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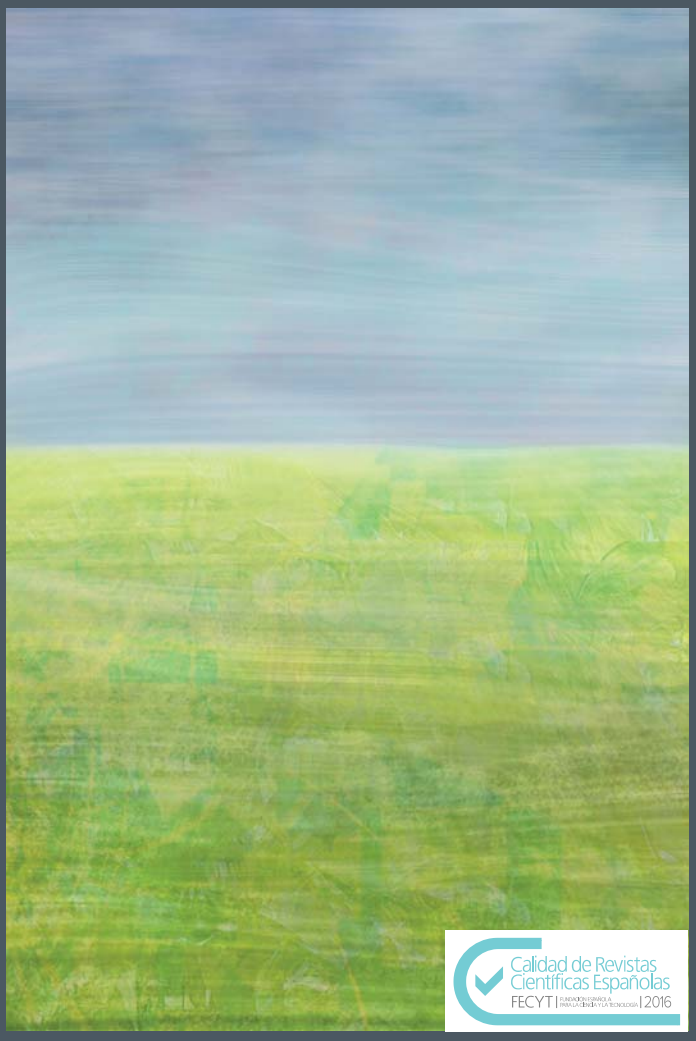

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Teaching practices and results in PISA 2015[1]

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Abstract

Teachers undoubtedly play an important role in education. However, there is debate about which specific issues have the biggest impact on students' academic performance. This research aims to analyse different teaching strategies applied by teachers working at the same school and the extent to which they contribute to improving student achievement. Apart from the usual separation into classical and modern techniques based on pedagogical criteria, this study also distinguishes between activities that promote active student learning and cognitive activation, as well as teacher-led strategies. Our empirical analysis refers to the Spanish education system. We use data from PISA 2015, which was the first PISA wave to provide information about classroom activities based on a questionnaire completed by teachers. Our estimation procedure is based on multilevel regression techniques, taking into account that students are grouped (or nested) at a higher level represented by schools. The results suggest that the application of traditional teaching strategies, in which teachers adopt a leadership role and manage the activities taking place in the classroom, lead to a significant improvement in educational achievement. In contrast, innovative strategies

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focused on increased student engagement, promoting the use of information and communications technologies and stimulating critical thinking do not have a significant impact and can, in some cases, even lead to worse outcomes.

Keywords: teachers, teaching strategies, determinants of performance, PISA 2015, education policy, multilevel regressions

Resumen

La importancia del papel que desempeñan los profesores en el sistema educativo está fuera de toda duda. Sin embargo, no existe consenso acerca de qué aspectos concretos tienen una mayor incidencia sobre los resultados académicos de los estudiantes. La presente investigación se centra en el estudio de las diferentes estrategias docentes utilizadas por los profesores que pertenecen a un mismo centro educativo y en qué medida éstas pueden contribuir a la mejora del rendimiento educativo de sus estudiantes. Además de la habitual distinción entre técnicas clásicas y modernas, basada en criterios pedagógicos, en el presente estudio diferenciamos entre las actividades que promueven el aprendizaje activo de los alumnos, aquellas dirigidas a promover la activación cognitiva y las estrategias basadas en la enseñanza dirigida por el profesor. Nuestro análisis empírico está referido al caso español y se basa en los datos proporcionados por la base de datos PISA 2015, que por primera vez incluye un cuestionario dirigido a los profesores, en el que éstos proporcionan información sobre las actividades desarrolladas en el aula. Mediante el uso de técnicas de regresión multinivel, con las que resulta posible tener en cuenta que los alumnos se agrupan (están anidados) en un nivel superior, el representado por las escuelas. Los resultados obtenidos ponen de manifiesto que la aplicación de estrategias docentes tradicionales, en las que los profesores adoptan un papel protagonista como conductores de las actividades que tienen lugar dentro del aula, contribuye a mejorar significativamente el rendimiento educativo, mientras que el uso de estrategias innovadoras con las que se pretende implicar en mayor medida al estudiante, promover el uso de las nuevas tecnologías de la información, y estimular el pensamiento crítico, no tienen una incidencia significativa e, incluso en algunos casos, pueden hacer que los resultados sean peores.

