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The Effect of Weekly Instruction Time on Academic Achievement: The Spanish Case*

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Abstract

This research checks if the amount of weekly instruction time received by 15 year-old Spanish students actually affects their academic achievement and if this effect differs by Autonomous Community. The employed student fixed effects between-subjects let us isolate this effect of instruction time from other covariates. Results show that there is not any significant effect of instruction time on academic achievement, being this conclusion extended to the Autonomous Communities under analysis. This result suggests that a previous evaluation of the weekly instruction time set by the Spanish 2013 education law would have been needed before its implementation.

Keywords: Weekly instruction time, Student fixed effects, Spain, Autonomous Communities, Secondary education.

JEL Classification: I20, I21, I28

1. Introduction

The high amount of instruction time that Spanish students are receiving is at the core of public debate in the Spanish social media. The idea behind this high number of instruction hours is based on the common belief that higher instruction time will be directly translated

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into higher academic achievement, as students will be in an educational environment for an extended period of time and, hence, they will learn more. However, this correlation is not that clear in the case of Spanish students, as compared to the case of other countries. According to OECD (2011a), 15 year-old Spanish students received a total of 1,050 hours of instruction time in 2009[1] and got an average score of 484 points[2] in PISA –Programme for International Student Assessment– 2009 (OECD, 2010), while, e.g., Finland presented a total of 856 hours of instruction and achieved –on average– 544 PISA scores or Australia, with 964 hours of instruction, reached scores of 519 –on average–. Conversely, in the case of Mexico the received instruction time was 1,089 hours, while the scores achieved by students were almost one standard deviation below Spain.

As we will see in the "Literature review" section, the evidence on the influence of instruction time on academic achievement is in most cases correlational and not conclusive: some research works have stated the existence of a positive influence of weekly instruction time on students' academic achievement, while others a null effect. This is partly due to the great difficulty to isolate the effect of instruction time from other characteristics which may be conditioning students' academic achievement. In this research we intend to overcome this (as our main objective), for the case of the Spanish secondary education, to contribute to the debate on the causal impact of instruction time on academic achievement, as there is a virtual absence of evidence for this country.

An additional important motivation (and second aim) for this research is to evaluate whether the capacity that Spanish Autonomous Communities (AACC) have to set the amount of weekly instruction time in their secondary schools may be causing a differential effect of the potential causal influence of instruction time on academic achievement[3]. This capacity of Spanish AACC to set their own amount of weekly instruction time is rooted in the transference of all the educative competences to them by the Spanish central government[4]. Thus, the heterogeneity in the quantity of instruction hours – that we are exploiting in this research – can be found in what authors as Doncel (2014) highlighted, i.e., Spanish AACC make use of these competences in order to set their own curriculum, in which they place a different amount of weekly instruction time on certain subjects (e.g. history, geography, certain languages, etc.) in order to claim their cultural identity and singularities.

Furthermore, this autonomy is also present in the competences that Spanish AACC have in the administration of the Spanish public expense in education, as they can manage about 91% of these expenses, as indicated in the report by Pérez *et al.* (2016). Those authors also highlight that, in Spain, these expenses represented 4.4% of the total GDP in 2012, although the public expense by student in real terms has been reduced in 27% from 2009 to 2012. Hence, this could be denoting the need to properly allocate these valuable economic resources to provide Spanish students with a proper education. To the extent that an inadequate amount of instruction time per week may mean more expenses (in terms of, e.g., teachers' salaries, school resources, etc.) the knowledge and analysis of its effect on academic achievement gets a great economic relevance.

