at a technical school). In terms of teaching grade, 56% of the teachers in the sample teach the 8th grade and 44% teach the 10th grade.

Our main variable of interest in this study is teacher mindset. The information in Panel B in Table 1 shows that 89% of teachers in our sample have a growth mindset. This is a very high percentage of teachers, especially when compared to the percentage of students with a growth mindset (42%) and their parents (66%). Similar studies looking at other countries have also found that growth mindsets among teachers are common; however, the exact percentage of teachers with a growth mindset can vary depending on how it is measured.[9] One possible explanation for the high percentage of teachers with a growth mindset is that people with a growth mindset are more likely to self-select into teaching compared to people with a fixed mindset (DeLuca, Coombs, & LaPointe-McEwan, 2019).

We also build a socioeconomic status index (SES) using the school vulnerability index[10] that is employed by the Ministry of Education in Chile to distribute free lunches and scholarships. This allows us to classify schools according to the percentage of low-income students

[9] Frondozo et al. (2020) use five items from the Implicit Theories Scale, adapted to measure teachers' mindset about teaching. They show that Filipino teachers have a mean of 5.00 on a scale that ranges from 1 to 6, where 6 is the highest value of disagreement with statements that suggest intelligence cannot be changed. Park et al. (2016) use eight items and find that teachers have a mean of 4.98 on a scale that ranges from 1 to 6. It is important to note that these averages are not entirely comparable because they use different items and scale sizes (ranging from 2 to 7 likert-type scale items). In addition, studies use different cutoffs for growth mindset because of the range of scale. For instance, Frondozo et al. (2020) use three categories: fixed, mixed, and growth mindset.

[10] The school vulnerability index (known by its Spanish acronym, IVE-SINAE) is an index that reports the percentage of students in a school who are labeled as priority because of their socioeconomic status. This index is calculated by the Chilean Department of Education to determine the recipients of free lunches and other benefits on a yearly basis. Private schools are not included in this index, but 92% percent of private schools are in the highest SES quintile and the remaining 8% percent are in a mid-level SES quintile, so we assume they have a concentration index score equal to zero. This is aligned with the literature on the Chilean education system. Gallego (2013) mentions that private non-subsidized schools serve a much wealthier population than the rest of the schools in the system. Furthermore, the family income of students that attend private schools is four times larger on average than students who attend other schools, and the mothers of private school students have on average five years more education (McEwan and Carnoy, 2000).

enrolled and separate the schools into quintiles. Thus, schools in quintile one of the SES index, the lowest quintile, are the schools with the highest percentage of low-income students. Table 1 shows that there are fewer teachers in the lowest SES quintile than other quintiles. This is mainly because the lowest SES quintile is composed of more rural schools, which are smaller.

Table 2 documents the differences between teachers with a growth mindset and a fixed mindset. First, we explore the differences in student expectations between teachers with a fixed mindset and a growth mindset. The descriptive statistics in Table 2 show that 72% of teachers with a growth mindset have high expectations for their students, whereas this figure is only 59% for teachers with a fixed mindset. The two groups of teachers also differ in their level of experience: teachers with a growth mindset have fewer years of experience than teachers with a fixed mindset. This is true both for total experience and experience at their current school. In terms of gender, teachers with a growth mindset are 6.5 percentage points more likely to be female.

Finally, teachers with a growth mindset are overrepresented in higher SES schools, whereas teachers with a fixed mindset are overrepresented in lower SES schools. To illustrate the latter, 17.1% of teachers with a fixed mindset teach in schools in the lowest SES quintile, whereas this figure is 19.7% for teachers with a growth mindset.

Table 1: Descriptive Statistics

Variables	Description	Mean	SD
(a) Students			
# of students		292,960	
SIMCE	Standardized test score at subject	0.000	1.000
Past SIMCE	Previous standardized test score at subject	0.000	1.000
Past subject GPA	Standardized previous GPA at subject	0.000	0.979
Mindset	Student's mindset: scale 1 to 4	2.742	0.681
Growth mindset	Dummy for students with growth mindset	0.416	0.493
Female	Female students	0.499	0.500
8th grade students	% of students in 8th grade	0.542	0.498
Family income (monthly)			
group1	% of family income between US$0 and US$367	0.334	0.472
group2	% of family income between US$368 and US$735	0.164	0.370
group3	% of family income between US$736 and US$1471	0.115	0.319
group4	% of family income between US$1,472 and US$2,205	0.228	0.420
group5	% of family income more than US$2,206	0.159	0.365
(b) Teacher characteristics			
# of Teachers		24,636	
Mindset	Mindset	3.522	0.548
Growth mindset	Growth mindset	0.891	0.311
Teacher expectations	Teacher expectations	0.701	0.458
Female	Female	0.627	0.484
Certification			
cer1	cer1	0.017	0.128
cer2	cer2	0.004	0.060
cer3	cer3	0.947	0.232
cer4	cer4	0.033	0.188
Experience as a teacher		12.477	11.259
Experience at the current school		7.658	8.654
Teacher subject	Teacher subject		
Math	Math	0.281	0.449
Nat	Nat	0.281	0.449
Spanish	Spanish	0.219	0.414
Soc	Soc	0.219	0.414
School SES quintile			
Lowest quintile (Q1)	Lowest quintile (Q1)	0.174	0.378
Middle low quintile (Q2)	Middle low quintile (Q2)	0.207	0.405
Middle quintile (Q3)	Middle quintile (Q3)	0.206	0.405
Middle high quintile (Q4)	Middle high quintile (Q4)	0.210	0.408
Highest quintile (Q5)	Highest quintile (Q5)	0.203	0.402
Rural/urban schools			
Rural	Rural	0.111	0.314

Table 2: Teachers descriptive statistics

Variables	Mean	SD	Mean	SD	Difference
	Teacher with Growth Mindset		Teacher with Fixed Mindset		
# of teacher	21,962		2,674		
Teacher expectations	0.716	0.451	0.585	0.493	0.131*** (0.000)
Female	0.634	0.482	0.570	0.495	0.064*** (0.000)
Certification					
Without certificate	0.017	0.130	0.012	0.012	0.005* (0.066)
Teachers' college	0,003	0.055	0,006	0.077	-0.003** (0.014)
University	0.947	0.224	0.943	0.232	0.004 (0.371)
IP-CFT	0.033	0.178	0.039	0.193	-0.006 (0.103)
Experience as a teacher	12.062	10.893	15.879	13.433	-3.817*** (0.000)
Experience in the current school	7.377	8.398	9.967	10.236	-2.590*** (0.000)
School SES quintile					
Lowest quintile (Q1)	0.171	0.376	0.197	0.398	-0.026*** (0.000)
Middle low quintile (Q2)	0.204	0.403	0.225	0.418	-0.021*** (0.006)
Middle quintile (Q3)	0.206	0.404	0.211	0.408	-0.005 (0.250)
Middle high quintile (Q4)	0.214	0.410	0.180	0.384	0.034*** (0.000)
Highest quintile (Q5)	0.205	0.404	0.186	0.390	0.019** (0.012)
Rural	0.105	0.307	0.155	0.363	-0.050*** (0.000)

Methodology

The main identification challenge faced by studies that measure teacher effects on students is the bias associated with the nonrandom distribution of students and teachers to a school and, within a school, to a classroom (Dee, 2007; Clotfelter et al., 2010; Metzler & Woessmann, 2012; Paredes, 2014). Previous studies have addressed this problem by estimating a model with student fixed effects, which allows for estimating the effect of teachers on students controlling for unobserved students' characteristics. Even when only cross-sectional data is available, if we can observe the same student in different subjects, we can use the within-student variation across subjects to estimate a model with student fixed effects—that is, we can use the variation in teacher characteristics across subjects for each individual student. In this study, we exploit the variation in teacher mindset within students' experiences to identify the effect of teacher growth mindset on student academic achievement.

