Teaching practices and student achievement*

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Abstract

Using data from a Spanish assessment program of fourth-grade pupils, this paper analyzes the relationship between standardized student test scores and the practices and materials used by the teacher in class. We group teaching practices and materials as traditional or modern. As a novelty, we construct those aggregate measures using the answers to the same question provided by the teacher and her students. We identify the effect of teaching practices and materials on student achievement by exploiting the within school variation across classes. Results show that modern practices are related to better achievement, specially in reading, while traditional practices, if anything, are detrimental. The sign of the effects obtained with students' answers is consistent with the sign found using the tutor's answers, although the coefficients are larger. Teacher characteristics are not significantly related to student test scores, with the notable exception of a negative relationship if the teacher's schooling is above a three-years college degree.

JEL classification: I20; I21; J24

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1 Introduction

Accumulated research finds that the level of knowledge acquired by people is an important predictor of both individual outcomes (such as future labor market careers) and aggregated outcomes (such as economic growth).[1] In the education production process, it is widely accepted that teachers matter to increase students' achievement.[2] However, the question about what attributes make a teacher more successful than another in enhancing students' performance has not been settled so far. As Hanushek and Rivkin (2006) point out, previous studies do not find consistent evidence that pupils' achievement is strongly correlated to observable teacher characteristics, such as gender, experience, certification, etc. Among exceptions, Rockoff (2004) and, Rivkin et al. (2005), who find significant effects of teacher experience (although the impact is small and concentrated in the first years), and Dee (2005, 2007) who obtain significant effects of teacher's gender and race. The lack of consistent evidence of observed characteristics contrasts with the general finding that teacher effectiveness, measured by teacher fixed effects, has an important impact on student achievement (see Rockoff (2004) and Rivkin et al. (2005)).

Since observed characteristics only explain a relatively small part of overall teacher quality, a recent line of research shifts the focus to teaching practices, that is, what teachers actually do in the classroom (Schwerdt and Wuppermann (2011), Lavy (2011), Bietenbeck (2014)). These studies show evidence that teaching practices matter for student achievement. However, findings on the relationship between the teaching style and student achievement are still scarce and not conclusive, especially to identify the best teaching practices. From a policy perspective, a better understanding of the relationship between in-class work and student outcomes is important. Most of the proposals to reform education advocate a greater use of modern teaching practices (real-world problem solving, presenting information, working in groups) in detriment of a traditional rote-learning style.

The objective of our paper is to analyze how different practices and materials used by teachers in their class work affect student achievement. We group teaching practices and class materials according to whether they are traditional or modern, and we relate those aggregated measures to standardized student test scores.

For our purpose, we use data from a national assessment program conducted in 2009 in

[1] Regarding the effect of human capital on labor market outcomes, see, for example, Murnane et al. (1995), Keane and Wolpin (1997), Cameron and Heckman (1993, 1998), Lazear (2003). With respect to the association between students' test scores and economic growth, see Hanushek and Kimko (2000) and Hanushek and Woessmann (2012).

[2] See Hanushek and Rivkin (2006) and Hanushek (2006) for a review. Recently, Hanushek (2011) quantifies that an effective teacher is equivalent to advancing knowledge in one academic year. Furthermore, Chetty et al. (2011a) conclude that teachers who raise test scores also increase the future income of the student, the probability of attending college and the neighborhood quality, while they decrease the probability of teenage pregnancy.

Spain, *"La Evaluación General de Diagnóstico"* (EGD2009). This program evaluates fourth grade students in several competencies, including the core ones (mathematics and reading). The EGD2009 also collects information on the characteristics of students, families, teachers and principals through a set of questionnaires. In addition, the teacher and her students answer several questions about the practices and materials used by the teacher in her class work. We use this information to construct our measures of traditional and modern practices following the taxonomy by Zemelman et al. (2005). Importantly, the program is designed to evaluate all students belonging to the same classroom, and in most schools, it evaluates two complete classes. In addition, it allows linking each student with her teacher. Students in fourth grade of primary education are nine years old. The classes for these young children are organized around a teacher, the tutor, who teaches them most of the subjects, including usually maths and reading.[3] Students also have the same classmates for the entire school day.

Our empirical strategy exploits the variation in teaching practices and test scores across classes within a school to identify the effect of teaching practices on student achievement. By focusing on the within-school variation, we deal with the problem of between-school sorting, which would bias the effect of the teaching practices because students are not randomly allocated to schools. Indeed, the choice of both the neighborhood and the school are nonrandom decisions of parents (for instance, motivated by the teaching philosophy of the school).

Another concern is whether there is within-school sorting, that is, if teachers and students are assigned to classrooms according to some nonrandom rule (for example, better teachers are assigned to classes with better students). In our data, this should not be a major concern since the Spanish schooling system is neither track-based in primary education, nor characterized by the practice of "teacher shopping" by parents. Consistently, our analysis shows broad evidence of no systematic assignment of teachers and students with specific characteristics to the same classroom. In addition, although classes were formed randomly, the teacher may still adapt her teaching style to the class level finally formed. We neither obtain evidence that supports this behavior. Nevertheless, our specification controls for a rich set of teacher variables (including tutorial activities and class climate) and student characteristics in order to minimize the possible presence of unobserved traits.

Our paper is related to the previous literature on teaching practices. Schwerdt and Wuppermann (2011) study the effect of lecture-style teaching versus in-class problem solving on standardized test scores using the TIMSS wave of 2003. Using a between-subject strategy to control for unobserved student traits, they find that a ten percentage point shift from problem solving to lecture-style presentation results in an increase in student achievement of about one percent of a standard deviation. This result stands in contrast to constructivist theories of learning. However, it is in line with Brewer and Goldhaber (1997) who conclude that instruction in small groups and emphasis on problem solving lead to lower student test scores.

[3]Throughout the paper, we use the terms "teacher" and "tutor" interchangeably.

Lavy (2011) analyzes the effect of traditional and modern teaching on student achievement in Israel using a panel data of pupils in fifth and eighth grade. His identification strategy is based on the within-school change in exposure to teaching practices among students attending both grades. Lavy (2011) concludes that traditional and modern practices do not necessarily crowd out each other. In particular, practices that emphasize "instilment of knowledge and comprehension", considered as traditional teaching, have a positive effect on test scores, especially of girls and pupils from low socioeconomic backgrounds. "Analytical and critical skills", viewed as modern teaching, have also a high payoff, especially among pupils from educated families.

Bietenbeck (2014) analyzes the effect of traditional and modern teaching practices on maths and science test scores using the TIMSS wave of 2007. He estimates a student fixed-effect model, where his identification strategy relies on the different student exposure to teaching practices between maths and science. He concludes that traditional teaching has a positive effect on overall test scores while modern teaching has a statistically insignificant effect. After splitting overall test scores by cognitive skills, modern practices have a positive and significant effect on reasoning, while traditional teaching increases knowing and applying skills.

Our work extends beyond those previous papers in the following. First, we analyze the impact of teaching practices on test scores of younger students (around nine years old). As many recent papers show, it is important to understand at early stages how the education process successfully improves student achievement and outcomes later in life (see, for instance, Heckman (2008), and Chetty et al. (2011b)). Second, in contrast to previous literature, we estimate the effect of teaching practices both using the information reported by the teacher and by her students. Most previous works use only one of these pieces of information, usually the one provided by the students. However, we consider that teacher's answers are more reliable to measure what she really does in the classroom, especially the younger the students. Nevertheless, since the same questions on teaching practices are asked to the students, we also construct the traditional and modern indexes using this information to compare with the results obtained using the teacher's answers, and with previous findings. Third, none of the previous studies has analyzed the impact of teacher attributes and teaching practices on student achievement in Spain. Providing evidence about this is important given the serious problems faced by the Spanish educational system: high dropout rate (23.5% in 2013 according to Eurostat) and lack of excellence (as shown by the low performance in PISA).

We find that modern teaching practices are related to better student achievement, while traditional practices, if anything, are detrimental. Teaching materials are not significantly related to test scores. We also show that there are heterogeneous effects across subjects: modern teaching practices are positive for reading scores, while they are not significant for maths scores. Finally, we compare the estimates obtained using the information on teaching practices reported by the own teacher and by her students. For most of the indexes, the sign of

the effects obtained with students' answers is consistent with the sign found using the tutor's answers. However, the magnitude of the coefficients is larger in the first case. In line with previous literature, observable teacher characteristics, such as gender or experience, are not strongly correlated with pupils' achievement. However, we obtain that having a teacher with more than three years of college is associated to lower test scores in maths and reading. This effect suggests that teachers with more than three years of college are negatively selected into primary education.

The rest of the paper is organized as follows. Section 2 describes the database and explains the construction of the teaching practices measures. Section 3 explains the empirical strategy. Section 4 presents the results. Section 5 concludes.

2 Data

We use data from *"La Evaluación General de Diagnóstico"*, a national assessment program conducted in 2009 by the Instituto Nacional de Evaluación Educativa (INEE), a Spanish institution belonging to the Ministry of Education. This program evaluates the competencies of fourth-grade students in several subjects using a standardized test, designed by the INEE following the PISA methodology. We focus on the analysis of the competencies in the two core subjects, maths and reading.[4]

EGD2009 evaluates 28,708 pupils belonging to 900 schools following a two-stage stratified sampling design. In the first stage, schools are selected with probabilities proportional to their fourth grade enrollment. In the second stage, one or two fourth grade classes of the school are randomly sampled and all students belonging to these classrooms are evaluated. The sample is designed so that the assessment results are representative at the national and regional level, and by type of school (public/private).

The test consists of both multiple-choice questions and constructed-response items, where the latter requires that students generate and write their own answers. Those type of questions are intended to measure facts, analytical skills and critical thinking (for details, see INEE (2009)). Student's overall achievement is made available through five *plausible values*. Like in other assessment programs, for each student, these values are random draws from an estimated proficiency distribution obtained using the student answers to the test items and applying the Item Response Theory. Scores were constructed to have mean equal to 500 and standard deviation equal to 100. However, we standardize scores to have mean zero and standard deviation one in order to interpret coefficients as fractions of a standard deviation.

In addition to assess student achievement, EGD2009 collects detailed information through questionnaires filled in by students, families, teachers, and school principals. Students and

[4]The program also evaluates students' competencies on the knowledge of the physical world and on civic values. The knowledge of the physical world refers to knowledge about life and health, the Earth and the environment. The civic competence assesses student's understanding of democratic, social and civic values.

families report, among other, gender, date of birth, country of origin, household composition, age at starting school, parents' education, parents' labor status, parents' support in doing homework, and whether the student repeated.[5]

The teacher questionnaire is answered by the tutor of the group. In Spain, fourth grade students are grouped into classrooms where a tutor teaches them most of the subjects, including the core ones (maths and reading). Therefore, pupils have the same classmates for the entire school day. It is also usual that students are assigned to a classroom in first grade and they continue with the same classmates until the end of primary education (sixth grade). Apart from the relatively standard set of variables of the teacher (gender, experience, degree, training), the tutor questionnaire provides rich information on the practices and materials used in her class work, subjects taught, tutorial activities and class climate.