Palabras clave: Profesores, Estrategias docentes, Determinantes del rendimiento, PISA 2015, Política educativa, Regresiones multinivel.

Introduction

Since the famous Coleman Report (Coleman, Campbell, Hobson, McPartland and Mood, 1966) was published over more than fifty years

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ago, there has been significant interest in trying to identify the key factors determining educational performance (Creemers and Kyriakides, 2007). After several decades of research, most authors single out the importance of the role played by teachers (Rivkin, Hanushek and Kain, 2005), although there is debate about which specific issues have a greater impact on academic outcomes (Hattie, 2009; Campbell, Kyriakides, Muijs and Robinson, 2012).

Most of the empirical research that has addressed this issue focuses on analysing which characteristics make a teacher more successful (Akiba, LeTendre, and Scribner, 2007; Godhaber and Anthony, 2007). Apart from being relatively easy to measure, these characteristics are especially appealing from an educational policy viewpoint, as many are used in teacher selection processes. However, more recent literature has shown a growing interest in studying the effectiveness of teaching strategies applied by teachers (Hattie, 2009; Schwerdt and Wuperman, 2011, Lavy, 2011, Bietenbeck, 2014, Hidalgo and López-Mayan, 2015). This is part of a commendable effort to try to offer information about what happens in the classroom. Regarded as a black box that is extremely difficult to explore, this question has traditionally been overlooked by the literature.

Teaching practices or methods refer to a wide range of processes and activities that cover classroom organization and resources, as well as the activities set for students to promote their learning. These activities must be adapted to the particular classroom setting (Razak and Shafaei, 2016). The specialized literature usually makes a distinction between basically two teaching models: classical/traditional and modern (Zemelman, Daniels and Hyde, 2005). The traditional teaching style advocates activities in which the teacher takes the leading role, explaining the contents or showing how to do exercises or solve problems. These practices lay the emphasis on learning foundational knowledge and basic skills through repetition. On the other hand, more modern teaching methods are student focused involving the completion of group assignments, classroom debates or the extrapolation of knowledge learned to everyday problems (Windschitl, 2002; Opdenakker and van Damme, 2006).

Recent studies conducted by OECD specialists (Echazarra, Salinas, Méndez, Denis and Rech, 2016; Le Donné, Fraser and Bousquet, 2016) offer an alternative classification that makes a distinction between three types of strategies: teacher-led learning, active learning and cognitive

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activation. Teacher-led learning is more or less consistent with the approach taken by traditional methods, whereas the others would be linked to modern teaching styles. Note, however, that active learning takes a more constructivist approach intended to promote student engagement through group work, the use of new information technologies or self-assessment processes, whereas cognitive activation promotes student autonomy, establishing motivational challenges that help to stimulate higher-level competencies like critical thinking or decision-making skills (Windschitl, 2002).

There is a growing current in many countries nowadays, advocating the increased use of modern student-focused practices in preference to more traditional learning methods (Capps, Crawford and Constas, 2012). In this context, the study of the effectiveness of the different teaching styles is a key issue with regard to the development of educational policy strategies. In particular, there is hardly any evidence available in respect of Spain. Therefore, this research is intended to contribute to a new debate based on sound empirical evidence on the role played by teachers in the context of Spanish education. Inquiries into the factors determining educational outcomes do not normally address this issue.

Researchers aiming to analyse the effectiveness of teaching methods face a major problem, namely, the shortage of reliable and relevant information on this type of practices. Until quite recently, the only international assessments that offered information in this regard were TIMSS (Third International Mathematics and Science) and PIRLS (Progress in International Reading Literacy Study). This is the reason why most of the papers that have examined this issue use these databases (Cordero, Cristóbal and Santín, 2017). The database setup, including primary or early secondary education students, means that each student can be connected with his or her actual teacher or teachers.

The OECD has recently developed two instruments that are very useful for studying issues related to teaching staff. The first is called the TALIS-PISA link. The TALIS-PISA link provides the statistical instruments required to establish a link between the information on students in PISA 2012 and data on teachers included in TALIS 2013. The countries that decided to participate in this module sampled TALIS teachers at the same schools in which the PISA test had been conducted the year before. Accordingly, it was possible to explore the relationship between teaching strategies implemented by teachers and student achievement at the same

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school (Méndez, 2015; Le Donné et al. 2016), as well as the inverse relationship, that is, how the school setting affects teaching practices implemented by teachers (Austin, Adesope, French, Gotch, Belanger and Kubacka, 2015). Subsequently, PISA included a questionnaire for teachers for the first time in the 2015 wave. This questionnaire was designed to gather information provided directly by teachers about a host of issues, including the teaching methods that they use in their classrooms, albeit applicable, in this case, to students and teachers at the same school in the same academic year.

The aim of this research is to leverage the information provided by science teachers for the sample of schools participating in PISA 2015 with the aim of examining how related the different teaching strategies implemented by all science teachers at each school are to students' science outcomes. In this respect, we should stress that the proposed empirical analysis assumes that teachers at the same school are inclined to use the same teaching strategies and even share the same teaching materials (Le Donné et al. 2016), developing what is known in the literature as a *teaching culture* (Echazarra et al. 2016). This is quite an innovative approach with respect to other earlier studies focusing on activities carried out by each teacher individually.