To measure the effect of teacher growth mindset on student academic achievement, we use the following model:

$$Y_{ijt} = \alpha_i + GM_t\delta + PastGPA_{ij}\vartheta + X_t\beta + \kappa_j + \mu_{ijt}\,, \quad (1)$$

where Y_{ijt} is the standardized test score for student i in subject j with teacher t, α_i is a student fixed effect, κ_j is a subject fixed effect, and X_t is a vector of teacher characteristics such as experience, certification, gender, and expectations. The variable GM_t is equal to 1 if the teacher has a growth mindset and 0 otherwise; therefore, δ captures the effect of being allocated to a teacher with a growth mindset on student academic achievement. We also control for subject-specific propensity for achievement using the students' previous year

GPA in each subject. $PastGPA_{ij}$ is the *i*th student's within-classroom standardized GPA for the previous year in subject j. Finally, μ_{ijt} is a student-specific error term. Students in Chile stay in the same classroom with the same peers for all subjects. Therefore, we cluster the errors at the classroom level.

The identification strategy in this model requires enough variation in teacher mindset within students. Using our sample, the variance decomposition shows that the within-student variance is as large as the between-student variance, representing 21% of the total variation.[11] Furthermore, our identification strategy requires that assignment to a teacher with a growth mindset does not depend on subject-specific propensity for achievement. To test if this is the case, we follow Clotfelter et al. (2010) and estimate the correlation of teacher growth mindset and past subject GPA, controlling for student fixed effects. If the probability of being assigned to a teacher with a growth mindset is not related to subject-specific propensity for achievement, then the coefficient associated with past subject GPA should not be significant. Column 1 in Table 3 shows that the past subject GPA is not statistically significant, which is evidence in favor of the identification strategy.

For the sample of 8th grade students, we also have past standardized test scores. We repeat the same exercise replacing past subject GPA with past standardized tests scores. Here, we again find a nonsignificant effect (Column 2 in Table 3). We also show results where we control for both past standardized test scores and past subject GPA. The coefficients on past

[11] In terms of the number of classrooms, from the 12,318 classrooms we have in our sample, 2,272 (18.44%) have both a growth mindset teacher and a fixed mindset teacher. The distribution of this subsample is almost the same as that of the whole sample. For example, 18.0% the teachers work in the lowest SES quintile, while 19.3% work in the highest quintile. See Table A1 in the Appendix for a comparison between the observable characteristics of the whole sample and the subsample of students who are assigned to one teacher with a fixed mindset and one teacher with a growth mindset.

achievement are always nonsignificant and very small. Finally, as shown in Panel B in Table 3, the same exercise is repeated again but this time restricting the sample to students who are assigned to one teacher with a fixed mindset and one teacher with a growth mindset. The results hold for this subsample of students too: past achievement is never statistically significant and the coefficients are very small.

Table 3: Identification Strategy. Effect of past test score and past GPA (in each subject) on future teacher mindset.

	(1)	(2)	(3)
	Teacher Growth Mindset		
(a) All sample			
Past SIMCE test score		0.000	0.000
		(0.002)	(0.003)
Past subject GPA	0.000		0.001
	(0.000)		(0.001)
Observations	585,960	245,796	245,796
(b) Sample used to identify effects			
Past SIMCE test score		0.001	0.000
		(0.012)	(0.013)
Past subject GPA	0.000		0.005
	(0.000)		(0.005)
Observations	104,690	49,732	49,732
Subject Fixed Effect	Yes	Yes	Yes
Student Fixed Effect	Yes	Yes	Yes

Notes: Standards errors, clustered at the classroom level, are presented in parentheses. All models include Student Fixed Effect and subject Fixed Effect. Model (2), and (3) only consider 8th grade due to available data. *** p<0.01, ** p<0.05, * p<0.1

One concern when using SIMCE test scores to measure student academic achievement is test score attrition. Previous studies have found that test day attendance is unlikely to be random (Cuesta, Gonzalez and Larroulet, 2020). Thus, it is possible that having a teacher with a growth mindset correlates with attendance on the day of the test. Because we use a balanced panel of students, selective attrition will not bias our results. Attrition may, however, be a

threat to the external validity of our results. We check if this is the case by estimating the probability of test day attendance on teacher growth mindset, subject fixed effect, and student fixed effect. We find that a teacher's growth mindset does not predict test attendance (Table A2).

Because we are also interested in assessing which students are more affected by teacher mindset, we estimate a specification where we interact the variable GM_t with student characteristics (Z_i):

$$Y_{ijt} = \alpha_i + GM_t\delta + GM_t \times Z_i\lambda + PastGPA_{ijt'}\vartheta + X_t\beta + \kappa_j + \mu_{ijt}\,, (2)$$

Specifically, we interact teacher growth mindset with student gender, student growth mindset, past GPA, family income, and SES school quintile.

An additional concern in the estimation of equations (1) and (2) is that teachers with a growth mindset may also differ in other characteristics. If other observed and unobserved teacher characteristics correlate with a growth mindset then the estimation of δ could be biased. This concern is especially important because Table 2 shows that teachers with a growth mindset and teachers with a fixed mindset differ in other observable characteristics, even in the specification where we control for classroom fixed effects (Column 6 in Table 2). To alleviate this concern, we include teacher controls (experience, certification, gender, and expectations); however, teachers may still differ in unobservable characteristics. Accordingly, we will be able to identify the impact of being assigned to a teacher with a growth mindset, but we will not be able to isolate the effect of that teacher's growth mindset.

Finally, we estimate an additional specification with a teacher fixed effect (ψ_t) to control for unobservable teacher characteristics:

$$Y_{ijt} = \alpha_i + \psi_t + GM_t \times Z_i\lambda + PastGrade_{ijt}\vartheta + \mu_{ijt}\,, \quad (3)$$

Even though it is not possible to identify GM in a specification with teacher fixed effects, we can identify the interactions of GM with student characteristics.

Main Results

Table 4 presents the results of estimating equation (1).[12] In Column 1 we present our baseline model, which includes student and subject fixed effects. In Column 2 we add controls for past GPA by subject. In Column 3 we add controls for teacher observable characteristics, which include gender, type of certification, and experience, both general and at the current school. Finally, in Column 4 we add a control for teacher expectations. In all our estimations, standard errors are clustered at the classroom level.[13]

In all our specifications, the effect of being assigned to a teacher with a growth mindset is positive and significant: being assigned to a teacher with a growth mindset increases students' SIMCE test scores by 0.017–0.20 standard deviations. This corresponds to 0.05 of the within-student standard deviation. This effect size is in the range found in other studies, such as the effect of being taught by a teacher with one year's teaching experience as opposed to one with no experience (Ladd & Sorensen, 2017), and the effect of teacher gender on student academic achievement for 8th graders in Chile (Paredes, 2014).

Table 4 also shows that the effect is remarkably stable in all four specifications. The coefficient of teacher growth mindset is robust to the inclusion of teacher characteristics. This is important because Table 2 shows that teachers with a growth mindset and teachers

[12] Table A3 in the Appendix shows the full set of controls.

[13] Students are observed in the same classroom for both subjects. Our sample has a total of 12,318 classrooms in 5,749 schools.

with a fixed mindset differ in observable characteristics and probably differ in unobservable ones as well. In Column 3, the F-test on the joint significance of teacher characteristics shows that the observable characteristics included in this specification are relevant. It does not appear, therefore, that the positive effect of a teacher growth mindset found in Columns 1 and 2 can be attributed to other teacher characteristics. Moreover, the effect of a growth mindset is robust to the inclusion of teacher expectations about students. The results in Column 4 show that teacher expectations also have a positive and significant effect on student academic achievement. The magnitude of the effect is the same as a teacher having a growth mindset (0.019 versus 0.017 standard deviations). The fact that the coefficient of a growth mindset is robust to controlling for teacher expectations is relevant because it shows that both measures are capturing different teaching impacts.

Finally, the results in Table 4 show that the effect of past GPA on students' standardized test scores is equal to 0.17 standard deviations. Because we showed that students are not assigned to teachers with a growth mindset based on past standardized test scores (Table 3), the effect of a growth mindset should be robust to the inclusion of past grades. This is indeed the case: the effect of teacher growth mindset is the same in Columns 1 and 2 in Table 4.