The original sample contains 28,708 pupils distributed into 1,358 classrooms in 900 schools. From this initial sample, we drop (i) students with missing maths or reading scores; (ii) classrooms with less than five pupils; (iii) students and teachers with blank questionnaires; (iv) teachers who do not teach maths nor reading, so we are sure that teachers in the final sample teach the subjects we analyze; (v) students and teachers with missing information in basic observed variables (gender, country of origin, parents' education and labor status, household composition, experience, type of teacher's degree)[6]; (vi) teachers with missing information on the items used to construct the teaching practices measures. In addition, in order to deal with the between-school sorting, we drop the schools with only one fourth-grade classroom surveyed. The final sample contains 11,774 students from 716 classrooms and 358 schools. We have checked that the characteristics of this sample are not significantly different from those in the initial sample. Therefore, the final sample is still representative of the target population of fourth-grade students in Spain.

Table 1 presents statistics describing the fourth grade teachers in primary school in Spain. Fourth grade teachers are mainly women, with more than thirty years of experience, teaching the core subjects of mathematics and reading in classes of an average size of sixteen students.[7] In addition, 74% of teachers teach to the same group of students in third and fourth grade. 17% of teachers present a level of education corresponding to a university degree of five years or a master degree. The rest of teachers hold a three-years degree, which is the minimum education level required by law to teach in primary education. Many teachers respond to have participated in some type of training in the last two years, although these variables present quite missing responses. Regarding the work as tutor, teachers meet with parents an

[5]Regarding household composition we construct two categories: living in single-parent household, and living with siblings. Regarding parents' education, we distinguish the following categories for both parents: primary or less, compulsory, high school, vocational training, and university. Regarding parents' labor status, we construct the following categories: self-employed, employee, unemployed, and inactive.

[6]Since we do control for both parents' education and labor status, we do not use information on home resources to avoid dropping too many individuals from the initial sample.

[7]Class size is the total number of surveyed students in a classroom in the initial sample.

average of three time per school year. It is more usual that the teacher asks for meetings. The characteristics of the learning environment and disciplinary climate are captured by the proportion of warning letters about student's behavior sent to her family, and by the percentage of warnings about temporary class suspension.

Table 2 reports descriptive statistics of student characteristics and family background. Around half of fourth-grade students are girls and 5% has repeated at least once. 7% live in single-parent households and most students live with at least one sibling. The proportion of non-Spanish pupils is 7% and most of them come from Non-Western Europe or Latin America. A high percentage of students started school with three years old or less, which is the usual age to start school in Spain. The schooling attainment of mothers and fathers is similar, while the proportion of unemployed or inactive mothers is higher than the proportion of fathers.

Table 3 presents average reading and mathematics test scores. For the full sample, average scores are similar in maths and reading. However, there are differences by gender: on average, girls perform better than boys in reading, while boys perform better in maths. By type of school, average scores are larger in both subjects for students from private schools.

2.1 Teaching practices and materials

In addition to personal characteristics, the tutor questionnaire collects information on the practices and materials that she uses in her class work.

The information related to teaching practices is derived from the question, "How often do you use the following teaching practices in your lessons this school year?". On a point-four scale, possible answers are "Never or almost never", "Sometimes", "Almost always", and "Always". Teachers respond about each of the following teaching practices: (a) "Most of the time I teach by telling", (b) "Students present works or topics to classmates", (c) "While I teach, I ask students questions about the lesson", (d) "While I teach, students ask me doubts", (e) "I promote discussions", (f) "Students work on exercises and activities proposed by me", (g) "Students work individually", (h) "Students work in small groups", (i) "I give different exercises or activities to best/worst students". We do not consider this last item in the analysis because it reflects the level of students in class and it would leave to a problem of reverse causality in the estimation. According to the taxonomy by Zemelman et al. (2005), practices (b), (e), and (h) can be unambiguously classified as modern, and practices (a), (f), and (g) as traditional. However, it is not possible to unambiguously match items (c) and (d) as traditional or modern. In principle, item (c) may be thought as traditional and item (d) as modern, but it is also possible the other way around.

EGD2009 data supports the classification based on the taxonomy. In Table 5 we show the correlation coefficients among the tutor's answers to all the items. We can observe that modern items (b), (e), and (h) are positively correlated (with coefficients around 0.26). The

same pattern appears for traditional items (a), (f), and (g), with coefficients ranging from 0.13 to 0.30. Items (d) and (c), classified as modern and traditional, respectively, present a positive, but smaller, correlation with the respective modern and traditional items. At the same time, item (c) is positively correlated with modern items, and item (d) with traditional ones, while this pattern is not observed for the rest of items (see bottom left of the Table). Moreover, these two items are correlated with a coefficient equal to 0.46. Therefore, we decide to not include items (c) and (d) in the baseline definition of teaching practices, although in Section 4.1 we check the robustness of the results to include them. The classification of the practices included in the baseline measures is displayed in Table 4.

For the ease of interpretation, we rescale the answers to each item by assigning a proportional value as follows: 0 to "Never or almost never", 0.34 to "Sometimes", 0.67 to "Almost always", and 1 to "Always". In this way, the responses are interpreted as the proportion of the time used in that activity. The aggregate measure of traditional teaching practices is the mean of the teacher's answers to items (a), (f) and (g); and the aggregate measure of modern teaching practices is the mean of the teacher's answers to items (b), (e) and (h).

The information related to teaching materials is derived from the question, "How often do you use in your lessons the following materials?". Using the same possible answers as in question 21, teachers respond about these items: (a) textbook, (b) workbook to do exercises, (c) books from school library, (d) your own materials, (e) newspapers, (f) computers and internet, (g) audiovisual materials. As commented above, we assign the proportional values 0, 0.34, 0.67, and 1, to each item. The traditional index is constructed by averaging the teacher's answers to items (a) and (b), and the modern index is constructed as the mean to items (f) and (g).

Unlike most previous papers, which use the information provided by the students, in our preferred specification, we use the teaching practices measures constructed with the teacher's responses. We consider that these answers are more reliable to measure accurately what teachers really do in the classroom, especially the younger the students. However, since the EGD2009 survey asks students about the same teaching practices and materials, we also construct the traditional and modern indexes using this information. In particular, the question on teaching practices is "In general, how is in-class work?". The items to answer about correspond exactly with items (a) to (h) from the teacher questionnaire and they are also coded using the same scale. The question on teaching materials is "How often do you use in the lessons the following materials?", and the items included in the answer are the same as those included in the teacher's question with the exception of item (d). Assigning the same proportional values (0, 0.34, 0.67, 1), and using the same classification of items, we construct modern and traditional indexes of teaching practices and materials by averaging the students' responses at the class level (excluding the student's own response). The results obtained using these measures are useful to compare with results from previous literature, and more impor-

tantly, to compare with results obtained using the teacher's answers. Regarding this, it should be noted that the student's question is about all class work and, although most of the subjects are taught by the tutor, the students' answers may refer to all teachers they have in fourth grade.

Table 6 contains the average and standard deviation of modern and traditional indexes, both reported by the tutor and by the students. According to the tutor, traditional style is more frequently used than modern one: 66% of the time, the tutor uses traditional practices and 43 % of time she uses modern practices. Traditional materials are also the most frequently used in class. Surprisingly, given that students are only nine years old, average pupils' answers are close to their tutor's response. On average, students slightly underreport modern teaching and materials, and overreport traditional teaching, but not traditional materials. The dispersion of the students indexes is smaller than the one from the tutor indexes.

We use the tutor indexes to estimate the effect on student test scores of what teachers do in the classroom. As we explain in Section 3, we consider two specifications, a first one where teaching practices are the regressors, and a second specification with the teaching materials. In turn, we estimate those regressions using the students' indexes. Thus, in each regression, we include jointly the traditional and modern index. In order to interpret the effects, we should note that the two measures do not imply a trade-off between using traditional or modern methods in class. Therefore, the estimated coefficient of one of the indexes should be interpreted as the effect on test scores holding constant the other index. In this way, we do not restrict the possibility that some teaching practices can be conducted, at least to some degree, simultaneously, even if one practice is traditional and the other is modern[8]. For instance, one possible activity proposed by the teacher (item (f), traditional) may be to promote discussions in class (item (e), modern). So, the two practices would happen simultaneously. Indeed, Table 5 shows a positive correlation between these two items. Nevertheless, we assess the sensitivity of our results to construct a new measure of teaching practices that impose that the time using traditional or modern activities must not violate the time budget constraint.

In Table 7 we show that the correlation between traditional and modern practices indexes is not significantly different from zero. However, this is the result of negative and positive correlations across individual items that may compensate each other (see bottom left of Table 5). The correlation between traditional and modern materials indexes is not zero, but it is small (0.11). According to the tutor indexes, the correlation between modern practices and materials is 0.22 and between traditional practices and materials is 0.36, both statistically significant at one percent level. Those correlations are a bit higher for the students indexes. The correlation among tutor's and students' answers is positive and significant, ranging from 0.10 to 0.24 (see matrix in the left bottom of Table 7). This positive correlation is evidence

[8]Note that the questions about teaching practices and materials do not impose either any restriction of this type.

that students capture the teaching style in the same way as their tutor. However, the small magnitude shows that pupils and tutor's perception is far from identical.

Finally, in Table 8 we show the overall, between- and within-school variance in teaching practices and materials. Not surprisingly, most of the variation in teaching practices happens between schools. However, there is still around 30% of the variation that happens within a school.

3 Empirical Strategy

EGD2009 evaluates all fourth-grade students belonging to the same classroom. In Spain, students in primary education have the same classmates for the entire school day. Moreover, it is usual that pupils are assigned to a classroom in first grade and they continue with the same classmates until the end of primary education (sixth grade). EGD2009 also collects information on the tutor of that fourth-grade classroom. The tutor is the main teacher, in charge of most of the subjects, including usually maths and reading. In the sample, this happens for 88% of tutors (see Table 1). In addition, this teacher makes tutorial work, such as meeting with students' parents to talk about the achievement of their children or about existing class-disruptive problems. Therefore, the structure of the EGD2009 allows linking each student with her tutor.

Using the matched-pairs data of teacher and students, we adopt an empirical strategy that exploits the within-school variation in teaching practices and test scores across classes to identify the effect of teaching practices on student achievement.[9] In particular, we estimate the following empirical model:

$$y_{ics} = \alpha + \gamma' TI_{cs} + \lambda' T_{cs} + \beta' X_{ics} + \phi_s + \varepsilon_{ics} \tag{1}$$

where y_{ics} is the standardized test score of student i in classroom c at school s. TI_{cs} is the vector of traditional and modern teaching indexes in class c in school s ($ModTI_{cs}$, $TradTI_{cs}$). We consider two specifications, a first one where the variables $ModTI_{cs}$ and $TradTI_{cs}$ are the teaching practices indexes, and a second specification where $ModTI_{cs}$ and $TradTI_{cs}$ are the teaching materials indexes. In turn, we run separate regressions for the indexes constructed using the tutor's and the students' answers[10]. T_{cs} is a vector of tutor variables and class size. X_{ics} is a vector of student characteristics. ϕ_s is a school fixed effect and ε_{ics} is the error term. We estimate (1) separately for maths and reading, and also, after pooling test scores from both subjects (including a dummy variable for maths).

[9]Identification based on within school variation has been used by Ammermueller and Pischke (2009), McEwan (2003), among others, to estimate peer effects within schools.