To perform this research we employed the differences in weekly instruction time presented within-student between-subjects using student fixed effects, for three different subjects analysed by PISA 2009 (reading, mathematics and science), making the most of the heterogeneity in the amount of instruction time per week between these subjects. This procedure, which has been employed by many researchers (Cattaneo *et al*., 2017; Dee and Cohodes, 2008; Lavy, 2015, 2010; Metzler and Woessmann, 2012; Rivkin and Schiman, 2015, among others), let us obtain the causal effect of weekly instruction time on academic achievement as we consider the rest of variables being the same across subjects. Thus, results will not be influenced by other confounding factors which could potentially bias the conclusions obtained. To the best of our knowledge[5], this is the first time that this issue has been analysed specifically for Spain and its AACC with PISA data.

This research is structured as follows: in section 2 a literature review on the effect of instruction time on students' academic achievement has been performed, followed by a description of the employed data in section 3; in section 4 the methodology and identification strategy are explained; section 5 shows the main results of the analysis and robustness checks, to conclude in section 6.

2. Literature review

As it has been indicated, the empirical evidence of the effect of weekly instruction time on students' academic achievement is quite mixed. First, there is a wide and extended strand of the literature which states that weekly instruction time has a positive effect on students' academic achievement. Within these research works we find Lavy (2015, 2010) analysing PISA 2006 for over 50 countries. This result was also found by Rivkin and Schiman (2015) for 72 countries in PISA 2009 and Andersen *et al*. (2016) for Denmark. Cattaneo *et al*. (2017) built on Lavy (2015) to analyse the case of Switzerland with data on PISA 2009 and also found that a higher number of hours of instruction would mean better academic results, although they claimed that this effect was lower than they expected. Additionally, Walberg *et al*. (1994) reviewed more than 100 studies and found that 88% indicated the existence of a positive relationship between instruction time and academic achievement. A more recent review of research by Patall *et al*. (2010) analysed literature since 1985 and also found that increasing instruction time can be positive for students' learning. In the same vein, OECD (2011b) indicated that countries in which students spent more time in regular school lessons also showed high scores in reading, mathematics and science; however, a high amount of out-of-school lessons and individual study time showed a negative effect. Thus, OECD (2011b) remarked that the highest effect of instruction time was appreciated in relative school time –the proportion of time at school lessons in relation to other learning activities–. Nevertheless, although being this relative instruction time relevant, OECD (2011b) stated that the solution to low performance would not be increasing it, but increasing the quality of lessons and teachers. The paper by Mullis *et al*. (2012) also remarked the positive effect of instruction time on academic achievement and the importance of its effective use.

These two latter references let us move to another strand of the literature which indicates that the effect of instruction time on students' academic achievement depends more on its effective use that in the amount of it. In this sense, Baker *et al*. (2004) analysed almost 52 countries in PISA 2000 and TIMSS –Trends in International Mathematics and Science Study– 1999 and found that there is low evidence of an increase of marginal academic achievement for each additional unit of instruction time exceeding the basic amount of it. They also highlighted that the influence of instruction time on academic achievement depends on the curriculum and instructional quality. Regarding to this argument Gromada and Shewbridge (2016) stated that, due to the high costs of increasing instruction time, one of the main priorities when increasing it should be to assure that it is used effectively, by an improvement of teaching quality and classroom management, so instruction time can be translated into engaged time. Similarly, OECD (2013) indicated for PISA 2012 that, as academic achievement is the result of the quantity and quality of instruction time, the cross-education system differences in the later may be affecting the relationship between the quantity of instruction time and academic achievement. On the other hand, Woessmann (2010) studied the education systems of 16 different states in Germany for three years and three subjects, applying a methodology which net out the influence of unobserved factors related to the country; he found that instruction time does not have influence on academic achievement.