As discussed previously and following the literature, we classify teachers as having a growth mindset if they disagreed or strongly disagreed with the statements suggesting that intelligence is not malleable (i.e., fixed mindset statements). This classification resulted in 89% of teachers in our sample having a growth mindset. As a robustness check, we construct a second measure of mindset. This new measure is equal to 1 only if teachers *strongly* disagree with all the fixed mindset statements and 0 otherwise (i.e., GM=4). Under this new classification, 43% of teachers have what we could call a *strong* growth mindset.

Table 4: Estimated Effects of Being Assigned to a Teacher with a Growth Mindset on SIMCE Test Scores

	(1) Student FE	(2) Student FE with Past GPA	(3) Added teacher controls	(4) Added teacher expectations	(5) Added teacher GM (>= 3)
	Test Score (std)				
Teacher growth mindset (>=3)[a]	0.020***	0.020***	0.019***	0.017***	0.017***
	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)
Teacher growth mindset (= 4)[b]					0.000
					(0.004)
Past subject GPA		0.166***	0.166***	0.166***	0.166***
		(0.002)	(0.002)	(0.002)	(0.002)
Teacher expectation				0.019***	0.019***
				(0.005)	(0.005)
Observations	585,960	585,960	585,960	585,960	585,960
Number of students	292,980	292,980	292,980	292,980	292,980
Number of classrooms	24,636	24,636	24,636	24,636	24,636
R-squared	0.845	0.849	0.849	0.849	0.849
Prob > F	-	-	0.000	0.000	0.000
Student fixed effect	Yes	Yes	Yes	Yes	Yes
Subject fixed effect	Yes	Yes	Yes	Yes	Yes
Teacher controls	No	No	Yes	Yes	Yes

Notes: Standard errors, clustered at the classroom level, are presented in parentheses. All models include student fixed effect and subject dummies. Prob > F refers to an F-test of the joint significance of the teacher controls. Model (2) and (3) include controls for teacher gender, type of certification, and teacher experience. [a] Following the previous literature, we classify teachers as having a growth mindset if they disagree or strongly disagree with the statements that suggest that intelligence is not malleable. [b] As a robustness check, we construct a second measure of mindset that is equal to 1 if the teacher only strongly disagrees with the same statement. *** p<0.01, ** p<0.05, * p<0.1

To test whether the level of disagreement with the statements matters, we estimate the following equation:

$$Y_{ijt} = \alpha_i + (GM \geq 3)_t\delta + (GM = 4)_t\psi + PastGrade_{ij}\vartheta + X_t\beta + \kappa_j + \mu_{ijt} \ , \quad (4)$$

where a significant ψ coefficient would indicate that the level of disagreement with the statements matter. Results are presented in Column 5 in Table 4. The results in Table 4

show that the level of disagreement with the statements does not have a significant effect on student academic achievement. The coefficient on (GM=4)—that is, teachers who strongly disagree with all fixed mindset statements—is statistically insignificant and very small. On the other hand, the coefficient on (GM≥3)—that is, teachers who (on average) both disagree or strongly disagree with the statements —is statistically significant and very similar in magnitude to the coefficients found in Column 4. The results in Column 5 suggest that the level of disagreement with the statements does not matter.

Heterogeneity Results

Our main results show that being assigned to a teacher with a growth mindset has a positive and significant impact on student academic achievement beyond other teacher characteristics, such as their experience and the expectations they hold for students. In addition to measuring the impact of a growth mindset, it is important to understand how its effects differ between groups. We therefore estimate different versions of equation (2) by interacting teacher mindset with student gender, student growth mindset, past GPA, family income, SES quintile, and subject. We explore these interactions in separate specifications. In all our specifications we include teacher controls, teacher expectations, student fixed effects, and subject fixed effects. The coefficients for the different subgroups are presented in Figure 1 (past GPA, student mindset, gender, and subject) and Figure 2 (family income and school SES quintile), and they are compared to the average effect (dashed line). The results of the different interactions are also presented in Table A5 in the Appendix.

The results in Figure 1 show that the impact of being assigned to a teacher with a growth mindset is larger for students who also have a growth mindset compared to those with a fixed mindset. The effect for students with a growth mindset is 0.025 standard deviations, which is more than twice the effect for students with a fixed mindset. This difference is significant at the 10% level.

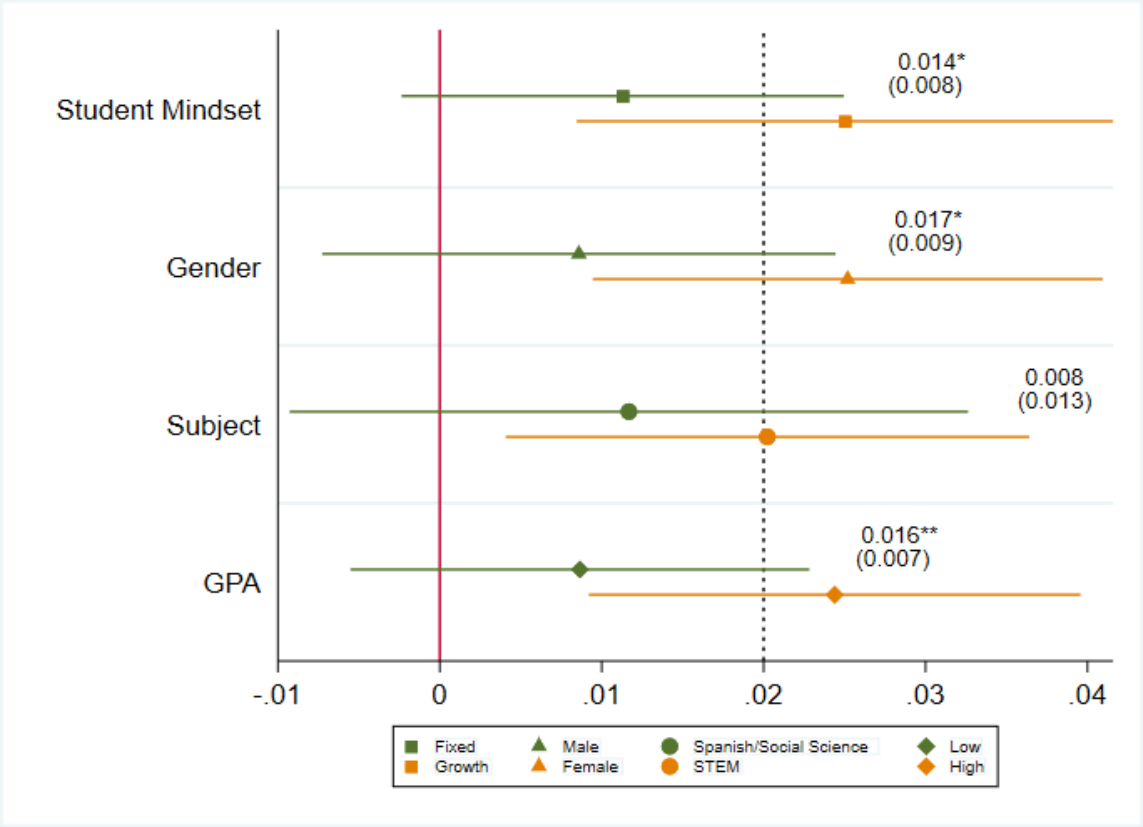
When we explore heterogeneity by student past GPA, we find that the effect is larger for students with a higher past GPA.[14] The magnitude of the effects for high achieving and low achieving students is very similar to the magnitude of the effects for students with a growth mindset and students with fixed mindset, respectively. This is not surprising given the positive correlation between a student having a past GPA above the median and having a growth mindset (a correlation of 0.12, significant at the 1% level). The effect of teacher mindset is not significant for students with a low past GPA.

We also explore the effect of being assigned to a teacher with a growth mindset by student gender. We find that the effect is positive and significant for girls and positive but not significant for boys. Again, the magnitude of the effects for girls is similar to the magnitude of the effect for students with a growth mindset and for students with a high past GPA (0.025, 0.025 and 0.024 respectively). One possible explanation is that gender, growth mindset, and high past GPA have a positive correlation. We have already shown that there is a positive correlation between a student having a past GPA above the median and a student having a growth mindset; however, there is not a positive correlation between being a female and having a growth mindset. Note that female students are 9 percentage points more likely than

[14] We consider a student to have a high GPA when their GPA average of the two evaluated subjects is greater than the median of their classroom.

boys to have a high past GPA, but they are 4 percentage points less likely than boys to have a growth mindset.