[10]Note that when we use the students' answers, the indexes are constructed excluding the student's own answer ($ModTI_{cs-i}$, $TradTI_{cs-i}$)

Since the identification of the effect of teaching practices on student achievement (γ) relies on the variation in scores and teaching practices across classes within a school, it is necessary that, after accounting for the school, there is still enough between-class variation. As shown in Table 8, most of the variation in teaching practices happens between schools, and the school fixed effect accounts for it. However, there is still an important fraction of the observed variation that happens within school.

The identifying assumption is that teaching practices (or materials) are uncorrelated with the error term conditional on the other regressors. One of the potential confounding factors is the endogenous selection of students and teachers across schools. This between-school sorting will happen if, for instance, students attending a school present specific characteristics as a consequence of the nonrandom choice of neighborhood by parents. Related to this, some parents may prefer a school that hires teachers with some specific characteristics or that has a certain teaching philosophy. We deal with this endogenous selection of students and teachers by focusing on the schools with two sampled classrooms and, thus, including school fixed effects in the empirical model.

However, even after accounting for between-school sorting, there may be still unobserved student and teacher traits (μ_{ics} and η_{cs}, respectively) in the error term that may bias the estimate of γ. In particular, γ would be biased:

- If there is some student unobserved trait that has a direct effect on y_{ics} while it is correlated with the teaching practices. That is, γ would be biased if $corr(\mu_{ics}, TI_{cs}) \neq 0$. This would happen if there is sorting of students to classes within school (so, the ability composition of the two classes will be different) and the teacher adapts her teaching practices to the resulting level of ability in the class (reverse causality). For example, if high-ability students are assigned to the same class and the teacher decides to use more modern teaching practices with those students, the estimate of γ will be biased. It is important to note that although μ_{ics} affects scores, if students are more or less randomly assigned to classes and teachers do not adapt their teaching style to the ability level of the class, γ will not be biased.

- If there are unobserved teacher traits, such as ability or motivation, which have a direct impact on y_{ics}, while they are correlated with the teaching practices. That is, γ would be biased if $corr(\eta_{cs}, TI_{cs}) \neq 0$. This would happen if there are unobserved teacher characteristics (such as the ability to teach) that affect the choice of teaching style and that have a direct effect on student test scores, aside from the effect through the teaching practices.

In the next Subsection we explain the way we deal with those concerns.

3.1 Within-school selection of students and teachers

Our key assumption is that teaching practices are uncorrelated with μ_{ics} and η_{cs} once we have accounted for the school and the rest of regressors. However, this assumption does not hold if teachers and students are assigned to classrooms according to some nonrandom rule. This within-school sorting arises, for instance, if parents try to influence who is the teacher assigned to their children. This is not a concern in this paper, since the practice of teacher shopping by parents is absent or very rare in Spain. Another possible source of within-school sorting is that the school principal uses an explicit nonrandom rule to assign students to teachers (for example, assigning better teachers to classes with better students). This would be a major concern in countries where the schooling system is strongly track-based. Although this is not the case in primary education in Spain, the presence of some type of within-school sorting could still be a concern. Therefore, we conduct the following analysis to assess if there is evidence of this type of sorting in our data.

First, we investigate whether students with certain family characteristics are more likely to be in classes with certain type of teacher. To this end, we regress different observed teacher variables on sociodemographic characteristics of students measured at the classroom level:

$$t_{cs} = \alpha_0 + \alpha_1' X_{cs} + \phi_s + v_{ics}$$

where t_{cs} is a characteristic of the tutor of class c in school s; X_{cs} is a vector of sociodemographic characteristics of class c at school s; and ϕ_s is a school fixed effect. Table 9 reports the results. Each column represents a separate regression. The variables that capture the sociodemographic characteristics of the class are parents' education, parents' employment, and percent of: non-Spanish, students with siblings, living in single-parent household, female, and repeater. With respect to the teacher variables, we consider gender, years of experience, holding a 5-years degree, taught subjects (maths and reading, only reading), and tutor in third and fourth grades. In the last two columns we regress modern and traditional teaching practices on the class-level variables. We do not find a systematic within-school relationship between teacher or teaching practices and class-level characteristics (i.e. with high proportion of immigrants, repeaters, students from low-educated families, etc). We also check the joint significance of the regressors with an F-test (see last rows of Table 9). In all regressions, F-statistics do not reject the null hypothesis that the joint effect of the class-level characteristics is zero at the five percent level.

Second, we analyze whether classrooms that differ in teaching practices, differ in pupils' characteristics as well. For this purpose, following Lavy (2011), we run a set of regressions of student-level characteristics on modern and traditional teaching practices, as reported by the tutor, and on school fixed effects:

$$x_{ics} = \beta_0 + \beta_1' TP_{cs} + \phi_s + \varphi_{ics}$$

where x_{ics} is the characteristic of student i in classroom c at school s, TP_{cs} is the vector of modern and traditional indexes of teaching practices, and ϕ_s is a school fixed effect. Student characteristics are: parents' education, parents' labor status, living in single-parent household, living with siblings, gender, repeater and non-Spanish origin. Table 10 presents the results. For each panel, each column represents a separate regression. Neither traditional nor modern teaching practices are systematically correlated with student-level characteristics. In most regressions, the effect of teaching practices is not significantly different from zero. In addition, F-statistics do not allow rejecting the null hypothesis that the effect of traditional and modern teaching is jointly zero. Thus, conditioning on the school, we conclude that students with certain characteristics are not more likely to be assigned to teachers using certain teaching practices.

To sum up, evidence from Tables 9 and 10 shows that there is no systematic within-school assignment of students with certain characteristics to certain type of teachers. However, even though classes are formed more or less randomly, they may receive other school resources differently. For instance, a teacher with a specific teaching style may be assigned to classes of certain size. To check this, we run the following set of regressions:

$$tp_{cs} = \lambda_0 + \lambda_1 size + \lambda_2 size^2 + \phi_s + \varsigma_{ics}$$

where tp_{cs} denotes the teaching practices measure (traditional or modern) reported by the tutor; $size$ is class size and ϕ_s is a school fixed effect. Results are shown in Table 11, where each column represents a separate regression. Results in columns one and three do not include school fixed effects. We test the joint significance of class size and class size squared on teaching practices. We do not find systematic correlation between class size and teaching practices, especially once we condition on the school.

Finally, we regress the measures of traditional and modern teaching practices on tutor variables, class size and school fixed effects:

$$tp_{cs} = \theta_0 + \theta_1' T_{cs} + \theta_2 size + \phi_s + \psi_{ics}$$

We include the following tutor characteristics: female, years of experience, holding a five-years degree, taught subjects, whether the tutor or parents ask for a meeting, number of meetings with parents, and being tutor of the class in third and fourth grade. The purpose of this analysis is to check whether a teaching style (traditional or modern) is correlated with certain teacher characteristics after controlling for school and class size. Results are shown in Table 12. Only holding a five-years college degree is significantly correlated with using a certain teaching style (traditional), although only at ten percent level. The rest of variables are not significantly related with traditional or modern teaching practices. Moreover, the set of tutor variables and class size is neither jointly significant (see bottom of Table 12). In sum, we do not find evidence that teachers with those observed characteristics self-select into a certain

teaching style. Therefore, it is plausible to assume that selection into teaching practices due to unobserved teacher characteristics will not be a big concern.

Using observational data to estimate the causal effect of teaching practices on student test scores has to deal with the problems of between and within-school sorting. Our empirical strategy accounts for between-school sorting by including school fixed effects. Regarding within-school sorting, we have shown here that, in our data, there is not evidence of systematic assignment of fourth-grade students and teachers within school. Nevertheless, in order to minimize any possible bias in the estimation of the effect of teaching practices, our empirical strategy includes a broad set of student and teacher variables. With respect to student characteristics (X_{ics}), we account for female, origin country, repeater, mother and father's education, mother and father's labor status, living in a single-parent household, living with siblings, born in the fourth quarter, age at starting school, whether a particular teacher or someone in the family helps a student with her homework. Note that this set of controls includes several variables as proxy for student ability and previous performance. With respect to the tutor characteristics (T_{cs}), we include not only the typical controls used in the literature (gender, experience, or type of degree), but also whether the tutor teaches only maths, only reading or both; and variables capturing teacher's work as tutor (number of meetings with parents, whether the tutor or the parents ask for a meeting, whether she was tutor of the class in third grade).

Although we cannot rule-out completely the presence of unobserved teacher or student traits, and consequently we have to be cautious in interpreting our estimates as causal, we should note that (i) we conduct an exhaustive analysis showing no evidence of within-school sorting; (ii) we do not find evidence of correlation of teaching practices with observed teacher and class characteristics, so it is plausible to assume that selection on unobservables is neither a big concern; (iii) we include a broad set of regressors to control for possible differences in the student background and tutor across classes, once we have accounted for the school; (iv) our variable of teaching practices is potentially less endogenous with respect to the test scores in a particular subject since the tutor and the students answer about the general teaching practices in class and not about the particular teaching style in a subject. We should recall that we are analyzing achievement of nine-years old children, where the tutor teaches them most subjects and, thus, children do not face a different teacher for each subject.

4 Results

Tables 13 to 16 present the results (standard errors are clustered at the school level). Table 13 shows the results from estimation of regression (1), where TP_{cs} is the vector of modern and traditional teaching practices. In Table 14, we present the results from estimating (1) but substituting TP_{cs} by the indexes of modern and traditional teaching materials. In both

Tables, results are obtained after pooling maths and reading, and including a dummy variable for maths. In Tables 15 and 16 we present the results from estimating separately regression (1) for maths and reading, respectively.

In Table 13, we present the results from separate regressions with the indexes of teaching practices constructed using the teacher's or the students' answers (columns (1) to (3), and columns (4) to (6), respectively). First, we estimate an specification of regression (1) that only includes the measures of traditional and modern teaching practices, and a dummy variable for mathematics. Then, in columns (2) and (5), we show the results after adding class size and teacher characteristics. Finally, we also include student characteristics. This last specification corresponds with the one shown in (1)[11]. Results show that the effect of modern teaching practices is positive, and significant in the specification including all teacher and student controls (column 3). The coefficient is 0.21, which implies that a 10% increase in the modern index is associated with a 2.1% of a standard deviation increase in test scores. In contrast, the effect of traditional teaching practices is small and not significant. The coefficient of both indexes hardly changes with the inclusion of additional teacher and student controls. When, instead of using tutor's answers, we use the information reported by students, the coefficients of traditional and modern teaching practices are larger. However, like in previous estimations, only the effect of modern teaching is significant. In the specification that includes all student and teacher controls, a 10% increase in the modern index is associated with a 3.4% of a standard deviation increase in the test score. Similar to using the tutor's answers, this effect is robust to the inclusion of additional control variables.