Thus, the relationship between weekly instruction time and academic achievement may not be as obvious as it seems, probably because it may be affected by the characteristics of the country or region under study and the great difficulty to isolate the effect of instruction time from other characteristics which may be conditioning students' academic achievement as, e.g. the quality of the curriculum, skills obtained in early childhood education (Mancebón *et al*., 2018), teacher quality and knowledge of the subject, the funding and socio-economic composition of the school (Di Paolo and Choi, 2014; Vega-Bayo and Mariel, 2018) or school climate. Furthermore, instruction time may present non-linear effects on academic achievement due to decreasing attention of students during lessons (Bunce *et al*., 2010). All this non-conclusive evidence suggests that this instruction time issue and its conclusions may be conditioned by the country under study and the employed method of analysis. This makes the particular case of Spain of special relevance for study, due to the lack of research – to the best of our knowledge – focused in this particular country.

3. Data

In this research the dataset employed is that from PISA 2009. The main intention of this programme is to measure 15 year-old students' competences in reading, mathematics and science, being conducted by the OECD with a three-year periodicity. The 2009 data contains two questions related to instruction time in the student questionnaire which let to obtain the total amount of weekly minutes of instruction that a certain student receives for reading, mathematics and science[6], so this is the main variable employed in the current analysis[7].

As in both PISA 2009 and 2012 the same educative legislation was applicable in Spain (*"Ley Orgánica de Educación"* of 2006, i.e. LOE; BOE, 2006), potential variations in the effect of weekly instruction time may not be related to regulatory changes, so we could take advantage of this and append both cycles. However, we focus on the 2009 year data because, due to the rotation procedure used for students' questionnaire in PISA 2012 (OECD, 2014), only two-thirds of the 2012 sample answered the question related to weekly instruction time[8], what could bias our results –as it is argued in the next section–. An additional advantage of using PISA 2009 is that it lets us obtain a continuous measure of instruction time in weekly minutes[9].

In PISA 2009 there are a total of 25,887 students in 889 schools who are attending tenth grade, which is equivalent to the fourth –last– course of Spanish secondary compulsory education –"Educación Secundaria Obligatoria" (ESO)–.

The analysis presented in this research is focused on students who did not repeat a course, because those who repeated may have different weekly minutes of instruction due to their attendance to a different grade from that of non-repeaters –PISA is focused on students at the age of 15 years and not in a particular course–. In PISA 2009 repeater students represent 30.33% (and 0.77% do not have information about repetition)[10].

In addition, non-repeater students who had missing values for any of the weekly instruction time variables of reading, mathematics and science were eliminated from the sample, as we are focusing on the variation between the three subjects. Furthermore, non-repeater students who reported zero minutes per week of instruction in reading and mathematics were also dropped from the analysis –as these are compulsory subjects in Spain (BOE, 2006), so this misleading information would be the consequence of a reporting error–, together with those students who reported zero weekly minutes of instruction in science[11,12]. In addition, students who reported an outlier number of lessons per week (1, 2, 6, 7, 8 or 9 lessons in the case of reading and mathematics and 1 in the case of science[13], which represented less than 1% of the total reports of instruction time in each subject) were not included. In the case of the minutes per lesson, all students reported between 40 and 60 minutes, hence it was not necessary to correct for any outlier. Students who were eliminated according to these criteria of the instruction time variable were 16.34% of the sample.

As it is indicated by PISA technical reports, not all students took cognitive tests for the three subjects in PISA; some of them only took one-subject booklet or two-subject booklet, and then have their scores imputed in all subjects[14]. Authors as Rivkin and Schiman (2015) suggest keeping only those students who actually answered questions about the subjects under analysis to study the effect of instruction time on academic achievement. However, the PISA Data Analysis Manual highly discourages this practice (OECD, 2009, pp. 79-80) as the difficulty of booklets is not balanced, so choosing students who only took certain booklets would bias the results. In addition, OECD (2009) indicates that this procedure of different content/difficulty booklets lets to obtain reliable results for the population under analysis. Furthermore, the composition of the booklets which contain questions on the three subjects is not balanced in terms of time, as booklets are composed by four clusters –each one worth one-subject half-hour content–, meaning this that the amount of time and questions would be approximately double in one subject that in the other two (OECD, 2012, p. 30). Because of these reasons, we do not select students by the content of the booklet that they took and rely on PISA procedures to get reliable results for the Spanish population[15].