Figure 1. Effects of Being Assigned to a Teacher with Growth Mindset by Student Subgroups



Notes: Figure 1 shows the estimated effect of teacher mindset on student academic achievement in independent regressions for each student subgroup and the confidence intervals at the 5% level. Student mindset refers to the mindset reported by each student in the student questionnaire answered on the same day they took the standardized test. Reported coefficients in the figure refer to the difference between the two categories. Standard errors, clustered at the classroom level, are presented in parentheses (details in Table A4). The vertical lines represent the 0 effect (continuous red line) and the average effect of teacher growth mindset (dashed line). *** p<0.01, ** p<0.05, * p<0.1

The larger effect of being assigned to a teacher with a growth mindset on female students is consistent with previous literature, which found that female students with a growth mindset

have higher math achievement than male students with a growth mindset (Degol et al, 2018). However, because the proportion of teachers who are female among teachers with a growth mindset is greater than the proportion of teachers who are female among teachers with a fixed mindset, the larger effect of teacher mindset on female students could be explained by the positive effect of teacher-student gender matching. Paredes (2014) shows that having a female math teacher increases the average scores of female students. To test if teacher-student gender matching explains our results, we control for the interaction of female teacher and female student in addition to the interaction between female teacher and growth mindset. We observe that teacher mindset effects are robust to the inclusion of the control for teacher-student gender matching, but the differential effect of teacher growth mindset between girls and boys is no longer significant, although it remains positive (details in Table A4 in Appendix). Thus, we cannot conclude that the effect of being assigned to a teacher with a growth mindset is larger for girls than for boys.

Finally, we explore the heterogeneity for different school subjects. We find that teachers with a growth mindset who teach math or science have a larger impact than those who teach social sciences or Spanish. This evidence is in line with Alan et al. (2019) in which a randomized educational intervention to promote growth mindset in students is evaluated and a higher effect on standardized math scores than on verbal scores is found. The results in Figure 1, however, show that the difference in the effect between subjects is not statistically significant. Moreover, an additional problem with this comparison is that we only observe the math and science teachers for students in the 8th grade and the social science and Spanish teachers for students in the 10th grade. Therefore, we do not know if the larger effect in STEM subjects is due to the subject or another effect related to student age or experience.

Next, we explore the heterogeneity of the effect in terms of income, which we illustrate in Figure 2. We classify students into five categories according to family income. Although the effect of teacher growth mindset is positive and significant for quintiles 1–4, the effect is negative but also not significant for the highest income quintile. Even though we cannot reject that the effect is equal for all family income quintiles (F=1.37), we do find significant differences in the effect for quintiles 2 and 3 and the effect for quintile 5.

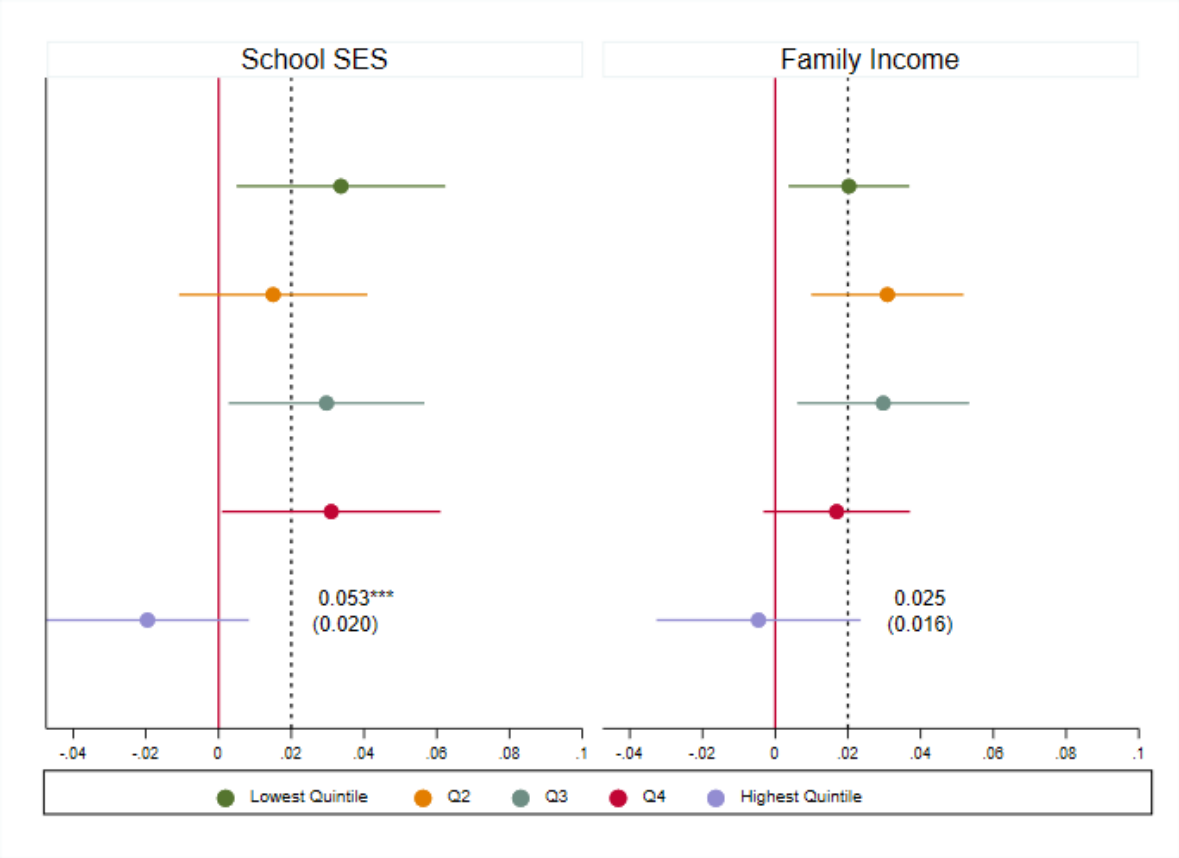
In line with the results for different family income levels, the results in Figure 2 show that the impact of being assigned to a teacher with a growth mindset is larger in schools in the lowest SES quintile. Our results show that the effect of a teacher's growth mindset is positive and significant for quintiles 1, 3 and 4, but is negative and not significant for schools in the highest quintile.[15] In contrast to the heterogeneity in terms of income, we can reject the null hypothesis that the effect is equal for all schools (F=2.49).

As discussed in the methodology section, an additional concern in the estimation of both equations (1) and (2) is that teachers with a growth mindset may differ in unobserved characteristics. To alleviate this concern, we include a teacher fixed effect in the estimation of equation (2). In the specification with teacher fixed effect, we cannot identify the effect of teacher mindset, but we can identify the interaction of teacher mindset with student characteristics.[16] We find that the coefficients of the difference between groups are robust to controlling for teacher fixed effects (Table A4 in the Appendix).

[15] We also find a positive and nonsignificant effect for students in quintile 2 schools, which we cannot fully explain.

[16] We cannot identify the interaction between teacher mindset and school or other teacher characteristics. Therefore, we present the results of specification (3) for the interaction between teacher mindset with student gender, student growth mindset, past GPA, and family income.

Figure 2. Effects of Being Assigned to a Teacher with Growth Mindset by Socioeconomic Subgroups



Note: School SES quintiles refers to the school SES index divided in quintiles. Family income refers to the quintiles of the monthly household income for 8th and 10th grade students reported by families at the time of the test. Reported coefficients in the figure refer to the difference between the lowest and the highest quintile. *** p<0.01, ** p<0.05, * p<0.1

Falsification Tests

Our results show that being assigned to a teacher with a growth mindset has a significant impact on student academic achievement. We claim that this effect is not due to students with a higher propensity for academic achievement being sorted to teachers with a growth mindset in that subject, because we show that, after controlling for student fixed effects, students are not sorted to teachers based on their previous subject achievement (Table 3). Building on this

evidence, in the following section we estimate two falsification tests based on placebo measures to demonstrate further that our results are causal.