In line with previous literature, we do not find strong evidence that pupils' achievement is correlated to observable teacher characteristics, such as gender or experience. The effect of being female is negligible and not significant. Having a teacher with more than five years of experience is associated with higher test scores, although the effect is only significant for teachers with 15 to 19, or with more than 30 years of experience. We neither find a clear relationship between test scores and taught subjects, or tutorial work. Regarding the latter, the only exception is the positive effect if the teacher was the tutor of the class both in third and fourth grade. This effect is significant in the estimation including all controls and the indexes constructed using the tutor's information (column 3). The most interesting effect is found for the type of degree that the tutor holds. Teachers with a university degree of five years or more are associated to a lower student achievement of 0.08 standard deviations compared to teachers with a three-years college degree. The effect is clearly significant and robust across all specifications. Since a three-years degree is the required degree to teach in primary education in Spain, that negative effect may suggest that teachers with a five-years college degree teaching in primary education are negatively self-selected. That is, they decide to work as primary education teachers after having failed to find a job in the private sector

[11]The estimated coefficients of student characteristics are presented in Tables A.1 and A.2 in the appendix.

and/or in secondary education (where the requirement is to hold at least a five-years college degree). Consequently, those teachers may lack motivation and good teaching skills, and this would explain the negative effect that we find.

In Table 14 we present the results from the estimation of the same specifications shown in Table 13 but after substituting the teaching practices by the teaching materials. Using traditional materials is associated with larger scores when the information is reported by the tutor, but with lower ones when the information is reported by students. The effect of modern materials is positive, and larger when using students' answers. Nevertheless, unlike Table 13, the effect of using traditional or modern materials is not significant. The effect of the rest of teacher characteristics hardly changes with respect to Table 13.

Next, we estimate specification (1) separately for maths and reading in order to assess whether the effect of traditional and modern teaching differs by subject. Results from these estimations are shown in Tables 15 and 16. The first two columns present the results for teaching practices and the last two columns for teaching materials. The positive and significant effect of using modern practices found in Table 13 comes through its effect on reading scores (see columns (1) and (2) in Table 16). The effect of modern teaching practices on maths scores is not significant. Indeed, nor teaching practices neither teaching materials have a significant effect on maths scores. However, we find that traditional practices are associated with lower reading test scores, and the effect is significant when they are reported by students. With respect to teaching materials, using modern ones is related to better student scores in reading, although the effect is only significant when the information is obtained from the student questionnaire. With respect to the rest of regressors, results are similar to those obtained with the pool of subjects. Some intervals of years of experience have a positive effect, and having a teacher with more than a three-years college degree reduce test scores in both subjects. However, considering subjects separately, we find a negative effect on maths scores related to having a tutor who only teaches reading, compared with only teaching maths. In contrast, we do not find an equivalent effect on reading scores.

All in all, we find that modern teaching practices are positive and significantly related to student achievement, both when information on teaching practices is reported by the tutor and the students. In contrast, traditional teaching is not significantly associated with test scores. The effect of using traditional or modern materials in class neither is significant. When we estimate separately for maths and reading, we find heterogeneous effects on test scores. In particular, the positive effect of modern teaching practices comes through its impact on reading, since modern teaching is not significantly associated with maths scores.

Our results provide new insights on the effect of teaching on achievement. Lavy (2011) obtains that both traditional and modern teaching practices have positive effects on test scores, although larger for traditional teaching. Bietenbeck (2014) concludes that only traditional teaching has a statistically significant and positive effect on overall test scores. Schwerdt and

Wuppermann (2011) find that teachers who spend more time lecturing are associated with higher test scores. Our evidence shows that, in contrast, modern teaching is related to better student achievement, while traditional teaching, if anything, is detrimental. In addition, most previous evidence is obtained using the teaching practices reported by students. We obtain results using that information and the one reported by the tutor. Although the sign of the effects obtained with students' answers is consistent with the sign found using tutor's answers, the magnitude of the coefficients is larger using student information. These differences suggest that in order to understand the role of teaching practices on student achievement, and draw policy implications, is important to take into account who reports the information about the class work.

In addition, we find that having a teacher with a university degree of five years or more is negatively related to student performance. This result differs from previous literature, which obtains that teachers with more years of college are related to better student performance. As we explained above, this may suggest that teachers with a five-years degree in primary education in Spain may be unmotivated or they may lack the adequate teaching skills. Educational authorities should take into account this misallocation problem when establishing the degree requirements to allow teachers to access primary education.

4.1 Sensitivity analysis

In this Section, we conduct several sensitivity tests in order to address potential reservations about our findings[12].

In the first set of tests, we assess whether the results hold after considering alternative ways of measuring teaching practices. Since the teacher's and student's questionnaires provide the information through a list of different teaching activities, there is not only a way to measure the class work. Our preferred regressor simply averages tutor's or students' answers across the activities that can be clearly classified as modern or traditional according to Zemelman et al. (2005)'s taxonomy and the correlations across items observed in the data. However, we assess the sensitivity of our results to use alternative measures.

In our baseline regression we include the traditional and modern measures jointly because, in principle, they do not imply a trade-off between using traditional or modern methods in class. Nevertheless, the individual correlation between some traditional and modern items is different from zero (see Table 5). Thus, a possible concern is whether including jointly the two measures may create any collinearity problem, which may influence the results. Table 17 shows that the results from the baseline regressions (columns (1), (4), (7) and (10)) do not change compared with the results from the regressions including each index one at a time.

[12]For the sake of brevity we only present the results obtained separately for maths and reading, although the results for the pool of subjects are available upon request.

In Table 18 we assess the robustness of the results to include items (c) "While I teach, I ask students questions about the lesson", and (d) "While I teach, students ask me doubts". Our baseline measures do not include these items because, as we have discussed, its classification as traditional or modern is ambiguous. In Panel A we redefine the traditional and modern indexes including item (c) as traditional and item (d) as modern, while in Panel B, we consider item (c) as modern and item (d) as traditional. Both panels show that the results from these regressions are similar to the baseline findings.

In Table 19, we redefine our measure of teaching practices as the share of the class time involved in modern activities. To construct this new measure, we impose the restriction that the total class time allocated to the six traditional or modern practices listed in Table 4 must be equal to one. In the baseline measure, we simply rescale the answers to each practice for the ease of interpretation but without imposing any additional restriction. Thus, it is possible that, for a given classroom, the sum of the traditional and modern indexes is larger than one, violating the time budget constraint. Indeed, using the teacher's answers, we observe this in 74% of the classrooms. This may reflect that some of the teaching activities listed in the questionnaire may be simultaneous, at least to some degree. However, it may also reflect measurement error or inconsistent responses (for instance, when someone answers "always" to all the items). In order to assess whether our results may be affected by this concern, we rescale the answers of a given teacher, or student, such as they sum to one. That is, for each teacher, or student, we sum the numerical values assigned to the answers of the six items (see Section 2.1). Then, we weight each answer by the inverse of that sum. In this way, we keep the relative frequency of use across teaching practices, but without violating the time budget constraint. The share of the class time using modern teaching practices is simply the sum of the time allocated to the three modern items. The rest of the time is for traditional practices. We construct the measure of the share of time using modern materials in the same way. Table 19 show that the results are qualitative and quantitative similar to the baseline estimates.

In Table 20 we present the results from other sensitivity tests where we include additional control variables to the baseline specification. In Panel A we include the class average of the student characteristics (excluding the student's own value). Controlling for these regressors hardly changes the effect of practices or materials on student achievement. This supports our previous evidence that there is not within-school sorting. If the results were driven by this type of selection, then, controlling for the sociodemographic characteristics of the class would change the results.

5 Conclusions

This paper analyzes the effect of teaching practices and materials on maths and reading test scores of Spanish primary students. One of the main challenges when analyzing the effect of

teaching on student achievement is the feature that schools and classrooms are not formed randomly. Our empirical strategy includes school fixed effects to deal with the problem of between-school sorting. Therefore, we identify the effect of teaching practices on achievement by relying on within-school variation across classrooms. With respect to the problem of within-school sorting, we conduct different types of analysis showing that there is no evidence of systematic assignment of students or teachers to classrooms within schools. In addition, our estimation controls for a rich set of student and teacher characteristics in order to minimize the presence of unobserved traits that might bias our estimates.

We do not find strong evidence that pupils' achievement is correlated to observable teacher characteristics, such as gender or experience. However, we obtain that having a teacher with more than a three-years college degree is associated to lower test scores in maths and reading. In addition, we find that modern teaching is related to better student achievement, while traditional teaching, if anything, is detrimental. Teaching materials are not significantly related to test scores. We also show that there are heterogeneous effects across subjects: modern teaching practices are positive for reading scores, while they are not significant for maths scores. Finally, we compare the estimates obtained using the information on teaching practices reported by the own teacher and by her students. The sign of the effects obtained with students' answers is consistent with the sign found using the tutor's answers. However, the magnitude of the coefficients is larger using student information. These differences suggest that in order to understand the role of teaching practices on student achievement, and draw policy implications, is important to take into account who reports the information about the class work.

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Tables

Table 1: Descriptive statistics of teacher

	Mean	Std. Dev.	Classrooms
Female	0.75	0.43	716
Experience (years):			
Less than 5	0.10	0.30	716
5 - 9	0.10	0.30	716
10 - 14	0.07	0.25	716
15 - 19	0.09	0.29	716
20 - 24	0.10	0.30	716
25 - 29	0.15	0.36	716
30 or more	0.39	0.49	716
5-years degree or more	0.17	0.37	716
Class size	16.44	4.61	716
Taught subjects:			
Reading and Maths	0.88	0.33	716
Reading	0.05	0.22	716
Maths	0.07	0.26	716
Training:			
Attending courses	0.95	0.21	538
Working teams at school	0.93	0.26	480
Congresses and teaching projects	0.88	0.33	386
Type of warnings to students:			
Letter to the family	0.68	0.46	679
Temporary class suspension	0.16	0.37	663
Person asking for a meeting:			
Parents	0.22	0.41	714
Teacher	0.33	0.47	714
Number of meetings with students' parents	3.04	0.97	711
Teacher at 3^{rd} and 4^{th} grades	0.74	0.44	709
Number of schools			358

Table 2: Descriptive statistics of students

	Mean	Std. Dev.	Observations
Female	0.49	0.50	11774
Repeater	0.05	0.23	11774
Born in 4th quarter	0.32	0.47	11774
Living in single-parent household	0.07	0.26	11774
Living with siblings	0.85	0.36	11774
Country of origin:			
Spain	0.93	0.26	11774
Western Europe	0.00	0.05	11774
Non-Western Europe	0.02	0.12	11774
Morocco	0.00	0.07	11774
Latin America	0.05	0.21	11774
Asia	0.00	0.04	11774
Other	0.00	0.06	11774
Age at starting school:			
2 years old or less	0.60	0.49	11774
3 years old	0.36	0.48	11774
4 years old	0.03	0.16	11774
5 years old	0.01	0.10	11774
6 years old	0.00	0.07	11774
Mother's education:			
Primary or less	0.10	0.30	11774
Compulsory	0.24	0.43	11774
High School	0.14	0.35	11774
Vocational training	0.20	0.40	11774
University	0.31	0.46	11774
Father's education:			
Primary or less	0.13	0.33	11774
Compulsory	0.26	0.44	11774
High School	0.15	0.36	11774
Vocational training	0.20	0.40	11774
University	0.26	0.44	11774
Mother's labor status:			
Self-employed	0.13	0.34	11774
Employee	0.52	0.50	11774
Unemployed	0.10	0.30	11774
Inactive	0.25	0.43	11774
Father's labor status:			
Self-employed	0.26	0.44	11774
Employee	0.65	0.48	11774
Unemployed	0.07	0.26	11774
Inactive	0.02	0.13	11774
Help with homework:			
Particular teacher	0.09	0.29	11602
Family	0.61	0.49	11602
Number of schools			358

Table 3: Descriptive statistics of test scores

	Maths	Reading
Full sample	0.13	0.14
	(1.00)	(0.98)
By gender:		
Male	0.21	0.09
	(1.03)	(0.97)
Female	0.06	0.19
	(0.96)	(0.98)
Gap (male-female)	0.15	-0.05
By type of school:		
Public	0.04	0.04
	(1.00)	(0.99)
Private	0.30	0.31
	(0.98)	(0.93)
Gap (public-private)	-0.26	-0.27
Students	11774	11774
Classrooms	716	716
Schools	358	358

Test scores are standardised with mean 0 and standard deviation 1. Standard deviation in parenthesis

Table 4: Matched teacher questionnaire items

Traditional Teaching Practices	Modern Teaching Practices
Item (a): Most of the time I teach by telling	Item (b): Students present works or topics to classmates
Item (f): Students work on exercises and activities proposed by me	Item (e): I promote discussions
Item (g): Students work individually	Item (h): Students work in small groups
Traditional Teaching Materials	**Modern Teaching Materials**
Item (a): Textbook to study and exercise	Item (f): Computers and internet
Item (b): Exercise booklet	Item (g): Audiovisual aids

Teachers respond to the question "How often do you use the following teaching practices/materials in your lessons this school year?". Possible answers are "Never or almost never", "Sometimes", "Almost always", and "Always".