Finally, we focused this analysis on those Autonomous Communities which had an extended sample for PISA 2009[16]. This left us with a sample of 13,605 non-repeater students, a figure which was later reduced due to the use of variables with missing values to analyse the adequacy of the identification strategy –these variables were included in the estimations in Table A1 (Appendix), which will be explained in the following section–.

4. Methodology and identification strategy

As previously stated, the aim in this research is twofold: firstly, it intends to analyse the potential causal effect –or the absence of it– of weekly instruction time on students' academic achievement by using information about them in three different subjects for each student –reading, mathematics and science–, while the second one is to check whether this potential causal effect is different across the Spanish Autonomous Communities. To accomplish these aims student fixed effects within-student between-subjects have been employed. Basically, the identification strategy establishes the assumption that the characteristics of a particular student and those of his/her school are the same for the three subjects under analysis, subsequently the potential differences in academic achievement between these subjects may be due to their uneven and heterogeneous instructional time[17] (Lavy, 2015). Therefore, these differences in academic achievement would not be due to heterogeneity in variables which are the same between subjects as, e.g., socio-economic background, study habits, school climate and quality, etc., remaining only those subject related factors associated with instruction time. Time varying characteristics are not a concern for our identification strategy, to the extent that we are focusing on cross-section data of a particular students' age at a particular moment of time. Furthermore, we have replicated these estimations by Ordinary Least Squares (OLS) to check whether the effect of weekly instruction time may vary according to the estimation method.

The procedures suggested by PISA (OECD, 2009) –weighting the data, using Balanced Repeated Replication (BRR) weights (to account for students being clustered at school level) and the five plausible values– have been applied in order to obtain reliable statistics and estimations[18].

The first aim has been carried out by the estimation of the following education production function, which will be named as our "base model" from now on when estimated using student fixed effects[19]:

$$Y_{kijc} = \alpha_i + \beta T_{kjc} + \gamma S_k + \sum_{c=1}^{p} \delta AACC_c + \rho X_{ijc} + \lambda SCH_{jc} + \psi_k + \sigma_j + \mu_c + \varepsilon_{kijc} \quad (1)$$

representing k the k^{th} subject; i the i^{th} student; j the j^{th} school; c the c^{th} Spanish Autonomous Community. Y_{kijc} is students' academic achievement in each subject; T_{kjc} is the school average of students' self-reported instruction time in each subject measured in weekly minutes[20,21]; S_k identifies the k^{th} subject (a subject fixed effect in our base model); $AACC_c$ is the c^{th} Spanish Autonomous Community with extended sample –for c=1,…,p AACC–, which measures, for example, observable variables as the average socio-economic background of the Autonomous Community; X_{ijc} are the observable student characteristics which are the same between subjects (e.g., sex, socio-economic background, immigrant status, etc.); SCH_{jc} are the observable school characteristics which are the same between subjects (for example, the politics of the school in terms of management, the number of teachers in the schools, the ratio of students per teacher, etc.); α_i is the student unobservable effect, which represents student's ability and other unobservable characteristics of the student; ψ_k represents the unobservable characteristics of the subject (for example, the difficulty of the subject), σ_j those of the school (for example, school education ideology) and μ_c those of the Autonomous Community (for example, the ideology of the Autonomous Community in terms of education); ε_{kijc} is the unobservable error term.