In our first falsification test, we estimate the effect of being assigned to a teacher with a growth mindset on students' past test scores.[17] Although this falsification test is very similar to the one presented in Table 3, when we use past scores as the dependent variable we can now also control for other teacher characteristics and teacher expectations. Being assigned to a teacher with a growth mindset today should have no effect on past achievement, so we expect the coefficient of the teacher mindset not to be significant. A significant effect of teacher mindset on students' past achievement would suggest that the results in Table 5 are biased.

Table 5: Falsification Test. Effect of Teacher Growth Mindset on Past SIMCE Test Score

	(1)	(2)	(3)	(4)
	Student FE	Student FE with past GPA	Added teacher controls	Added teacher expectations
Variables	Previous Test Score (std)			
Teacher growth mindset	0.000	0.000	-0.001	-0.001
	(0.007)	(0.007)	(0.007)	(0.007)
Past subject GPA		0.165***	0.165***	0.165***
		(0.003)	(0.003)	(0.003)
Teacher expectations				0.003
				(0.006)
Observations	245,796	245,796	245,796	245,796
R-squared	0.858	0.861	0.861	0.861
Student Fixed Effect	Yes	Yes	Yes	Yes
Subject Fixed Effect	Yes	Yes	Yes	Yes

Notes: Standards errors, clustered at the classroom level, are presented in parentheses. All models include Student Fixed Effect. This identification strategy only considers 8th grade due to available data. Model (2) and (3) include controls for teacher gender, type of certification, and experience.
*** p<0.01, ** p<0.05, * p<0.1

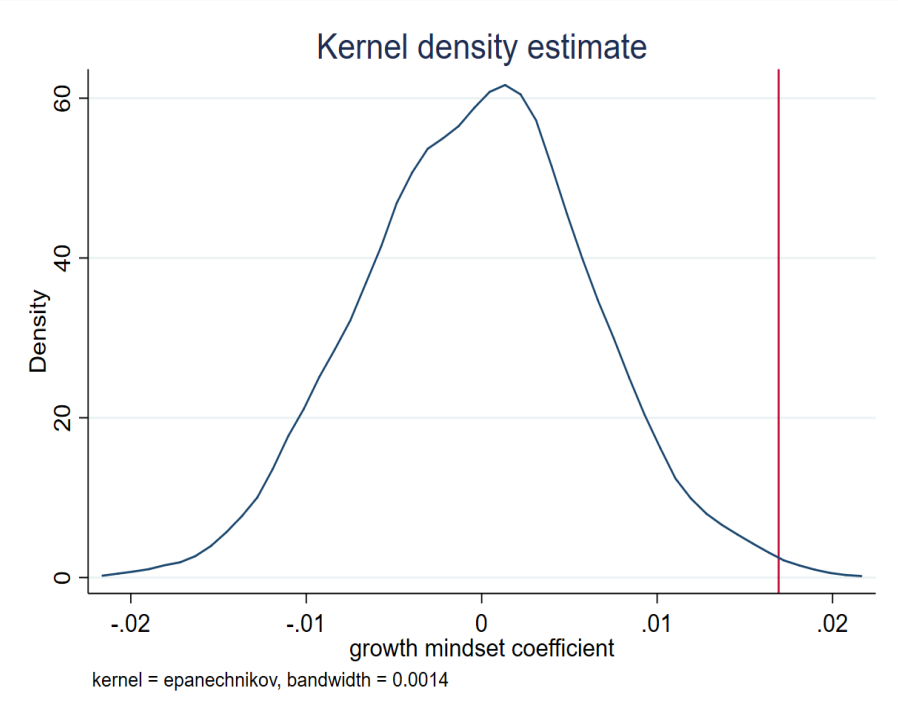
[17] Students in 8th grade in 2017 were evaluated in the same subjects (math and science) in the 4th grade in 2013.

The results in Table 5 show that being assigned to a teacher with a growth mindset does not correlate with past test scores. All estimates are statistically insignificant. Moreover, the estimated coefficients are much smaller than when the true dependent variable is used. In Table 4 the coefficient of growth mindset is between 0.018 and 0.020, whereas in Table 6 the coefficient is -0.001 to 0.000. The results suggest that students are not sorted to teachers based on their previous subject achievement.

In our second falsification test, we conduct a permutation test where we randomly assign a growth mindset to teachers to estimate the effect on student test scores. Because growth mindset is randomly assigned in this exercise, we do not expect a significant coefficient from the mindset variable. We repeat this exercise 1,000 times for each model and present a histogram of the coefficients.[18] Figure 3 shows the results for the model that controls for teacher characteristics and expectations. Only 8 out of the 1,000 replications estimated a greater coefficient than the coefficient estimated using the original data (and less than 4 out of 1,000 replications for the other models). Therefore, the probability that our results are given by chance is very low.

[18] We use the randomization procedure described in Hess (2017).

Figure 3. Permutation Test



Notes: Kernel densities of estimates of the growth mindset coefficient under the null hypothesis obtained through resampling, following the procedure described in Hess (2017). The vertical line indicates the location of the estimate using the original data.

Possible Mechanisms for the Teacher Mindset Impact

The previous literature has found that teacher growth mindset can have an impact on student achievement and that it mainly does so through two mechanisms. First, teachers with a growth mindset may have an impact on students' learning because a growth mindset influences teachers´ pedagogical practices. For example, a teacher with a growth mindset may give better feedback to a student who fails a test (Rattan et al., 2012) or may be more diligent at continuing to learn new teaching skills and methods. Second, teachers with a growth mindset can have an impact by shaping the growth mindsets of their students

(Schmidt et al., 2015), which, in turn, would help students persist, take on more learning challenges, and thus increase their learning (Yeager et al., 2019; Bettinger et al., 2017).

To test the first mechanism we use the 2017 SIMCE student survey, where students answered several questions related to teacher practices. We identified four questions relating to pedagogical practices that could be influenced by a teachers' mindset. These questions were only available for the Spanish subject.[19] In our sample, 95% of students in 10th grade answered these questions. For each different practice, students were asked how often their Spanish teacher implemented the practice on a 4-point Likert-type Scale.[20] We construct four indicator variables that take the value of 1 if the student answers that the teacher uses the practice always or the majority of the time. According to the survey, 62% of the students agreed that their teacher checks that everyone has done their homework, and 85% of students said that their teacher provides homework feedback in class. In addition, 71% of the students said that their teacher explains the course material again if a student asks, and 81% agreed that their teacher explains the answers to test questions that were answered incorrectly.[21]

Then, we estimate simple ordinary least squares (OLS) regressions of the teacher growth mindset on pedagogical practices in the subject of Spanish:

$$P_{its}^{n} = \gamma GM_t + X_t\beta + Z_i\delta + S_s\alpha + \mu_{its} \ , \quad (5)$$

where P_{its} is the pedagogical practice *n* of teacher *t* evaluated by student *i* from school *s*. ɣ is the coefficient of interest that represents the relationship between teacher mindset and

[19] We do not have the same information for the other teachers in the analysis; therefore, we can only run descriptive analysis for Spanish teachers.

[20] There were four alternatives for the Likert-type scale: always, the majority of the time, sometimes, and never.

[21] Our four measurements can be considered as part of growth mindset pedagogy (Rissanen et al., 2019), such as supporting students' individual learning processes and teaching the positive role of mistakes.

pedagogical practices. X_t is a vector of teacher characteristics, such as experience, certification, gender, and expectations, and Z_i is a vector of student characteristics, such as GPA, gender, family income, and mother's education. Finally, S_s is a vector of school characteristics, such as SES index score and a rural dummy. Even though this estimation does not provide causal effects it does give us information about the relationship between teachers and pedagogical practices.