The content of the paper is organized as follows. Section 2 briefly reviews previous research literature concerning the role of teachers, focusing on papers that are concerned with teaching strategies. Section 3 reports the key characteristics of the database used, as well as the procedure used to build the representative indicators of teaching strategies. Section 4 presents and discusses the results of applying different multilevel regressions. As usual, the paper ends with some conclusions.

Literature review

Some of the issues concerning the influence of teacher quality on achievement that have received most attention in the literature are the characteristics of teaching staff and teaching practices developed in the classroom (Palardy and Rumberger, 2008).

The first issue focuses on analysing the effect of teachers' cognitive skills, experience level, sex or qualifications (Ehrenberg and Brewer,

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1994; Clotfelter, Ladd and Vigdor, 2007; Clotfelter, Ladd and Vigdor, 2010). However, the available evidence about the impact of these characteristics on academic achievement is weak (Hanushek, 1986, 1997), especially for information is sourced from international databases, where the failure to use of common indicators to correctly measure qualifications or experience can lead to rather inconclusive results (Hanushek, 2011). The only definite result is that teachers' performance usually improves during the early years of their teaching experience (Rockhoff, 2004; Croninger, Rice, Rathbun and Nishio, 2007).

There is even less evidence with regard to the line of research examining the influence of teaching practice on outcomes, which is the focus of this paper, since these activities are tricky to measure and quantify. However, the studies that do manage to make this type of measurements conclude that they have a very significant effect on student learning (Schacter and Thum, 2004) in both primary (Santín and Sicilia, 2014) and secondary education (Carbonaro and Gamoran, 2002; Wentzel, 2002).

Furthermore, the empirical evidence on secondary education regarding this type of activities available in the literature highlights the positive impact of traditional practices based on the repetition of contents and knowledge acquisition exercises or problem solving (Brewer and Goldhaber, 1997; Schwerdt and Wuppermann, 2011; Bietenbeck, 2014). The same also applies to teaching styles based on problem solving and homework (De Witte and Van Klaveren, 2014). Likewise, students usually achieve better academic outcomes when the information is presented repeatedly, stressing the key concepts through repetition (Rosenshine and Stevens, 1986). However, there are other studies that do not find any relationship between the time spent on these activities and student achievement (e.g., Van Klaveren, 2011). A possible explanation for this result is that these strategies tend to be used more often with students whose performance is worse (Echazarra et al. 2016).

On the other hand, the more innovative teaching methods based on group work, classroom debates, student coaching or extrapolating learned concepts to real-world problems do not appear to be very successful (Lavy, 2011) and may, in some cases, even have negative effects on achievement (Murname and Phillips, 1981; Brewer and Goldhaber, 1997). An alternative interpretation of these results is, however, that these types of teaching practices possibly have more to do

with students developing other skills, such as reasoning ability (Bietenbeck, 2014), or improving their social capital (Algan, Cahuc and Shleifer, 2013) than with the acquisition of the knowledge or competencies that are usually assessed by international knowledge tests.

Most of the above studies refer specifically to education in the United States, where students are accustomed to group work. However, very different teaching methods and teaching materials are used in other countries (Hiebert, 2003). Therefore, this research conducted in a setting like Spain that is worlds apart from America should make an important contribution to the existing literature on what role teachers play in developing students' cognitive skills.

Data and Variables

PISA (Programme for International Student Assessment) is an international study that assesses the knowledge and skills of 15-year-old students once every three years. PISA's biggest potential is that it provides comparable data for a very wide-ranging set of countries. In fact, 540,000 students from schools in 72 economies participated in the last wave (43 countries participated in the first PISA wave, 28 of which were OECD members).

In 2015 all tests were computer based, and the key competence assessed was science. In this country, an extended sample from all the Spanish Autonomous Communities participated, that is, a total sample composed of 37,205 students from 980 schools whose results are comparable internationally. We picked a subsample composed of 6738 students from 201 schools from all the Autonomous Communities from the above sample. We allocated the appropriate sampling weights to the Autonomous Communities to assure that the data were representative of the whole country.

As mentioned in the introduction, one of the major PISA 2015 innovations was that, apart from questionnaires completed by students and school principals, teachers from the schools based in several countries that were assessed took a survey including wide-ranging questions about their training, experience and classroom activities[2]. In this respect, note that it is not possible to establish an exact connection between students and teachers on two grounds: the sampling structure used in PISA, where the 35 students from each school may be members

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of different classes, and the characteristics of secondary school teaching, where teachers rotate around different classes. In particular, we selected a random set of 25 secondary school teachers for each school in the representative subsample (10 science teachers and 15 teachers of other competencies) (OECD, 2016), such that a total of 4,286 Spanish teachers completed the teacher questionnaire.

The selected teachers had 30 minutes to complete a computer-based questionnaire module, including wide-ranging questions about their background, previous experience, professional development and teaching beliefs. Science teachers, in particular, answered a number of questions about science teaching/learning environments existing at the school, as well as the teaching strategies that they applied in their classrooms. These teaching practices are the focus of this paper and are detailed below.

Most of the questions concerning teaching strategies are generally stated as follows: How often does the following happen in your science class? This question is followed by a description of the activities: "Students are asked to draw conclusions", "I demonstrate an idea", "Students read materials from a textbook", etc. Additionally, there is another block of questions directly concerning the application of a series of teaching techniques. The response format is very similar in both blocks: a four-category Likert scale: (1) Never or almost never; (2) Some lessons; (3) Many lessons; (4) Every lesson or almost every lesson.