The main identification strategy of this analysis establishes the assumption that the education production function for reading, mathematics and science is the same, so the effect on students' academic achievement of, e.g., one weekly minute of instruction, is the same for all subjects; otherwise, the estimation of β would be biased. However, although many research works make this assumption without further checking (Lavy, 2015; Rivkin and Schiman, 2015), we have analysed whether this assumption holds in our research (or not) by using a similar procedure to that of Cattaneo *et al*. (2017), who replicated it from Metzler and Woessmann (2012) –the latter used it to check whether the influence of teachers' subject knowledge on students' academic achievement was the same across reading and mathematics subjects–. To do this, we define the unobservable student effect α_i as:

$$\alpha_i = \varphi_1 T_{1jc} + \varphi_2 T_{2jc} + \varphi_3 T_{3jc} + \tau X_{ijc} + \omega SCH_{jc} + \theta_i \quad (2)$$

where the φ_k coefficient which accompanies T_{kjc} –for k=1,…,3, being k=1 for reading, k=2 for mathematics and k=3 for science– represents the unobserved k^{th} subject-specific effect of the instruction time per week due to students' unobservables –like ability– on the k^{th} subject; X_{ijc} are the unobservable characteristics of the student which are the same between subjects; SCH_{jc} are the unobservable characteristics of the school which are the same between subjects; θ_i is the remaining student unobserved term and it is uncorrelated with the other independent variables.

When substituting equation (2) in (1), rearranging terms and defining s=1,2,3 specifications, one for each of the k=1,2,3 subjects, we get:

$$Y_{sijc} = (\beta_s + \varphi_s)T_{sjc} + \sum_{k \neq s} \varphi_k T_{kjc} + \sum_{c=1}^{p} \delta AACC_c + (\rho + \tau)X_{ijc} + \\ +(\lambda + \omega)SCH_{jc} + \theta_i + \sigma_j + \mu_c + \varepsilon_{sijc} \quad (3)$$

The three specifications –one for each subject– are estimated as a seemingly unrelated regression equation (SURE) system. In this model, β_s represents the effect of the s^{th} subject weekly instruction time on students' s^{th} subject academic achievement; φ_s is the s^{th} subject-specific effect of weekly instruction time on students' s^{th} subject academic achievement due to students' unobservables –e.g. ability–, i.e., it shows students' ability to take advantage of weekly instruction time in that s^{th} particular subject; φ_k is the subject-specific effect of weekly instruction time on students' s^{th} subject academic achievement due to students' unobservables –like ability– on the k^{th} subject, being $k \neq s$, i.e., it shows students' ability to take advantage of the weekly instruction time on other k^{th} subject –different from s– which affects their academic achievement on the s^{th} subject.

Hence, in order to interpret β in the base model as the causal effect of weekly instruction time on students' academic achievement in the three subjects, we have to check two main hypothesis: the first assumption that $\varphi_1=\varphi_2=\varphi_3$ holds, so that the effect of weekly instruction time on students' academic achievement in the subject due to student subject-specific unobservables –e.g. ability– is the same for the three subjects[22]; the second assumption is that β_s of the three specifications are the same, i.e., $\beta_1=\beta_2=\beta_3$, what means that instruction time per week affects academic achievement in the same way for all subjects, so that the effect of β in the base model would not be biased[23]. The results of these tests are presented in Table 1, while the estimations –one for each subject– from which these tests were calculated are displayed in Table A1[24] (Appendix A) for PISA 2009. It can be appreciated that both hypothesis are accepted, so we can use student fixed effects to get unbiased estimates of β as a causal effect.

Table 1
CHECK OF THE EQUALITY OF STUDENTS' UNOBSERVED SUBJECT-SPECIFIC EFFECT OF WEEKLY INSTRUCTION TIME ON ACADEMIC ACHIEVEMENT AND THE EQUALITY OF THE EFFECT OF WEEKLY INSTRUCTION TIME ON ACADEMIC ACHIEVEMENT OF ALL SUBJECTS

	Chi-square	P-value
$\varphi_2 = \varphi_3$	0,12	0,73
$\varphi_1 = \varphi_3$	0,35	0,56
$\varphi_1 = \varphi_2$	0.00	0,99
$\beta_1 = \beta_2 = \beta_3$	0,27	0,87

Note: Tests based on the estimations in Table A1 (Appendix A) for PISA 2009.
Source: Authors' own calculations.