Table 5: Correlation across teaching practices (Tutor's answers)

		Modern items				**Traditional items**			
		(b)	(e)	(h)	(d)	(a)	(f)	(g)	(c)
Modern items	(b)	1.00							
	(e)	0.25**	1.00						
		(0.00)							
	(h)	0.26**	0.26**	1.00					
		(0.00)	(0.00)						
	(d)	0.07	0.18**	0.12**	1.00				
		(0.08)	(0.00)	(0.00)					
Traditional items	(a)	0.09**	-0.03	-0.02	0.10**	1.00			
		(0.01)	(0.37)	(0.65)	(0.01)				
	(f)	0.07	0.09**	0.06	0.26**	0.13**	1.00		
		(0.06)	(0.02)	(0.12)	(0.00)	(0.00)			
	(g)	-0.05	-0.10**	-0.13**	0.09**	0.25**	0.30**	1.00	
		(0.22)	(0.01)	(0.00)	(0.02)	(0.00)	(0.00)		
	(c)	0.11**	0.19**	0.07	0.46**	0.20**	0.14**	0.09**	1.00
		(0.00)	(0.00)	(0.05)	(0.00)	(0.00)	(0.00)	(0.02)	

Sample: 358 schools, 716 classrooms, 11774 students. Standard deviation in parenthesis. ** $p < 0.05$. (b): "Students present works or topics to classmates"; (e): "I promote discussions"; (h): "Students work in small groups"; (d): "While I teach, students ask me doubts"; (a): "Most of the time I teach by telling"; (f): "Students work on exercises and activities proposed by me"; (g): "Students work individually"; (c): "While I teach, I ask students questions about the lesson".

Table 6: Descriptive statistics of indexes

	Mean	Std. Dev.	Min.	Max.	Classrooms
Tutor's answers:					
Modern practices	0.43	0.14	0.00	0.89	716
Traditional practices	0.66	0.15	0.11	1.00	716
Modern materials	0.34	0.16	0.00	1.00	716
Traditional materials	0.65	0.20	0.00	1.00	716
Students' answers:					
Modern practices	0.40	0.10	0.13	1.00	716
Traditional practices	0.76	0.08	0.37	0.95	716
Modern materials	0.32	0.10	0.00	0.81	716
Traditional materials	0.65	0.08	0.33	0.87	716

Table 7: Correlations

			Tutor's answers				Students' answers			
			Practices		Materials		Practices		Materials	
			Mod.	Trad.	Mod.	Trad.	Mod.	Trad.	Mod.	Trad.
Tutor's answers	Practices	Mod.	1.00							
		Trad.	0.00	1.00						
			(0.98)							
	Materials	Mod.	0.22***	-0.04	1.00					
			(0.00)	(0.27)						
		Trad.	0.00	0.36***	-0.03	1.00				
			(0.91)	(0.00)	(0.49)					
Students' answers	Practices	Mod.	0.24***				1.00			
			(0.00)							
		Trad.		0.19***			-0.01	1.00		
				(0.00)			(0.80)			
	Materials	Mod.			0.17***		0.37***	0.04	1.00	
					(0.00)		(0.00)	(0.31)		
		Trad.				0.10***	0.19***	0.44***	0.11***	1.00
						(0.00)	(0.00)	(0.00)	(0.00)	

Sample: 358 schools, 716 classrooms, 11774 students. Standard deviation in parenthesis. *** $p < 0.01$

Table 8: Decomposition of variance in class-level means

	Tutor's answers			
	Teaching		Materials	
	Modern	Traditional	Modern	Traditional
Overall	0.18	0.21	0.23	0.38
Between	0.13	0.14	0.18	0.30
Within	0.06	0.07	0.05	0.08
% within	30.61	33.59	23.31	21.16
	Students' answers			
	Teaching		Materials	
	Modern	Traditional	Modern	Traditional
Overall	0.09	0.06	0.09	0.05
Between	0.06	0.04	0.06	0.03
Within	0.03	0.02	0.03	0.02
% within	32.23	30.86	35.37	41.16

Sample: 358 schools, 716 classrooms, 11774 students

Table 9: Within-school assignment of teachers to classrooms: effect of class-level characteristics

	Dependent variable: Teacher characteristic												
		Years of experience						5-years	Taught subjects		Teacher	Teach. Practices	
	Female	5-9	10-14	15-19	20-24	25-29	≥30	degree	Read-Maths	Read	3^{rd}-4^{th} g.	Trad.	Mod.
Mother educ.:													
Compulsory	0.17	0.21	0.16	0.01	-0.20	-0.42*	0.30	0.18	-0.23	0.06	0.25	-0.08	-0.05
	(0.27)	(0.21)	(0.18)	(0.23)	(0.19)	(0.23)	(0.37)	(0.21)	(0.23)	(0.21)	(0.25)	(0.10)	(0.09)
High School	0.27	-0.07	0.45**	-0.10	-0.06	-0.34	0.19	0.31	-0.10	0.03	0.04	-0.08	-0.04
	(0.35)	(0.26)	(0.18)	(0.25)	(0.28)	(0.31)	(0.44)	(0.30)	(0.24)	(0.22)	(0.32)	(0.12)	(0.10)
Vocational	-0.04	0.08	0.29	-0.06	-0.26	-0.16	0.24	0.01	-0.14	-0.02	-0.07	-0.23*	0.01
	(0.34)	(0.24)	(0.20)	(0.23)	(0.29)	(0.31)	(0.46)	(0.30)	(0.26)	(0.22)	(0.35)	(0.13)	(0.10)
University	0.07	0.04	0.34*	0.02	-0.35	-0.43	0.28	0.19	-0.17	-0.00	-0.36	-0.01	-0.10
	(0.36)	(0.22)	(0.19)	(0.23)	(0.27)	(0.29)	(0.45)	(0.32)	(0.25)	(0.23)	(0.34)	(0.12)	(0.10)
Father educ.:													
Compulsory	-0.29	-0.09	0.03	-0.06	0.49*	0.33	-0.36	-0.19	0.57***	-0.34*	0.20	0.06	0.04
	(0.35)	(0.21)	(0.20)	(0.25)	(0.25)	(0.26)	(0.43)	(0.26)	(0.20)	(0.19)	(0.32)	(0.11)	(0.10)
High School	-0.61*	-0.04	-0.43**	0.15	0.56*	0.56*	-0.30	-0.44	0.04	0.04	0.40	0.15	-0.07
	(0.36)	(0.23)	(0.19)	(0.21)	(0.29)	(0.29)	(0.42)	(0.32)	(0.19)	(0.21)	(0.30)	(0.11)	(0.10)
Vocational	-0.35	-0.03	-0.19	0.16	0.39	0.62**	-0.77*	-0.57*	0.23	-0.17	-0.04	0.11	0.01
	(0.35)	(0.22)	(0.19)	(0.23)	(0.29)	(0.31)	(0.42)	(0.30)	(0.23)	(0.21)	(0.34)	(0.10)	(0.09)
University	-0.13	0.15	-0.12	-0.19	0.65**	0.40	-0.67	-0.28	0.13	-0.18	0.19	-0.01	0.02
	(0.36)	(0.22)	(0.19)	(0.24)	(0.29)	(0.32)	(0.43)	(0.32)	(0.20)	(0.20)	(0.32)	(0.11)	(0.10)
% non-Spanish													
10-20%	-0.02	0.05	0.02	-0.08	-0.07*	-0.02	0.04	0.13**	-0.02	0.00	0.01	0.01	-0.01
	(0.07)	(0.05)	(0.03)	(0.05)	(0.04)	(0.07)	(0.08)	(0.05)	(0.03)	(0.02)	(0.06)	(0.02)	(0.02)
More 20%	-0.11	0.05	0.11*	-0.03	-0.07	-0.01	-0.11	0.24**	-0.04	0.05	-0.07	-0.01	0.03
	(0.10)	(0.08)	(0.06)	(0.06)	(0.08)	(0.08)	(0.12)	(0.10)	(0.07)	(0.05)	(0.10)	(0.03)	(0.03)
% siblings	-0.19	0.19	0.05	-0.07	-0.09	-0.11	0.19	-0.07	0.11	-0.18	0.37*	0.11	-0.01
	(0.21)	(0.17)	(0.12)	(0.12)	(0.18)	(0.19)	(0.23)	(0.24)	(0.16)	(0.11)	(0.22)	(0.07)	(0.06)

Each column is a separate regression, including school fixed effects. Reference outcomes: primary education, < 10% non-Spanish, self-employed. Standard errors clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. (*Continued on next page*)

Table 9: (continued)