Table 6 shows the results of estimating the equation for each pedagogical practice independently. The results show that a growth mindset among teachers of Spanish has a positive and significant correlation with all four pedagogical practices. This evidence suggests that teachers with a growth mindset may have classroom practices that are different from teachers with a fixed mindset, and that this may have an impact on the academic performance of their students. This is consistent with previous literature, which reports that teachers with growth mindset may shape their own behaviors and exercise different pedagogical practices (Rattan et al., 2012; Schmidt et al., 2015).

This analysis suggests that teachers with a growth mindset may impact student academic achievement by implementing different classroom practices than teachers with a fixed mindset. This, however, may not be the only mechanism through which teacher mindset impacts learning. Another possibility is that a teacher's growth mindset helps create or support a growth mindset in their students (Schmidt et al., 2015), which helps the students improve their learning. In our dataset we have measures of student mindset for math and Spanish separately.[22] The information about teacher mindset, however, is only available for

[22] Specifically: "If I am not naturally intelligent for Mathematics, I will never do well in this subject" and "If I am not naturally intelligent for Language Arts (Spanish class), I will never do well in this subject." These two items are an adaptation of the general mindset measure developed by Farrington et al. (2012).

one teacher per student. Therefore, we cannot use a fixed effects methodology to measure a causal effect of teacher growth mindset on student mindset. We again estimate a simple OLS regression presented in formula (4) to estimate the predictive power of teacher growth mindset on student mindset in the corresponding subject.

Table 6. Relationship between Teacher Growth Mindset and Pedagogical Practices

	(1)	(2)	(3)	(4)
	Practice 1	Practice 2	Practice 3	Practice 4
	Spanish			
Teacher growth mindset	0.025***	0.024***	0.032***	0.022***
	(0.009)	(0.007)	(0.010)	(0.007)
Observations	107,867	107,867	107,867	107,867
R-squared	0.004	0.011	0.007	0.006
Student Controls	Yes	Yes	Yes	Yes
Teacher Controls	Yes	Yes	Yes	Yes
School Controls	Yes	Yes	Yes	Yes

Notes: Standard errors, clustered at the classroom level, are presented in parentheses. Student controls include GPA, gender, family income, and mother's education. School controls include SES index and a rural dummy. Teacher controls include gender, type of certification, experience, and expectation. Practice 1 refers to the teacher checking that everyone has done their homework. Practice 2 refers to the teacher providing feedback on homework in class. Practice 3 refers to the teacher explaining the course material again if a student asks. Practice 4 refers to the teacher explaining the answer to test questions that were answered incorrectly. *** p<0.01, ** p<0.05, * p<0.1

Table 7 shows the results. They suggest that the teacher growth mindset does not have a significant correlation with student mindset. Although this implies that the main mechanism through which teacher growth mindset impacts student academic achievement is a difference in teacher practices, this evidence should be taken with caution. First, the instrument we use to measure student mindset is constructed using only one question for each subject, which may sacrifice reliability. Second, because we only observe the mindset of one teacher per student, we cannot estimate a causal effect and the results in Table 7 should be interpreted as correlations.

Table 7. Relationship between Teacher Growth Mindset and Student Growth Mindset by Subject

	(1)	(2)
	Student Growth Mindset in Spanish	Student Growth Mindset in Math
Teacher growth mindset	0.007	-0.000
	(0.005)	(0.004)
Observations	109,874	133,588
R-squared	0.044	0.075
Student Controls	Yes	Yes
School Controls	Yes	Yes
Teacher Controls	Yes	Yes

Notes: Standard errors, clustered at the classroom level, are presented in parentheses. Student controls include GPA, gender, family income, and mother's education. School controls include SES index and a rural dummy. Teacher controls include gender, type of certification, experience, and expectation. *** p<0.01, ** p<0.05, * p<0.1

Conclusion

Many studies have shown the importance of student growth mindset on academic development (Yeager et al., 2019; Alan et al., 2019; Paunesku et al., 2015; Blackwell et al., 2007). And although these studies have shown that a growth mindset intervention directly applied to students can lead to an increase in academic achievement, there is little evidence on how teacher growth mindset affects student achievement.

This study explores the effect of being assigned to a teacher with a growth mindset on student academic achievement through a student fixed effect design. Using a nationwide dataset from 2017 of students in 8th and 10th grade in Chile that includes teacher surveys, we show an effect of being assigned to a teacher with a growth mindset on students' standardized test scores. Being assigned to a teacher with a growth mindset increases student standardized test

scores by 0.02 standard deviations. This corresponds to 5% of the within-student standard deviation. The estimated effect sizes are as large as the effect of having a teacher with more than one year of experience versus a teacher with no teaching experience (Ladd & Sorensen, 2017). Our findings add to the literature on growth mindset and teacher effects, particularly on the role of teachers and their impact on learning. The effect of being assigned to a teacher with a growth mindset is also robust to the inclusion of teacher expectations. This is relevant because it shows that although high teacher expectations and a high growth mindset have a positive correlation, the measures are capturing different teacher impacts.

Furthermore, we find that being assigned to a teacher with a growth mindset has a larger effect on students with a higher GPA in the previous year. This result contradicts previous literature that has found growth mindset interventions have a larger effect on students with lower grades (Paunesku et al, 2015; Yeager et al, 2019). One difference between our study and previous studies is that in Paunesku et al (2015) and Yeager et al (2019) a mindset intervention was directly applied to students and targeted at changing students' mindsets. The previous studies show that this type of intervention is more beneficial for students who start out with a low GPA or students with more fixed mindsets. In our study, it seems that being assigned to a teacher with a growth mindset affects students' educational outcomes not by changing the students' mindsets but because of the differences between the pedagogical practices of teachers with a growth mindset and teachers with a fixed mindset. It is therefore possible that being assigned to a teacher with a growth mindset is more beneficial to those students who were already more engaged in the educational process. Along the same lines, we also find that being assigned to a teacher with a growth mindset has a larger effect on students with a growth mindset, which correlates with having a high GPA.

We also find that the effect is larger in schools with a larger percentage of low-income students, and we do not find a significant effect of teacher mindset on student academic achievement in high SES schools (that is, the 20% of schools with fewest low-income students). We find similar results when we explore heterogeneity in terms of family income: the effect is larger for lower-income families, but the difference between the highest income and lowest income categories is not significant. These results are consistent with the previous literature that estimates that mindset is a stronger predictor of achievement for low-income students than high-income students (Claro et al., 2016). It may be important to consider that the status of low-SES schools in Chile masks other potentially relevant school characteristics in the country's education system.[23] This larger effect of being assigned to a teacher with a growth mindset on low-income students, added to the fact that there is a lower proportion of teachers with a growth mindset in low-SES schools compared to high-SES schools, suggests that attempting to shift the mindsets of teachers could be a policy tool to reduce the academic gap between low- and high-SES schools.

We also explore two possible mechanisms to see how being assigned to a teacher with a growth mindset may impact student academic achievement. First, we find that a teacher with a growth mindset has a positive and significant correlation with different pedagogical practices. This result is consistent with previous studies that show that teachers with a growth mindset may put greater effort into shaping their own behavior and practices (Rattan et al., 2012; Rissanen et al., 2019). Second, we analyze the possibility that a teacher with a growth mindset has an effect on the growth mindset of their students (Schmidt et al., 2015). In our

[23] Low-SES schools are more likely to be administered by municipalities and receive more public funding because of Chile's school progressive subsidies programs (Aguirre, 2020).

data we find that teacher growth mindset does not correlate with student growth mindset. Thus, we suggest that one main mechanism through which teacher growth mindset impacts student academic achievement is through the difference in teacher practices. Although these results are not conclusive because we cannot estimate causal effects, this information gives us a perspective on future channels for further work.