As there is a wide-ranging set of questions related to teaching strategies, one of the first actions that we took was to build indicators to summarize the information provided by teachers. Based on previous literature, we applied two different criteria to set up teaching styles for this purpose. The first is based on the proposal by Le Donné et al. (2016), which makes a distinction between active learning, cognitive activation and teacher-led learning. The second criterion groups the teaching strategies into classical or modern (Zemelman et al. 2005; Bietenbeck, 2014; Hidalgo and López-Mayán, 2015). By using both criteria to build indicators, we can use the results to test their robustness. Table I shows the classification of questions for teachers according to each of the two alternatives[3].

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(2) A total of 18 countries offer this information, nine of which are members of the OECD.

(3) The other variables for the teaching practices module completed by science teachers do not belong to only one of the created categories and were not therefore used to compute the indicator.

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To help with the interpretation of the different responses, we established the following weights for each of the responses: (1) 0%, (2) 33%, (3) 66%, and (4) 100%. Accordingly, the responses stand for the percentage of time spent on each of the teaching activities carried out by each teacher. Note that the teaching methods used are not mutually exclusive, that is, each teacher can apply more than one teaching method in the same class, while spending a different amount of time on each activity. After rescaling the variable values, we built the indicators using the classification proposed in Table I.

TABLE I. Definition of teacher variables and classification according to Criterion 1 (cognitive, active and teacher-led) and Criterion 2 (classical and modern)

Criterion 1		
Cognitive	(a)	Students are asked to draw conclusions.
	(b)	Students are given opportunities to explain their ideas.
	(c)	The teacher discusses questions that students ask.
Active	(d)	A whole class discussion takes place.
	(e)	Current scientific issues are discussed.
	(f)	Students write up laboratory reports.
Teacher-led	(g)	The teacher explains scientific ideas.
	(h)	The teacher demonstrates an idea.
	(i)	Tailored tasks are assigned to the weakest as well as to the best students.
Criterion 2		
Classical	(g)	The teacher explains scientific ideas.
	(c)	The teacher discusses questions that students ask.
	(f)	Students write up laboratory reports.
	(h)	The teacher demonstrates an idea.
Modern	(a)	Students are asked to draw conclusions.
	(b)	Students are given opportunities to explain their ideas.
	(d)	A whole class discussion takes place.
	(e)	Current scientific issues are discussed.

Received: 26-05-2017 Accepted: 20-10-2017

After building the indicators representing the activity carried out by each teacher (how often he or she applies each of the teaching strategies), we clustered this information at school level. On the abovementioned grounds (no direct link between the student and teacher), it was necessary to work at school level, that is, we had to summarize the information provided by teachers in a single school-level indicator (for each teaching strategy) by calculating the average value of the indicators for each teacher employed by the school. In other words, our working hypothesis is that each teacher has a teaching style defined by his or her teaching methods. The school teaching style is the sum of the teaching styles of all teachers. Considering the structure of the teaching strategy indicators and the indicator of each strategy at school level, greater indicator values can be taken to mean that the school's teachers apply this type of strategies more often in their science lessons[4].

In the process of building the teaching style indicators, the data were debugged according to several methods in order to be able to guarantee data reliability. On one hand, we only accounted for teachers who answered 100% of the questions covered by the teaching strategy indicators. As these variables were the main targets of our study, we opted not to use any missing value imputation procedure, relying exclusively on the information provided by the teachers that provide all the responses (85% of the sample). On the other hand, we found that there was a low percentage response from teachers at some schools. In such cases, we opted to remove any schools where the ratio of the percentage response to the teacher questionnaire (with respect to all schools selected for this purpose) over school size was less than 20%. This procedure was designed to assure that the strategies reported by only one teacher or very few teachers were not attributed to a school[5].

The information provided by science teachers is also used to create a set of control variables that are included in our estimations: average age, average experience, and the percentage of teachers with a higher qualification than required. The model should account for the different types of teachers existing at a school in order to discount their effect on student achievement in order to analyse the specific influence of the different teaching strategies.

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(4) Although teachers may each have a different teaching style, their scores will all be taken into account to calcúlate the school's mean score.

(5) The application of the criterion reduces the number of schools to 167 (5,411 students), but there is a guarantee that there is a high enough percentage response at the remaining schools.

Finally, the database that contains the information on teachers aggregated at school level has been merged with the databases for students and schools, using the common school identifier provided by PISA. This provides access to a data file containing detailed information on student characteristics, the school that they attend and the teachers at that school.

The dependent variable used in our model was the first plausible value of the science outcome (main competence assessed in PISA 2015)[6]. It also includes a set of explanatory variables at individual and school level that are consistent with the ones usually reported in the literature (see, for example, Calero and Escaríbul, 2007 or Cordero, Crespo and Pedraja, 2013) as being the key determinants of educational achievement (sex, grade retention, mother's educational level, number of books in the home, school ownership and location or peer effect, i.e., average ESCS variable for the students at the school[7]). Table II summarizes all the selected variables, also including representative indicators of the teaching strategies and teacher characteristics with their respective descriptive statistics.