	Dependent variable: Teacher characteristic												
		Years of experience						5-years	Taught subjects		Teacher	Teach. Practices	
	Female	5-9	10-14	15-19	20-24	25-29	≥30	degree	Read-Maths	Read	3^{rd}-4^{th} g.	Trad.	Mod.
% single-hh	0.04	0.02	0.11	0.03	-0.26	-0.19	0.41	-0.19	0.11	0.01	0.28	-0.02	-0.17*
	(0.31)	(0.21)	(0.19)	(0.21)	(0.28)	(0.29)	(0.41)	(0.33)	(0.20)	(0.16)	(0.31)	(0.10)	(0.10)
% female	-0.33*	0.14	0.03	-0.01	-0.09	0.06	-0.01	0.05	-0.10	-0.07	0.22	-0.01	0.06
	(0.20)	(0.13)	(0.12)	(0.14)	(0.15)	(0.18)	(0.25)	(0.18)	(0.13)	(0.13)	(0.18)	(0.06)	(0.06)
% repeater	0.17	0.42*	0.00	-0.27	-0.01	0.10	-0.13	0.28	0.56***	-0.29	0.05	0.12	0.04
	(0.41)	(0.23)	(0.28)	(0.25)	(0.30)	(0.33)	(0.44)	(0.32)	(0.22)	(0.19)	(0.38)	(0.11)	(0.10)
Mother employm.:													
Employee	0.57**	-0.07	-0.07	0.02	-0.06	0.34	-0.39	0.05	-0.17	0.07	-0.10	0.02	0.04
	(0.25)	(0.18)	(0.18)	(0.20)	(0.17)	(0.22)	(0.29)	(0.25)	(0.14)	(0.12)	(0.22)	(0.08)	(0.08)
Unemployed	0.23	-0.11	0.12	-0.21	-0.09	0.02	0.24	0.10	-0.50**	0.32**	-0.22	0.09	-0.08
	(0.31)	(0.26)	(0.24)	(0.25)	(0.23)	(0.28)	(0.40)	(0.34)	(0.21)	(0.16)	(0.29)	(0.11)	(0.09)
Inactive	0.36	-0.01	-0.04	-0.00	-0.19	0.60**	-0.49	-0.04	-0.11	0.06	-0.12	0.05	0.00
	(0.28)	(0.19)	(0.19)	(0.23)	(0.21)	(0.26)	(0.36)	(0.27)	(0.17)	(0.15)	(0.27)	(0.10)	(0.09)
Father employm.:													
Employee	0.01	0.14	0.01	0.19	-0.29*	-0.04	-0.02	-0.23	0.21	-0.02	0.11	0.04	-0.14***
	(0.22)	(0.13)	(0.10)	(0.16)	(0.16)	(0.18)	(0.25)	(0.21)	(0.15)	(0.10)	(0.18)	(0.06)	(0.05)
Unemployed	-0.50	0.12	0.13	0.49*	0.11	-0.06	-0.83*	-0.63*	0.01	-0.02	-0.17	-0.07	-0.24***
	(0.35)	(0.29)	(0.24)	(0.26)	(0.27)	(0.30)	(0.43)	(0.35)	(0.20)	(0.12)	(0.35)	(0.11)	(0.09)
Inactive	-0.85	-0.54	0.31	-0.05	-0.73	1.00	0.10	0.29	0.60	-0.68**	0.43	0.07	-0.18
	(0.67)	(0.38)	(0.39)	(0.37)	(0.51)	(0.61)	(0.84)	(0.51)	(0.38)	(0.30)	(0.59)	(0.19)	(0.15)
Observations	11774	11774	11774	11774	11774	11774	11774	11774	11774	11774	11664	11774	11774
R^2	0.59	0.58	0.58	0.61	0.53	0.57	0.56	0.55	0.73	0.59	0.65	0.68	0.71
F-test	1.22	0.88	0.92	0.70	1.17	1.22	0.94	1.15	1.36	0.86	0.92	0.89	1.44
p-value	0.24	0.61	0.56	0.82	0.28	0.24	0.53	0.30	0.14	0.64	0.56	0.60	0.10

Each column is a separate regression, including school fixed effects. Reference outcomes: primary education, < 10% non-Spanish, self-employed.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at the school level in parentheses. F-test: joint significance of class-level variables.

Table 10: Within-school assignment of teachers to classrooms: effect of teaching practices

	Dependent variable: Student characteristic				
	Single-parent hh	Siblings	Female	Repeater	Non-Spanish
Traditional teaching	-0.01	0.07	0.00	0.03	-0.01
	(0.03)	(0.04)	(0.05)	(0.02)	(0.03)
Modern teaching	-0.05	0.02	0.07	-0.00	-0.00
	(0.03)	(0.04)	(0.06)	(0.03)	(0.03)
F-test	1.51	1.34	0.78	0.80	0.22
p-value	0.22	0.26	0.46	0.45	0.80
R^2	0.04	0.06	0.05	0.06	0.13
Observations	11774	11774	11774	11774	11774
	Mother's education				
	Compulsory	High School	Vocational training	University	
Traditional teaching	-0.02	0.01	-0.08*	0.05	
	(0.05)	(0.04)	(0.04)	(0.05)	
Modern teaching	-0.00	-0.01	0.04	-0.04	
	(0.05)	(0.04)	(0.05)	(0.05)	
F-test	0.09	0.07	2.07	1.09	
p-value	0.91	0.93	0.13	0.34	
R^2	0.11	0.05	0.06	0.21	
Observations	11774	11774	11774	11774	
	Father's education				
	Compulsory	High School	Vocational training	University	
Traditional teaching	-0.02	0.05	0.03	-0.03	
	(0.04)	(0.04)	(0.04)	(0.05)	
Modern teaching	0.02	-0.04	0.00	0.01	
	(0.05)	(0.04)	(0.05)	(0.05)	
F-test	0.15	1.09	0.23	0.29	
p-value	0.86	0.34	0.79	0.75	
R^2	0.10	0.04	0.06	0.22	
Observations	11774	11774	11774	11774	
	Mother's labor status				
	Employee	Unemployed	Inactive		
Traditional teaching	-0.00	0.03	-0.00		
	(0.06)	(0.03)	(0.05)		
Modern teaching	0.02	-0.06	0.03		
	(0.06)	(0.04)	(0.05)		
F-test	0.04	1.58	0.17		
p-value	0.96	0.21	0.85		
R^2	0.10	0.06	0.09		
Observations	11774	11774	11774		
	Father's labor status				
	Employee	Unemployed	Inactive		
Traditional teaching	0.04	-0.01	0.01		
	(0.05)	(0.03)	(0.01)		
Modern teaching	-0.07	-0.06**	-0.01		
	(0.05)	(0.03)	(0.01)		
F-test	1.10	2.29	0.20		
p-value	0.33	0.10	0.82		
R^2	0.05	0.08	0.04		
Observations	11774	11774	11774		

Each column in each panel is a separate regression, including school fixed effects. Traditional and modern teaching reported by tutor. Standard errors clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. F-test: joint significance of traditional and modern teaching indexes.

Table 11: Within-school assignment of teachers to classrooms: effect of class size

	Traditional teaching practices		Modern teaching practices	
Class size	0.01*	-0.00	-0.00	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Class size^2	-0.00	-0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
F-test	1.90	0.31	0.29	0.59
p-value	0.15	0.74	0.75	0.56
School fixed effects	No	Yes	No	Yes
R^2	0.00	0.67	0.00	0.70
Observations	11774	11774	11774	11774

Traditional and modern teaching reported by tutor. Standard errors clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. F-test: joint significance of class size and class size^2.

Table 12: Within-school assignment of teachers to classrooms: Effect of teacher characteristics

	Dependent variable: Teaching index	
	Traditional	Modern
Female	-0.02	0.02
	(0.02)	(0.02)
Years of experience (ref: < 5):		
5 - 9	0.03	0.01
	(0.03)	(0.03)
10 - 14	0.04	0.02
	(0.03)	(0.03)
15 - 19	0.02	0.03
	(0.03)	(0.04)
20 - 24	0.02	0.01
	(0.03)	(0.03)
25 - 29	0.00	0.02
	(0.03)	(0.03)
30 or more	0.03	0.02
	(0.03)	(0.03)
5-years degree or more	-0.04*	-0.00
	(0.02)	(0.02)
Taught subjects (ref: Maths):		
Reading and Maths	-0.00	-0.01
	(0.04)	(0.03)
Reading	0.01	0.01
	(0.06)	(0.05)
Person asking for a meeting:		
Parents	0.01	-0.02
	(0.03)	(0.02)
Teacher	-0.01	-0.01
	(0.02)	(0.02)
# of meetings with parents	0.02	-0.00
	(0.02)	(0.02)
Teacher at 3^{rd} and 4^{th} grades	-0.00	-0.01
	(0.02)	(0.02)
Class size	-0.00	-0.00
	(0.00)	(0.00)
Constant	0.45***	0.57***
	(0.09)	(0.08)
F-test	0.79	0.20
p-value	0.68	1.00
School fixed effects	Yes	Yes
R^2	0.69	0.70
Observations	11583	11583

Traditional and modern teaching reported by tutor. Standard errors clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. F-test: joint significance of teacher characteristics.

Table 13: Estimation results (Teaching practices)

	Tutor's answers			Students' answers		
	(1)	(2)	(3)	(4)	(5)	(6)
Traditional practices	-0.01	0.03	0.00	-0.17	-0.17	-0.21
	(0.11)	(0.11)	(0.11)	(0.18)	(0.18)	(0.16)
Modern practices	0.15	0.15	0.21*	0.33*	0.45**	0.34*
	(0.13)	(0.13)	(0.12)	(0.17)	(0.18)	(0.17)
Maths dummy	-0.00	-0.00	-0.01	-0.00	-0.00	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Class size		0.01	0.01		0.01	0.00
		(0.01)	(0.01)		(0.01)	(0.01)
Teacher variables:						
Female		0.02	0.01		0.02	0.00
		(0.03)	(0.03)		(0.03)	(0.03)
Years of epx. (ref: < 5):						
5 - 9		0.02	0.04		0.01	0.03
		(0.06)	(0.06)		(0.06)	(0.06)
10 - 14		0.10	0.11		0.08	0.11
		(0.07)	(0.07)		(0.07)	(0.07)
15 - 19		0.10	0.11*		0.10	0.11*
		(0.06)	(0.06)		(0.06)	(0.06)
20 - 24		0.02	0.01		0.00	0.02
		(0.06)	(0.05)		(0.06)	(0.06)
25 - 29		0.08	0.07		0.06	0.07
		(0.06)	(0.05)		(0.06)	(0.06)
30 or more		0.09*	0.09*		0.09*	0.11**
		(0.05)	(0.05)		(0.05)	(0.05)
5-years degree or more		-0.09**	-0.09**		-0.10***	-0.09***
		(0.04)	(0.03)		(0.03)	(0.03)
Taught subjects (ref: Maths):						
Reading and Maths		-0.11	-0.05		-0.09	-0.04
		(0.07)	(0.06)		(0.07)	(0.07)
Reading		-0.14*	-0.12		-0.14*	-0.11
		(0.08)	(0.08)		(0.08)	(0.08)
Person asking for a meeting:						
Parents		0.00	0.02		-0.01	0.00
		(0.04)	(0.04)		(0.04)	(0.04)
Teacher		-0.00	0.04		-0.00	0.02
		(0.05)	(0.04)		(0.05)	(0.05)
Number of meetings with parents		-0.02	-0.02		-0.03	-0.02
		(0.03)	(0.03)		(0.03)	(0.03)

Dependent variable: Student test score in maths and reading. Standard errors clustered at school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. (*Continued on next page*)

Table 13: (continued)

	Tutor's answers			Students' answers		
	(1)	(2)	(3)	(4)	(5)	(6)
Teacher at 3^{rd} and 4^{th} grades		0.03	0.06*		0.03	0.04
		(0.03)	(0.03)		(0.04)	(0.04)
Constant	0.81***	0.69***	0.37	0.95***	0.92***	0.73***
	(0.09)	(0.25)	(0.25)	(0.13)	(0.27)	(0.27)
Student's characteristics	No	No	Yes	No	No	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	23548	23166	22826	21452	21100	20900
R^2	0.15	0.15	0.22	0.14	0.14	0.21

Dependent variable: Student test score in maths and reading. Standard errors clustered at school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Student's characteristics: female, origin country, repeater, mother and father's education, mother and father's labor status, single-parent household, siblings, born in 4^{th} quarter, age at starting school, particular teacher/family helps with homework.