Finally, because of the positive impact of being assigned to a teacher with a growth mindset on student academic achievement, our paper suggests that an important question for policy makers is how to increase the number of teachers with a growth mindset. Even though most teachers in our sample report having a growth mindset,[24] there can still be important achievement gains for the 10% of students who are assigned to a teacher with a fixed mindset. Furthermore, Kraft (2020) suggests that the size of the effect of an education intervention should be judged by taking the study features, costs, and scalability of the interventions into account. There is evidence that low-cost and scalable interventions can influence the mindset of participants (Yeager et al., 2019), and that a teacher's mindset can change after as little as six training sessions (Seaton, 2018). However, though it may be possible to implement low-cost interventions to develop growth mindsets in teachers, an important and still unanswered question is whether it is possible to change and sustain the mindsets of teachers at scale, while still keeping costs low. Additionally, because we identify the effect of being assigned to a growth mindset teacher and not the effect of mindset itself, we cannot give assurances that an intervention aimed at developing a growth mindset in teachers will obtain the benefits estimated in the study.

[24] Studies looking at other countries have also found that growth mindsets among teachers are common (Park et al., 2016; Seaton, 2017; Frondozo et al., 2020).

This study is a first step towards assessing, on a national scale, the potential benefits of being assigned to a teacher with a growth mindset. The findings suggest that it may be beneficial to monitor and increase the number of teachers with growth mindsets. A better understanding of how teachers evolve their mindset in the first place (Zilka, Grinshtain, & Bogler, 2019) and of how a mindset can be changed and sustained may help child and youth development, especially for those living in low-income communities.

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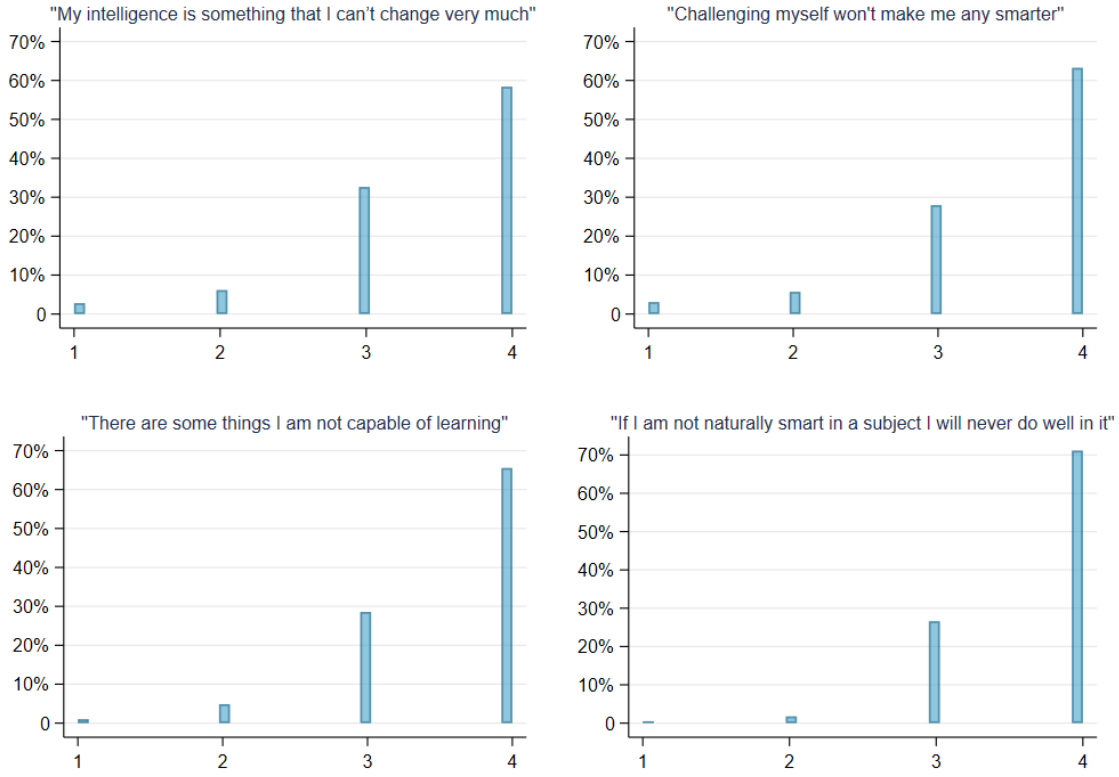
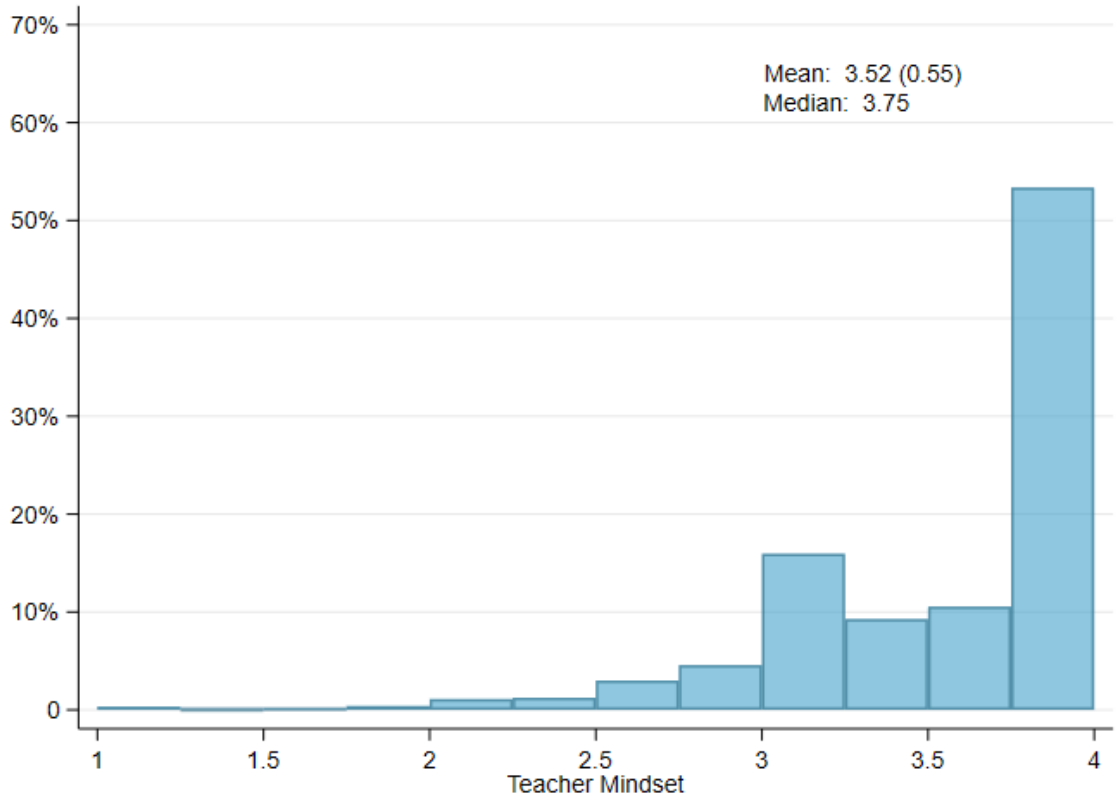
Appendix

Figure A1. Distribution of the Four Items



Note: Items were coded for the highest value to mean the least fixed mindset. Questions have 4 Likert-type scale alternatives, ranging from strongly agree to strongly disagree.