(6) It is acceptable, according to PISA specialists, to use a single plausible value or all five values available in the data base, as this does not lead to an appreciable difference in large samples (see OECD, 2009, p. 44).

(7) ESCS (index of economic, social and cultural status) is prepared by PISA specialists combining information on parent educational level and occupational status with household indicators.

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TABLE II. Descriptive statistics of the variables included in the model

	Mean	D.T	Min.	Max.
Student level				
First plausible science value	498.48	85.89	210.69	754.33
Sex (Female)	0.50	0.50	0.00	1.00
Has repeated a year	0.27	0.44	0.00	1.00
First-generation immigrant	0.08	0.28	0.00	1.00
Mother's educational level (higher than post-compulsory secondary education)	0.62	0.49	0.00	1.00
Owns computer	0.92	0.26	0.00	1.00
More than 200 books in the home	0.25	0.43	0.00	1.00
Teacher level				
Average age of teachers	45.72	0.31	37.89	55.32
Average work experience	18.09	3.55	8.66	28.33
Higher than required qualification	0.26	0.44	0.00	1.00
Active teaching practices indicator	0.46	0.10	0.18	0.68
Cognitive teaching practices indicator	0.71	0.07	0.48	0.92
Teacher-led teaching practices indicator	0.72	0.08	0.46	0.94
Classical teaching practices indicator	0.67	0.07	0.46	0.82
Innovative teaching practices indicator	0.55	0.09	0.33	0.79
School level				
School ownership (private/grant-aided private)	0.32	0.47	0.00	1.00
Town centre	0.62	0.49	0.00	1.00
ESCS (school mean)	-0.47	0.68	-1.89	1.06

Results

In this section, we report and discuss the results of the empirical analysis conducted to assess the influence of teaching strategies on student outcomes. We first estimate a hierarchical or multilevel regression model including all the individual, school and teacher variables described above. This methodological approach takes into account that students from the same school have similar values for school variables. As a result, the

average correlation between the variables (including variables related to teaching practices) will be greater for students at the same school than for students at different schools (Hox, 2002).

The aim of the model is to discover what relationship there is between school teacher teaching strategies (as well as other control variables) and student achievement for science, making a distinction between the above two criteria used to build the indicators. We then estimate a quantile regression model (Koenker and Bassett, 1978), again with a multilevel structure. The approach is designed to study whether the teaching strategies have a different effect for different science score cut-off points (). This is a more precise approach, as the design accounts for four segments within the results distribution (four quartiles) and estimates the effect of the explanatory variables on each segment. Accordingly, the slopes for the dependent variable may vary.

All the estimates were made using bootstrap techniques that cluster the data by schools, using 50 iterations to calculate the approximate standard error, as per OECD instructions (OECD, 2013). The errors are heteroscedasticity-consistent standard or robust errors. Students' original scores for science have been transformed into z-scores, meaning that the mean is 0 and the standard deviation is 1. This makes the results easier to interpret in terms of deviation.

Table III shows the results of the estimations for teaching practices considering the two alternative criteria.

Focusing on the key variables of interest, the results show that there is a statistically significant and positive relation between the indicator representing teacher-led teaching practices and academic achievement. This means that students get better scores for science at schools where the teacher uses this type of strategies more often (standard deviation of 0.838). On the other hand, the sign is negative for the other two strategies (cognitive activation and active learning), that is, marks tend to be lower, although the relation between the variables is not statistically significant. If instead of using three techniques, we separate by classical and innovative methods only, the results are even more conclusive, as the classical techniques have greater positive impact on science achievement (standard deviation of 0.997), whereas the relationship is again negative for the modern methods and is, in this case, also statistically significant.

Generally speaking, the positive and significant relationship detected for the more classical (traditional and teacher-led) activities is consistent

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with some of the evidence available in the previous literature (Schwerdt and Wuppermann, 2011; Bietenbeck, 2014), as is the negative impact of more innovative practices (Brewer and Goldhaber, 1997). However, some recent studies based on PISA data have discovered a positive relationship between cognitive activation strategies and student achievement in some participant countries (Le Donné et al. 2016), as well as for specific activities like small group work or the use of new technologies to carry out projects or complete classroom exercises (Méndez, 2015). Note, however, that these studies refer to mathematics teachers and focus on their relationship with mathematics achievement.

TABLE III. Estimation of student achievement for science depending on teaching strategies

Variables	Criterion 1	Criterion 2
Sex	-0.193***	-0.193***
	(0.0212)	(0.0229)
Has repeated a year	-0.937***	-0.936***
	(0.0218)	(0.0235)
First-generation immigrant	-0.161***	-0.162***
	(0.0350)	(0.0464)
Mother's educational level	0.126***	0.124***
	(0.0230)	(0.0257)
Owns computer	0.157***	0.155***
	(0.0392)	(0.0409)
More than 200 books in the home	0.283***	0.282***
	(0.0214)	(0.0253)
ESCS (school mean)	0.207***	0.190***
	(0.0232)	(0.0219)
School ownership	-0.0771**	-0.0108
	(0.0340)	(0.0354)
Town centre	0.0947***	0.0990***
	(0.0255)	(0.0242)
Mean age of teaching staff	0.0336***	(0.158)
	(0.00806)	0.0400***
Mean job experience	-0.0196***	(0.00830)
	(0.00677)	-0.0216***
Higher teaching qualification than prescribed	0.0871***	(0.00695)
	(0.0254)	0.0768***
Cognitive teaching practices indicator	-0.390	
	(0.261)	
Teacher-led teaching practices indicator	0.838***	
	(0.197)	
Active teaching practices indicator	-0.206	
	(0.179)	
Classical teaching practices indicator		0.997***
		(0.241)
Innovative teaching practices indicator		-0.747***
		(0.158)
Constant	-1.210***	-1.522***
	(0.326)	(0.271)
Observations	5,411	5,411
Number of groups	167	167