Table 14: Estimation results (Teaching materials)

	Tutor's answers			Students' answers		
	(1)	(2)	(3)	(4)	(5)	(6)
Traditional materials	0.13	0.10	0.13	0.00	-0.03	-0.15
	(0.11)	(0.11)	(0.11)	(0.16)	(0.16)	(0.16)
Modern materials	0.07	0.04	0.03	0.15	0.23	0.21
	(0.11)	(0.11)	(0.11)	(0.18)	(0.18)	(0.17)
Maths dummy	-0.00	-0.00	-0.01	-0.01	-0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Class size		0.01	0.01		0.01	0.01
		(0.01)	(0.01)		(0.01)	(0.01)
Teacher variables:						
Female		0.02	0.01		0.03	0.02
		(0.03)	(0.03)		(0.03)	(0.03)
Years of epx. (ref: < 5):						
5 - 9		0.02	0.04		0.04	0.04
		(0.06)	(0.05)		(0.06)	(0.06)
10 - 14		0.10	0.10		0.10	0.11
		(0.07)	(0.07)		(0.07)	(0.07)
15 - 19		0.10	0.11*		0.11*	0.12**
		(0.06)	(0.06)		(0.06)	(0.06)
20 - 24		0.02	0.02		0.00	0.01
		(0.06)	(0.05)		(0.06)	(0.05)
25 - 29		0.09	0.08		0.08	0.08
		(0.06)	(0.05)		(0.06)	(0.05)
30 or more		0.09*	0.09*		0.07	0.08*
		(0.05)	(0.04)		(0.05)	(0.04)
5-years degree or more		-0.09**	-0.08**		-0.11***	-0.09***
		(0.04)	(0.03)		(0.04)	(0.03)
Taught subjects (ref: Maths):						
Reading and Maths		-0.11	-0.05		-0.09	-0.04
		(0.07)	(0.06)		(0.06)	(0.06)
Reading		-0.14*	-0.12		-0.14*	-0.12
		(0.07)	(0.08)		(0.07)	(0.08)
Person asking for a meeting:						
Parents		-0.00	0.01		0.01	0.02
		(0.04)	(0.04)		(0.04)	(0.04)
Teacher		-0.00	0.04		0.00	0.04
		(0.05)	(0.04)		(0.05)	(0.05)
Number of meetings with parents		-0.03	-0.02		-0.01	-0.01
		(0.03)	(0.03)		(0.03)	(0.03)

Dependent variable: Student test score in maths and reading. Standard errors clustered at school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. (*Continued on next page*)

Table 14: (continued)

	Tutor's answers			Students' answers		
	(1)	(2)	(3)	(4)	(5)	(6)
Teacher at 3^{rd} and 4^{th} grades		0.03	0.06*		0.04	0.05
		(0.03)	(0.03)		(0.03)	(0.03)
Constant	0.77***	0.70***	0.40	0.83***	0.57**	0.49*
	(0.09)	(0.25)	(0.25)	(0.10)	(0.26)	(0.26)
Student's characteristics	No	No	Yes	No	No	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	23548	23166	22826	21926	21578	21360
R^2	0.15	0.15	0.22	0.14	0.14	0.21

Dependent variable: Student test score in maths and reading. Standard errors clustered at school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Student's characteristics: female, origin country, repeater, mother and father's education, mother and father's labor status, single-parent household, siblings, born in 4^{th} quarter, age at starting school, particular teacher/family helps with homework.

Table 15: Estimation results (Maths)

	Tutor	Students	Tutor	Students
	(1)	(2)	(3)	(4)
Traditional practices	0.03	-0.11		
	(0.13)	(0.21)		
Modern practices	0.11	0.25		
	(0.15)	(0.20)		
Traditional materials			0.10	-0.10
			(0.13)	(0.20)
Modern materials			-0.08	-0.06
			(0.13)	(0.22)
Class size	0.01	0.00	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Teacher variables:				
Female	-0.01	-0.00	-0.01	0.00
	(0.03)	(0.04)	(0.04)	(0.04)
Years of epx. (ref: < 5):				
5 - 9	-0.01	-0.02	-0.01	-0.01
	(0.07)	(0.07)	(0.06)	(0.06)
10 - 14	0.06	0.09	0.06	0.08
	(0.08)	(0.09)	(0.08)	(0.09)
15 - 19	0.14*	0.13*	0.14*	0.15**
	(0.07)	(0.08)	(0.07)	(0.07)
20 - 24	0.05	0.05	0.05	0.05
	(0.07)	(0.07)	(0.07)	(0.07)
25 - 29	0.08	0.07	0.09	0.09
	(0.06)	(0.07)	(0.06)	(0.06)
30 or more	0.08	0.10*	0.09	0.08
	(0.06)	(0.06)	(0.06)	(0.06)
5-years degree or more	-0.08**	-0.09**	-0.07**	-0.08**
	(0.04)	(0.04)	(0.04)	(0.04)
Taught subjects (ref: Maths):				
Reading and Maths	-0.06	-0.05	-0.06	-0.05
	(0.08)	(0.08)	(0.07)	(0.07)
Reading	-0.16	-0.17*	-0.16*	-0.16
	(0.10)	(0.10)	(0.10)	(0.10)
Person asking for a meeting:				
Parents	0.04	0.02	0.04	0.04
	(0.05)	(0.05)	(0.05)	(0.05)
Teacher	0.03	0.02	0.02	0.03
	(0.05)	(0.05)	(0.05)	(0.05)

Dependent variable: Student test score in maths. Standard errors clustered at school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. (*Continued on next page*)

Table 15: (continued)

	Tutor	Students	Tutor	Students
	(1)	(2)	(3)	(4)
Number of meetings with students' parents	-0.02	-0.02	-0.02	-0.01
	(0.03)	(0.03)	(0.03)	(0.03)
Teacher at 3^{rd} and 4^{th} grades	0.07*	0.06	0.07*	0.06
	(0.04)	(0.04)	(0.04)	(0.04)
Constant	0.52*	0.77**	0.59*	0.69**
	(0.31)	(0.35)	(0.32)	(0.33)
Student's characteristics	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes
Observations	11413	10450	11413	10680
R^2	0.23	0.23	0.23	0.23

Dependent variable: Student test score in maths. Standard errors clustered at school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Student's characteristics: female, origin country, repeater, mother and father's education, mother and father's labor status, single-parent household, siblings, born in 4^{th} quarter, age at starting school, particular teacher or family helps with homework.

Table 16: Estimation results (Reading)

	Tutor	Students	Tutor	Students
	(1)	(2)	(3)	(4)
Traditional practices	-0.03	-0.32*		
	(0.12)	(0.18)		
Modern practices	0.31**	0.43**		
	(0.13)	(0.21)		
Traditional materials			0.16	-0.19
			(0.11)	(0.17)
Modern materials			0.13	0.48**
			(0.12)	(0.19)
Class size	0.01	0.00	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Teacher variables:				
Female	0.02	0.01	0.03	0.03
	(0.03)	(0.03)	(0.03)	(0.03)
Years of epx. (ref: < 5):				
5 - 9	0.09	0.08	0.09	0.10
	(0.07)	(0.07)	(0.07)	(0.07)
10 - 14	0.15**	0.14*	0.15*	0.14*
	(0.07)	(0.08)	(0.07)	(0.08)
15 - 19	0.07	0.09	0.08	0.10
	(0.07)	(0.07)	(0.07)	(0.07)
20 - 24	-0.03	-0.02	-0.02	-0.03
	(0.07)	(0.07)	(0.07)	(0.07)
25 - 29	0.06	0.06	0.07	0.07
	(0.06)	(0.07)	(0.07)	(0.07)
30 or more	0.09	0.12**	0.09	0.09
	(0.06)	(0.06)	(0.05)	(0.06)
5-years degree or more	-0.09**	-0.09**	-0.09**	-0.11**
	(0.04)	(0.04)	(0.04)	(0.04)
Taught subjects (ref: Maths):				
Reading and Maths	-0.04	-0.02	-0.04	-0.04
	(0.09)	(0.09)	(0.09)	(0.09)
Reading	-0.09	-0.05	-0.09	-0.08
	(0.10)	(0.09)	(0.09)	(0.10)
Person asking for a meeting:				
Parents	0.00	-0.01	-0.01	0.01
	(0.04)	(0.05)	(0.04)	(0.05)
Teacher	0.05	0.03	0.05	0.05
	(0.05)	(0.05)	(0.05)	(0.05)

Dependent variable: Student test score in reading. Standard errors clustered at school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. (*Continued on next page*)

Table 16: (continued)

	Tutor	Students	Tutor	Students
	(1)	(2)	(3)	(4)
Number of meetings with students' parents	-0.02	-0.03	-0.03	-0.01
	(0.03)	(0.03)	(0.03)	(0.03)
Teacher at 3^{rd} and 4^{th} grades	0.05	0.03	0.04	0.04
	(0.04)	(0.04)	(0.04)	(0.04)
Constant	0.22	0.69**	0.21	0.29
	(0.28)	(0.30)	(0.27)	(0.29)
Student's characteristics	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes
Observations	11413	10450	11413	10680
R^2	0.24	0.23	0.24	0.23

Dependent variable: Student test score in reading. Standard errors clustered at school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Student's characteristics: female, origin country, repeater, mother and father's education, mother and father's labor status, single-parent household, siblings, born in 4^{th} quarter, age at starting school, particular teacher or family helps with homework.

Table 17: Robustness to include each index one at a time in the regression

	Maths						**Reading**					
	Tutor's answers			Students' answers			Tutor's answers			Students' answers		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A. Teaching practices												
Traditional index	0.03	0.04		-0.11	-0.07		-0.03	-0.01		-0.32*	-0.21	
	(0.13)	(0.13)		(0.21)	(0.19)		(0.12)	(0.12)		(0.18)	(0.17)	
Modern index	0.11		0.11	0.25		0.20	0.31**		0.31**	0.43**		0.38*
	(0.15)		(0.15)	(0.20)		(0.19)	(0.13)		(0.13)	(0.21)		(0.20)
Observations	11413	11413	11413	10450	10762	10691	11413	11413	11413	10450	10762	10691
B. Teaching materials												
Traditional index	0.10	0.10		-0.10	-0.10		0.16	0.16		-0.19	-0.05	
	(0.13)	(0.13)		(0.20)	(0.19)		(0.11)	(0.11)		(0.17)	(0.16)	
Modern index	-0.09		-0.09	-0.06		-0.08	0.13		0.12	0.48**		0.42**
	(0.13)		(0.13)	(0.22)		(0.21)	(0.12)		(0.12)	(0.19)		(0.18)
Observations	11413	11413	11413	10680	11010	10742	11413	11413	11413	10680	11010	10742

Standard errors clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions control for student and teacher characteristics, class size and school fixed effects. Columns (1), (4), (7) and (10) report baseline estimations from Tables 15 and 16. Each column in each Panel (A and B) represents a separate regression.