Figure A2. Distribution of Teacher Mindset Index



Note: Teachers with an average equal to or higher than three were classified as teachers with a growth mindset. The rest were classified as not having a growth mindset. As a robustness check in the results, we constructed a second measure of mindset. This new measure is equal to one only if teachers strongly disagree with the statements suggesting that intelligence is not malleable. The internal consistency analysis indicates that all four survey measures were internally consistent, with Cronbach's alpha scores of 0.772

Table A1: Descriptive Statistics of All Sample and Sample used to Identify Effects

Variables	Mean	SD	Mean	SD
	All Sample		Sample used to identify effects	
(a) Students				
# of students	292,960		52,345	
SIMCE	0.000	1.000	-0.063	0.993
Past SIMCE	0.000	1.000	-0.021	0.996
Past subject GPA	0.000	0.979	0.000	0.978
Mindset	2.742	0.681	2.721	0.680
Growth mindset	0.416	0.493	0.404	0.404
Female	0.499	0.500	0.502	0.500
8th grade students	0.542	0.498	0.613	0.487
Family income				
group1	0.334	0.472	0.347	0.476
group2	0.164	0.370	0.163	0.369
group3	0.115	0.319	0.112	0.312
group4	0.228	0.420	0.226	0.418
group5	0.159	0.365	0.152	0.359
(b) Teacher characteristics				
# of teachers	24,636		4,544	
Mindset	3.522	0.548	3.030	0.713
Growth mindset	0.891	0.311	0.500	0.500
Teacher expectations	0.701	0.458	0.643	0.479
Female	0.627	0.484	0.596	0.491
Certification				
University	0.947	0.232	0.941	0.236
Without certificate	0.017	0.128	0.016	0.126
Teachers' College	0.004	0.060	0.003	0.055
IP-CFT	0.033	0.188	0.040	0.196
Experience as a teacher	12.477	11.259	13.957	12.346
Experience at the current school	7.658	8.654	8.791	9.611
# of students				
SIMCE	0.281	0.449	0.314	0.464
Past SIMCE	0.281	0.449	0.314	0.464
Past subject GPA	0.219	0.414	0.186	0.389
Mindset	0.219	0.414	0.186	0.389
Growth mindset				
Female	0.174	0.378	0.180	0.385
8th grade students	0.207	0.405	0.223	0.416
Family income	0.206	0.405	0.209	0.406
group1	0.210	0.408	0.195	0.396
group2	0.203	0.402	0.193	0.395
group3	0.111	0.314	0.138	0.345

Table A2: Correlation between Teacher with Growth Mindset and Student Attendance

	(1)	(2)	(3)	(4)
	Student FE	Student FE with past GPA	Added teacher controls	Added teacher expectations
	Attendance			
Teacher growth mindset	0.002	0.002	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	699,130	699,130	699,130	699,130
R-squared	0.858	0.858	0.858	0.858
Student fixed effect	Yes	Yes	Yes	Yes
Subject fixed effect	Yes	Yes	Yes	Yes
Teacher controls	No	No	Yes	Yes

Notes: Standard errors, clustered at the classroom level, are presented in parentheses. All models include student fixed effect and subject dummies. Prob > F refers to an F-test of the joint significance of the teacher controls. Model (2) and (3) include controls for teacher gender, type of certification, teacher experience, and teacher subject.

*** p<0.01, ** p<0.05, * p<0.1

Table A3. Estimated Effects

VARIABLES	(1) Student FE	(2) Student FE with past GPA	(3) Added teacher controls	(4) Added teacher expectation
Teacher growth mindset	0.0197***	0.0197***	0.0185***	0.0169***
	(0.00651)	(0.00651)	(0.00654)	(0.00655)
Previous subject GPA		0.166***	0.166***	0.166***
		(0.00206)	(0.00206)	(0.00206)
Teacher expectations				0.0185***
				(0.00523)
Female teacher			0.00654	0.00617
			(0.00436)	(0.00436)
Teacher's college certification			0.0327	0.0304
			(0.0499)	(0.0500)
University certification			0.0388**	0.0386**
			(0.0163)	(0.0163)
IP-CFT certification			0.0173	0.0168
			(0.0202)	(0.0202)
Experience at the current School			0.00103***	0.00103***
			(0.000280)	(0.000280)
Experience as a teacher			-0.00109***	-0.00107***
			(0.000216)	(0.000216)
Constant	-0.0178***	-0.0178***	-0.0600***	-0.0716***
	(0.00601)	(0.00601)	(0.0185)	(0.0188)
Observations	585,960	585,960	585,960	585,960
R-squared	0.845	0.849	0.849	0.849
Subject Fixed Effect	Yes	Yes	Yes	Yes
Student Fixed Effect	Yes	Yes	Yes	Yes

Notes: Standards errors, clustered at the classroom level, are presented in parentheses. All models include Student Fixed Effect.
*** p<0.01, ** p<0.05, * p<0.1

Table A4. Estimated Effects of Teacher Growth Mindset on SIMCE Test Scores with Teacher-Student Gender Matching Control

VARIABLES	(1) General model	(2) Added teacher-student matching	(3) General model with teacher expectations	(4) Added teacher-student matching	(5) General model with gender interaction	(6) Added teacher-student matching	(7) General model with teacher expectations and gender interaction	(8) Added teacher-student matching	(9) Two fixed effects	(10) Added teacher-student matching
					Test Score					
Teacher growth mindset	0.0185***	0.0180***	0.0169***	0.0164**	0.0103	0.0130	0.00859	0.0112		
	(0.00654)	(0.00654)	(0.00655)	(0.00656)	(0.00807)	(0.00805)	(0.00809)	(0.00807)		
Past subject GPA	0.166***	0.164***	0.166***	0.164***	0.166***	0.164***	0.166***	0.164***	0.166***	0.164***
	(0.00206)	(0.00206)	(0.00206)	(0.00206)	(0.00205)	(0.00206)	(0.00205)	(0.00206)	(0.00206)	(0.00206)
Teacher expectations			0.0185***	0.0186***			0.0185***	0.0186***		
			(0.00523)	(0.00523)			(0.00523)	(0.00523)		
Female student X female teacher		0.111***		0.111***		0.110***		0.110***		0.109***
		(0.00586)		(0.00586)		(0.00587)		(0.00586)		(0.00547)
Teacher growth mindset X male student					0.0164*	0.0100	0.0166*	0.0102	0.0183**	0.0123
					(0.00938)	(0.00930)	(0.00939)	(0.00931)	(0.00866)	(0.00854)
Observations	585,960	585,960	585,960	585,960	585,960	585,960	585,960	585,96	585,960	585,960
R-squared	0.849	0.849	0.849	0.849	0.849	0.849	0.849	0.849	0.870	0.870
Prob > F	0.000	0.000	0.000	0.000	-	-	-	-	-	-
Student Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Subject Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Teacher Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standards errors, clustered at the classroom level, are presented in parentheses. All models include Student Fixed Effect and Subject Fixed Effect. Prob > F refers to an F-test of the joint significance of the teacher controls. All models include controls for teacher gender, type of certification, and teacher experience.

*** p<0.01, ** p<0.05, * p<0.1

Table A5. Estimated Effects with Interactions

		(1) Regressions by subgroup	(2) Interaction coefficient	(3) Interaction coefficient	(4) N
Variables		Test Score (sd)			
Student Mindset	Growth	0.025*** (0.008)	0.014* (0.008)	0.020*** (0.007)	570,918
	Fixed	0.011 (0.007)			
Past GPA	High	0.024*** (0.008)	0.016** (0.007)	0.015** (0.007)	585,960
	Low	0.008 (0.007)			
Gender	Female Students	0.025*** (0.008)	0.017* (0.009)	0.018** (0.009)	585,960
	Male Students	0.008 (0.008)			
Family Income	Lowest Quintile	0.020** (0.008)	0.025[b] (0.016)	0.011[b] (0.015)	512,624
	Q2	0.031*** (0.011)			
	Q3	0.030** (0.012)			
	Q4	0.017 (0.010)			
	Highest Quintile	-0.005 (0.014)			
School SES index[a]	Lowest Quintile	0.034** (0.015)	0.053***[b] (0.020)	-	585,544
	Q2	0.015 (0.013)			
	Q3	0.030** (0.014)			
	Q4	0.031** (0.015)			
	Highest Quintile	-0.019 (0.014)			
Subject/level	STEM (eighth grade)	0.020** (0.008)	0.008 (0.013)	-	585,960
	Humanities (tenth grade)	0.012 (0.011)			
	Subject Fixed Effect	Yes	Yes	Yes	
	Student Fixed Effect	Yes	Yes	Yes	
	Teacher Fixed Effect	No	No	Yes	

Notes: Standards errors, clustered at the classroom level, are presented in parentheses. All models include Student Fixed Effect and subject dummies. All models include controls for teacher gender, type of certification, teacher experience, and teacher expectations. Model (3) Includes Teacher Fixed effects. [a] Index was built considering School Vulnerability where the lowest quintile is schools with the highest percent of vulnerable students. [b] Difference between the lowest quintile and highest quintile. *** p<0.01, ** p<0.05, * p<0.1