Standard error in parentheses *** p<0.01, ** p<0.05, * p<0.1

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It is also noteworthy that the results for the parameter estimates of the control variables included in the model are generally what we expected. Thus, outcomes are worse for girls than for boys, student grade retention or immigrant status lowers science scores, and outcomes are better for students who own a computer, have more books at home and whose mother has a higher educational level. With respect to school variables, we find that outcomes are significantly and positively related to schools in urban areas and with a higher socioeconomic level and negatively correlated with private and grant-aided private schools[8]. Finally, with regard to school teachers, there is a significant and positive correlation of outcomes with age and qualifications, whereas experience has an unexpected, albeit small negative value.

The results of applying quantile regressions for the main segments of the science score distribution (25%, 50% and 75%) corroborate and, in some cases, fine-tune the results reported above. For simplicity's sake, Table IV only reports the values of the parameter estimates for the key analysed variables, as the sign and significance of the values of the other variables are very similar to the above. The results suggest that teacher-led teaching practices have a positive impact on only the top segments (quartile 50 and 75). On the other hand, the use of cognitive activation strategies is detrimental for students with better marks, as are active practices for students with poorer grades.

This evidence is not consistent with the results of some previous studies, which found that students that perform worse gain most from teacher-led strategies, whereas the better students benefit from the use of cognitive activities (Lavy, 2011, Le Donné et al. 2016)[9]. Although these are studies addressing different competencies and contexts outside Spain, this inconsistency between the results leads us to raise the need to conduct future research exploring other possible factors that may be affecting the relationship between teaching methods and academic outcomes.

Finally, we find that, if grouped into only two categories (innovative vs. classical), the estimates have significant, albeit disparate, values for all the segments. In fact, the coefficients of traditional strategies are

(8) The inclusion of the mean school ESCS variable in the model accounts for this result.

(9) These studies deal with students from a favourable or unfavourable socioeconomic background, although this condition is known to be clearly correlated with academic achievement.

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positive (and upward), whereas they are negative (and downward) for innovative practices.

TABLE IV. Estimation of the relationship between science outcomes and teaching strategies by means of multilevel quantile regressions

	Three strategies			Two strategies		
VARIABLES	Q25	Q50	Q75	Q25	Q50	Q75
Cognitive practices indicator	0.142	-0.784**	-0.644*			
	(0.337)	(0.327)	(0.383)			
Teacher-led practices indicator	0.305	1.039***	0.909***			
	(0.264)	(0.233)	(0.306)			
Active practices indicator	-0.442*	0.0387	0.0755			
	(0.242)	(0.227)	(0.233)			
Innovative practices indicator				-0.791***	-0.725***	-0.706***
				(0.223)	(0.243)	(0.201)
Classical practices indicator				0.884***	1.002***	1.014***
				(0.263)	(0.267)	(0.255)
Student controls	X			X		
School controls	Y			Y		
Teacher controls	Z			Z		
Constant	-1.553**	-1.065**	-0.832	-1.963***	-1.681***	-1.020**
	(0.780)	(0.525)	(0.530)	(0.614)	(0.519)	(0.419)

Standard errors in parentheses
*** p<0.01. ** p<0.05. * p<0.1

Conclusions

This paper examined the relation between teaching strategies used by teachers from the same school and the results achieved by their students. The empirical analysis conducted for the specific context of secondary education in Spain is based on information available in the PISA 2015 database. This is the first PISA database to include information supplied by teachers about the teaching practices that they apply within the classroom. Based on the responses by teachers to a broad spectrum of questions, we built diverse indicators representing different teaching styles according to several criteria used in previous studies related to this issue.

The results of our estimations suggest that traditional methods, which are usually correlated with practices where the teacher plays a leading role as a conveyor of knowledge, are the ones that contribute most to improving the educational achievement of Spanish students in the science competence field, which was the focus of the PISA 2015 test. This result is constant across all the segments of the results distribution, as we infer from the estimates based on quantile regressions. On the other hand, the use of more innovative practices, which aim to promote student engagement through group work and the use of new technologies, as well as by setting challenges to stimulate critical thinking, does not appear to contribute to improving achievement and, in some cases, can even turn out to be detrimental. The competence assessment method used in the PISA test surely accounts for this result, as, despite the OECD's aim is to assess students' capacities to apply knowledge and skills in everyday life, it is very much linked to the knowledge acquired.