Table 18: Robustness to include items (c) and (d) in teaching practices measures

	Maths		**Reading**	
	Tutor	Students	Tutor	Students
A. Item (c) traditional; item (d) modern				
Traditional practices index	0.08	0.00	0.00	-0.36*
	(0.15)	(0.24)	(0.15)	(0.22)
Modern practices index	0.15	0.13	0.34**	0.34
	(0.17)	(0.21)	(0.15)	(0.22)
B. Item (c) modern; item (d) traditional				
Traditional practices index	0.11	-0.20	0.00	-0.42*
	(0.15)	(0.24)	(0.14)	(0.22)
Modern practices index	0.11	0.30	0.34**	0.39*
	(0.18)	(0.22)	(0.15)	(0.22)
Observations	10994	10435	10994	10435

Standard errors clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions control for student and teacher characteristics, class size and school fixed effects. Item (c): "While I teach, I ask students questions about the lesson". Item (d): "While I teach, students ask me doubts".

Table 19: Robustness to constraint total time allocated to items

	Maths				**Reading**			
	Tutor		Students		Tutor		Students	
Share of time using modern practices	0.11		0.23		0.43**		0.56*	
	(0.20)		(0.28)		(0.18)		(0.29)	
Share of time using modern materials		-0.28		-0.07		-0.05		0.41*
		(0.20)		(0.26)		(0.17)		(0.23)
Observations	11413	11413	10443	10649	11413	11413	10443	10649

Standard errors clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions control for student and teacher characteristics, class size and school fixed effects. Each cell represents a separate regression.

Table 20: Robustness to include additional control variables

	Maths		**Reading**	
	Tutor	Students	Tutor	Students
A. Class-average characteristics				
Traditional practices index	0.03	-0.12	0.03	-0.29*
	(0.13)	(0.21)	(0.12)	(0.18)
Modern practices index	0.10	0.29	0.28**	0.47**
	(0.15)	(0.20)	(0.14)	(0.20)
Traditional materials index	0.12	-0.12	0.26**	-0.20
	(0.14)	(0.20)	(0.11)	(0.18)
Modern materials index	-0.06	0.03	0.09	0.58***
	(0.14)	(0.23)	(0.11)	(0.20)

Standard errors clustered at the school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions control for student and teacher characteristics, class size and school fixed effects.

Appendices

A Estimated coefficients of student characteristics

Table A.1: Within-school estimation (Teaching practices)

	Tutor's answers			Students' answers		
	Pool	Maths	Reading	Pool	Maths	Reading
Female	-0.01	-0.13***	0.11***	-0.02	-0.14***	0.10***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Repeater	-0.37***	-0.33***	-0.41***	-0.39***	-0.37***	-0.41***
	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
Single-parent household	-0.05*	-0.04	-0.07*	-0.06**	-0.03	-0.09**
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.04)
Siblings	-0.05***	-0.03	-0.08***	-0.05**	-0.02	-0.07***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
Born in 4th quarter	-0.15***	-0.15***	-0.15***	-0.15***	-0.15***	-0.14***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Age at starting school (ref: ≤2 years old):						
3 years old	-0.03*	-0.02	-0.04**	-0.03*	-0.02	-0.04**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
4 years old	-0.09*	-0.09	-0.09	-0.08	-0.08	-0.08
	(0.05)	(0.06)	(0.06)	(0.05)	(0.06)	(0.06)
5 years old	-0.17***	-0.08	-0.26***	-0.18**	-0.09	-0.26***
	(0.06)	(0.08)	(0.08)	(0.07)	(0.10)	(0.09)
6 years old	-0.38***	-0.26**	-0.49***	-0.35***	-0.22*	-0.49***
	(0.09)	(0.12)	(0.10)	(0.10)	(0.13)	(0.11)
Country of origin (ref: Spain):						
Western Europe	-0.04	0.28*	-0.37**	0.02	0.35**	-0.31
	(0.12)	(0.14)	(0.18)	(0.13)	(0.16)	(0.19)
Non-Western Europe	-0.17***	-0.13*	-0.21***	-0.19***	-0.16**	-0.23***
	(0.05)	(0.07)	(0.06)	(0.05)	(0.07)	(0.07)
Morocco	-0.16*	-0.07	-0.24**	-0.08	-0.02	-0.15
	(0.09)	(0.11)	(0.11)	(0.09)	(0.11)	(0.12)
Latin America	-0.22***	-0.22***	-0.23***	-0.23***	-0.23***	-0.24***
	(0.04)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)
Asia	-0.26*	-0.14	-0.38**	-0.23	-0.06	-0.40**
	(0.15)	(0.23)	(0.17)	(0.16)	(0.23)	(0.19)
Other	-0.29**	-0.25*	-0.33**	-0.29**	-0.26*	-0.32**
	(0.12)	(0.13)	(0.14)	(0.14)	(0.15)	(0.16)
Mother's education (ref: Primary or less):						
Compulsory	0.10***	0.10***	0.10***	0.09***	0.08**	0.09**
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.04)

Standard errors clustered at school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

(*Continued on next page*)

	Tutor's answers			Students' answers		
	Pool	Maths	Reading	Pool	Maths	Reading
High School	0.19***	0.16***	0.22***	0.19***	0.16***	0.23***
	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
Vocational training	0.15***	0.15***	0.15***	0.16***	0.15***	0.16***
	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
University	0.34***	0.34***	0.33***	0.33***	0.33***	0.32***
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Mother's labor status (ref: Self-employed):						
Employee	0.05**	0.05*	0.05**	0.05**	0.04	0.05*
	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)
Unemployed	0.03	0.03	0.03	0.03	0.02	0.04
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.04)
Inactive	0.02	0.03	0.01	0.02	0.03	0.00
	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Father's education (ref: Primary or less):						
Compulsory	0.08***	0.05*	0.10***	0.05**	0.04	0.07**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
High School	0.22***	0.18***	0.26***	0.19***	0.16***	0.23***
	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
Vocational training	0.17***	0.15***	0.19***	0.15***	0.14***	0.16***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
University	0.32***	0.28***	0.35***	0.29***	0.25***	0.32***
	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)
Father's labor status (ref: Self-employed):						
Employee	-0.00	-0.01	0.01	-0.01	-0.02	0.00
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Unemployed	-0.03	-0.06	-0.00	-0.05	-0.08*	-0.01
	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
Inactive	-0.03	-0.05	-0.01	-0.04	-0.04	-0.04
	(0.05)	(0.07)	(0.06)	(0.05)	(0.07)	(0.07)
Help with homework:						
Particular teacher	-0.43***	-0.41***	-0.45***	-0.42***	-0.40***	-0.44***
	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Family	-0.09***	-0.12***	-0.06***	-0.09***	-0.12***	-0.05***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Constant	0.37	0.52*	0.22	0.73***	0.77**	0.69**
	(0.25)	(0.31)	(0.28)	(0.27)	(0.35)	(0.30)
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Teacher characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Observations	22826	11413	11413	20900	10450	10450
R^2	0.22	0.23	0.24	0.21	0.23	0.23

Standard errors clustered at school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.2: Within-school estimation (Teaching materials)

	Tutor's answers			Students' answers		
	Pool	Maths	Reading	Pool	Maths	Reading
Female	-0.01	-0.13***	0.11***	-0.02	-0.14***	0.10***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Repeater	-0.37***	-0.33***	-0.41***	-0.39***	-0.36***	-0.42***
	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
Single-parent household	-0.05*	-0.04	-0.07*	-0.05*	-0.03	-0.07*
	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)
Siblings	-0.05**	-0.03	-0.08***	-0.05**	-0.02	-0.07***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
Age at starting school (ref: ≤2 years old):						
3 years old	-0.03*	-0.02	-0.04**	-0.02	-0.02	-0.03
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
4 years old	-0.09*	-0.09	-0.08	-0.09*	-0.09	-0.09
	(0.05)	(0.06)	(0.06)	(0.05)	(0.06)	(0.06)
5 years old	-0.17***	-0.08	-0.26***	-0.20***	-0.11	-0.28***
	(0.06)	(0.08)	(0.08)	(0.07)	(0.09)	(0.08)
6 years old	-0.38***	-0.26**	-0.49***	-0.40***	-0.30**	-0.50***
	(0.09)	(0.12)	(0.10)	(0.10)	(0.13)	(0.11)
Born in 4th quarter	-0.15***	-0.15***	-0.15***	-0.15***	-0.15***	-0.15***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Country of origin (ref: Spain):						
Western Europe	-0.05	0.28*	-0.38**	-0.01	0.31**	-0.33*
	(0.12)	(0.14)	(0.18)	(0.12)	(0.15)	(0.18)
Non-Western Europe	-0.17***	-0.13*	-0.21***	-0.16***	-0.11	-0.21***
	(0.05)	(0.07)	(0.06)	(0.05)	(0.07)	(0.07)
Morocco	-0.16*	-0.07	-0.24**	-0.16	-0.08	-0.24**
	(0.09)	(0.11)	(0.11)	(0.10)	(0.11)	(0.12)
Latin America	-0.22***	-0.22***	-0.23***	-0.22***	-0.20***	-0.24***
	(0.04)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)
Asia	-0.27*	-0.14	-0.40**	-0.23	-0.06	-0.40**
	(0.15)	(0.22)	(0.17)	(0.15)	(0.23)	(0.18)
Other	-0.28**	-0.24*	-0.32**	-0.28**	-0.26*	-0.31*
	(0.12)	(0.13)	(0.15)	(0.13)	(0.14)	(0.16)
Mother's education (ref: Primary or less):						
Compulsory	0.10***	0.10***	0.10***	0.08***	0.08**	0.08**
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.04)
High School	0.19***	0.16***	0.22***	0.18***	0.14***	0.22***
	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
Vocational training	0.15***	0.15***	0.15***	0.14***	0.13***	0.15***
	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
University	0.34***	0.34***	0.33***	0.32***	0.31***	0.32***
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)

Standard errors clustered at school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

(*Continued on next page*)

	Tutor's answers			Students' answers		
	Pool	Maths	Reading	Pool	Maths	Reading
Mother's labor status (ref: Self-employed):						
Employee	0.05**	0.05*	0.05**	0.05**	0.04	0.06**
	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)
Unemployed	0.03	0.03	0.03	0.04	0.04	0.03
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.04)
Inactive	0.02	0.03	0.01	0.02	0.02	0.01
	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Father's education (ref: Primary or less):						
Compulsory	0.08***	0.05	0.10***	0.05**	0.04	0.07**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
High School	0.21***	0.18***	0.25***	0.20***	0.16***	0.23***
	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
Vocational training	0.17***	0.15***	0.19***	0.15***	0.14***	0.16***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)
University	0.31***	0.28***	0.35***	0.30***	0.27***	0.33***
	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)
Father's labor status (ref: Self-employed):						
Employee	-0.00	-0.01	0.01	-0.01	-0.02	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Unemployed	-0.03	-0.06	-0.01	-0.04	-0.08*	0.00
	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
Inactive	-0.03	-0.05	-0.01	-0.04	-0.07	-0.00
	(0.05)	(0.07)	(0.06)	(0.05)	(0.07)	(0.06)
Help with homework:						
Particular teacher	-0.43***	-0.41***	-0.45***	-0.43***	-0.41***	-0.44***
	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Family	-0.09***	-0.12***	-0.06***	-0.09***	-0.13***	-0.05***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Constant	0.40	0.59*	0.21	0.49*	0.69**	0.29
	(0.25)	(0.32)	(0.27)	(0.26)	(0.33)	(0.29)
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Teacher characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Observations	22826	11413	11413	21360	10680	10680
R^2	0.22	0.23	0.24	0.21	0.23	0.23

Standard errors clustered at school level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.