The reported results must be carefully analysed, as they cannot be interpreted in terms of causality. This would require optimal experimental conditions where the teaching practices applied by teachers were independent of student achievement. Some previous studies have tried to emulate this ideal scenario by applying fixed effects at student level and discovering the effects of varying teaching practices across two different subjects for the same student (Cordero et al., 2017). However, this type of strategy can only be implemented if students can be linked to the teacher who actually taught the analysed subjects. Unfortunately, the PISA database does not meet this criterion, as teacher information cannot be matched to student data. This led us to use aggregate, school-level data. This procedure is applicable considering that, as several previous studies have suggested (e.g. Méndez. 2015 or Le Donné et al. 2016), the teaching practices of the teachers from the same school are correlated with each other. If this is the case, the results derived from the fixed effects analysis based on the variation between teaching practices applied by teachers teaching different subjects can, in fact, be biased if there is such a correlation.

The results reported in this research aim to contribute to the debate on a very hot topic, namely, the role of teachers in the Spanish education system. On this issue, one of the points made by the recent White Paper on the Teaching Profession and the Educational Environment (Marina, Pellicer and Manso, 2015, p.11) was the need to "study and evaluate more

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efficient international educational innovations and advise teachers on the best teaching procedures and techniques". In this respect, this study provides empirical evidence on an issue that is as yet an open field in Spain because there are hardly any reliable data on the classroom activities performed by teachers. However, more and more databases are providing information in this regard (TIMSS, PISA –as of 2015 and previously by means of the TALIS-PISA link– or the different diagnostic tests developed by the Spanish Ministry of Education). On this ground, it is to be expected that other studies analysing this question and offering further potentially useful evidence for decision making on this key issue of practices that can help to improve our students' learning process will be published in the near future.

References

Algan, Y,, Cahuc, P. and Shleifer. A. (2013). Teaching practices and social capital. *American Economic Journal: Applied Economics*, 5(3), 189–210.

Akiba, M., LeTendre, G. K. and Scribner, J. P. (2007). Teacher quality, opportunity gap, and national achievement in 46 countries. *Educational Researcher*, 36(7), 369-387.

Austin. B., Adesope, O., French, B., Gotch, C., Belanger, J. and Kubacka, K, (2015). Examining school context and its influence on teachers: linking Talis 2013 with PISA 2012 student data. *OECD Education Working Papers, No. 115,* Paris: *OECD Publishing*, http://dx.doi.org/10.1787/5js3f5fgkns4-en

Bietenbeck, J. (2014). Teaching practices and cognitive skills. *Labour Economics*, 30, 143-153.

Brewer, D. J. and Goldhaber, D. D. (1997). Why don't schools and teachers seem to matter? Assessing the impact of unobservables on educational productivity. *Journal of Human Resources*, 32(3), 505-523.

Calero, J. and Escardíbul, J.O. (2007). Evaluación de servicios educativos: el rendimiento en los centros públicos y privados medido en PISA-2003. *Hacienda Pública Española / Revista de Economía Pública*, 183-4, 33-66.

Campbell, J., Kyriakides, L., Muijs, D. and Robinson, W. (2012). *Assessing teacher effectiveness: different models*, London: Routledge Falmer.

Capps, D. K., Crawford, B. A. and Constas, M. A. (2012). A review of empirical literature on inquiry professional development: Alignment with best practices and a critique of the findings. *Journal of Science Teacher Education*, 23(3), 291-318.

Carbonaro, W. J. and Gamoran, A. (2002). The production of achievement inequality in high school English. *American Educational Research Journal*, 39, 801–827.

Clotfelter, C.T., Ladd, H.F. and Vigdor, J.L. (2007). Teacher credentials and student achievement: Longitudinal analysis with student fixed effects. *Economics of Education Review*, 26(6), 673–82.

Clotfelter, C.T., Ladd, H.F. and Vigdor, J.L. (2010). Teacher credentials and student achievement in high school: a cross-subject analysis with student fixed effects. *Journal of Human Resources*, 45(3), 655–682.

Coleman, J., Campbell, E.Q., Hobson, C.F. McPartland, J. and Mood, A.M. (1966): *Equality of Educational Opportunity*. Washington: U.S. Office of Education.

Cordero, J. M., Crespo, E. and Pedraja, F. (2013). Rendimiento educativo y determinantes según PISA: una revisión de la literatura en España. *Revista de Educación*, 362, 273-297.

Cordero, J.M., Cristóbal, V. and Santín, D. (2017). Causal Inference on Education Policies: A Survey of Empirical Studies Using PISA. TIMSS and PIRLS. *Journal of Economic Surveys* (in press). doi: 10.1111/joes.12217

Creemers, B. and Kyriakides, L. (2007). The dynamics of educational effectiveness: A contribution to policy, practice and theory in contemporary schools. New York: Routledge.

Croninger, R. G., Rice, J. K., Rathbun, A. and Nishio, M. (2007). Teacher qualifications and early learning: Effects of certification, degree, and experience on first-grade student achievement. *Economics of Education Review*, 26(3), 312–324.

De Witte, K. and Van Klaveren, C. (2014). How are teachers teaching? A nonparametric approach. *Education Economics*, 22(1), 3-23.

Echazarra, A., Salinas. D., Méndez, I., Denis, V. and Rech, G. (2016). How teachers teach and students learn: Successful strategies for school. *OECD Education Working Papers, No. 130.* Paris: OECD Publishing. http://dx.doi.org/10.1787/5jm29kpt0xxx-en.

Received: 26-05-2017 Accepted: 20-10-2017

Ehrenberg, R. G. and Brewer, D. J. (1994). Do school and teacher characteristics matter? Evidence from high school and beyond. *Economics of Education Review*, 13, 1–17.

Goldhaber, D. and Anthony, E. (2007). Can teacher quality be effectively assessed? National board certification as a signal of effective teaching. *The Review of Economics and Statistics*, 89(1), 134-150.

Hanushek, E. A. (1986). The economics of schooling: Production and efficiency in public schools. *Journal of Economic Literature*, 24. 1141–1177.

Hanushek, E. A. (1997). Assessing the effects of school resources on student performance: An update. *Educational Evaluation and Policy Analysis*, 19, 141–164.

Hanushek, E. A. (2011). The economic value of higher teacher quality. *Economics of Education Review*, 30(3), 466-479.

Hattie, J. (2009). *Visible Learning: A Synthesis of over 800 Meta-analysis Relating to Achievement. Abingdon: Routledge.*

Hidalgo, A. and López-Mayan, C. (2015). Teaching styles and achievement: Student and teacher perspectives. *Economic Analysis Working Paper Series 2/2015.* Universidad Autónoma de Madrid.

Hiebert, J. (2003). *Teaching mathematics in seven countries: Results from the TIMSS 1999 video study*. Washington: DIANE Publishing.

Hox, J. (2002). *Multilevel Analysis. Techniques and Applications*. Mahwah: Lawrence Erlbaum Associates.

Koenker, R. and Bassett Jr. G. (1978). Regression quantiles. *Econometrica: Journal of the Econometric Society*, 46(1), 33-50.

Lavy, V. (2011).What makes an effective teacher? Quasi-experimental evidence. *NBER Working Paper 16885.*

Le Donné, N., Fraser. P, and Bousquet, G. (2016). Teaching Strategies for Instructional Quality: Insights from the TALIS-PISA Link Data. *OECD Education Working Papers*, No. 148, Paris: OECD Publishing. http://dx.doi.org/10.1787/5jln1hlsr0lr-en

Marina, J.A., Pellicer, R. and Manso, J. (eds.) (2015). *Libro Blanco de la profesión docente y su entorno escolar.* Madrid: Ministerio de Educación. Cultura y Deporte.

Méndez, I. (2015). Prácticas Docentes y Rendimiento Estudiantil: Evidencia a partir de PISA 2012 y TALIS 2013. Madrid: *Instituto Nacional de Evaluación Educativa y Fundación Santillana.*

Murnane, R. J. and Phillips, B. R. (1981). What do effective teachers of inner-city children have in common? *Social Science Research*, 10(1), 83-100.

OCDE (2009). PISA Data Analysis Manual. SPSS Second Edition. Paris: *OECD Publishing*.

OCDE (2013). Advancing National Strategies for Financial Education. Paris: OECD Publishing.

OCDE (2016). PISA 2015 Technical Report. PISA. Paris: *OECD Publishing*.

Opdenakker, M.C. and Van Damme, J. (2006). Teacher characteristics and teaching styles as effectiveness enhancing factors of classroom practice. *Teaching and Teacher Education*, 22, 1–21.

Palardy, G. J. and Rumberger, R. W. (2008). Teacher effectiveness in first grade: The importance of background qualifications, attitudes, and instructional practices for student learning. *Educational Evaluation and Policy Analysis*, 30(2), 111-140.

Razak, N. A. and Shafaei, A. (2016). The Variation in Teaching and Learning Practices and their Contribution to Mathematics Performance in PISA 2012, in Thien, L.M., Razak, N.A., Keeves, J.P. and Darmawan (eds.). *What Can PISA 2012 Data Tell Us? Performance and Challenges in Five Participating Southeast Asian Countries* (123-157).-. Rotterdam: Sense Publishers.

Rivkin, S.G., Hanushek, E.A. and Kain, J.F. (2005). Teachers, schools, and academic achievement. *Econometrica,* 73(2), 417–58.

Rockoff, J.E. (2004). The impact of individual teachers on student achievement: Evidence from panel data. *American Economic Review,* 94(2), 247–52.

Rosenshine, B. and Stevens, R. (1986). Teaching functions, in Wittrock, M.C. (Ed.) *Handbook of research on teaching* (376-391). New York: MacMillan.

Santín, D., and Sicilia, G. (2014). *The teacher effect: an efficiency analysis from a natural experiment in Spanish primary schools*. Workshop on Efficiency in Education. Lancaster University Management School. London.

Schwerdt, G. and Wuppermann, A. C. (2011). Is traditional teaching really all that bad? A within-student between-subject approach. *Economics of Education Review*, 30(2), 365-379.

Van Klaveren, C. (2011). Lecturing Style Teaching and Student Performance. *Economics of Education Review*, 30, 729-739.

Received: 26-05-2017 Accepted: 20-10-2017

Wentzel, K. R. (2002). Are effective teachers like good parents? Teaching styles and student adjustment in early adolescence. *Child Development*, 73, 287–301.

Windschitl, M. and Sahl, K. (2002). Tracing teachers' use of technology in a laptop computer school: The interplay of teacher beliefs, social dynamics, and institutional culture. *American Educational Research Journal*, 39(1), 165-205.

Zemelman, S., Daniels, H. and Hyde, A. (2005). *Best practice: Today's standards for teaching and learning in America's schools*. Portsmouth: *Heinemann*.

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