This hypothesis contrast was performed for PISA 2009 and 2012 using their common sample of extended AACC for comparison purposes –from the total 18 Spanish AACC Castile-La Mancha, Ceuta and Melilla, Canary Islands, Valencia and Extremadura were not included–. However, in the case of PISA 2012, only $\varphi_1=\varphi_2$ was accepted[25]. Consequently, due to the inadequacy of PISA 2012 to perform the analysis that we want to accomplish, we opted to focus on PISA 2009 for the rest of the research –results on PISA 2012 will be provided upon request to the authors–.

Furthermore, the current research relies also in the existence of enough variation in the weekly instruction time between subjects for the Autonomous Communities under analysis. This is accomplished for the current research, as (taking half-hour intervals of school average weekly instruction time for two-subject comparison) 78% of schools present different average amounts of half-hour categories in weekly instruction time for mathematics and science, 76% for reading and science and 41% for reading and mathematics. In addition, taking the school average weekly lessons, 61% of schools present different average amounts of weekly lessons in mathematics and science, 62% for reading and science and 23% for reading and mathematics.

The second aim of this research, related to the existence of a different effect of weekly instruction time depending on the AACC, has been checked by introducing in the base model an interaction of weekly instruction time with each one of the AACC.

Complementarily, once analysed these two aims, we performed some robustness checks to see whether our results hold conditioned on certain factors. The first attempt is to check whether the effect of weekly instruction time could be conditioned by the socio-economic status of the student, the relative risk of poverty of the AACC or by the ability grouping that some schools perform –which may suppose adapting the amount of instruction time per week to the ability of the student–. The latter analysis is performed using information on students being grouped according to their ability within the class or into different classes, so that we can check whether the differences of the weekly instruction time reported by students within the same school may be due to their attendance to a different group –in other class or within the same class– with different timetables or not. If it is not the case, the aggregation of students' self-reported weekly instruction time by school level that we performed may be a good representation of students' real instruction time per week. In addition to these estimations, we analysed the potential existence of non-linearities in the effect of weekly instruction time.

As previously argued in the "Literature review" section, the potential causal effect of weekly instruction time on academic achievement may be due to its quality more than its quantity. Because of that, we also checked whether the influence of the quality of the school, students and teachers may be influencing the effect of this instruction time. As PISA does not contain teacher-level variables, we have made use of school climate-related variables, which gather factors like school resources, disruption in classes, student-teacher relationships, etc. We cannot check for classroom peer effects because the sampling procedure used by PISA selects students by age randomly from the school, so it is not possible to know the classroom of the student.

5. Results

5.1. Main results

Descriptive statistics for the sample under analysis are presented in Table A2 (Appendix A) by Autonomous Communities[26]. The number of observations differs by AACC; however this is not an issue as we are making use of the weighting procedures recommended by the OECD. From the view of these statistics it does not seem that there is a clear relationship between academic achievement and weekly instruction time. Most of the AACC are located in the range between 180 and 220 minutes of instruction time per week –in the case of science this band is located between 220 and 250 minutes per week, as it gathers more than one subject in PISA–, but they present different levels of academic achievement, what could be advancing the result that academic achievement may not be affected by weekly instruction time for the case of the Spanish AACC. Furthermore, the cases of Canary Islands in reading and mathematics or Andalusia in mathematics and science outstand, as they show a high amount of instruction time per week but low academic performance, what seems opposite to that argued in the previous literature based on international evidence.

In order to provide additional evidence to the unconditional analyses, in Table 2 we present the estimated coefficients for the base model. Scores have been standardised using PISA 2009 mean and standard deviation (SD) for Spain for each subject (OECD, 2010)[27], to facilitate the comparison of the results of the current research with others dealing with different countries. From the results obtained for the student fixed effects model we can infer that weekly instruction time may not affect academic achievement of Spanish students, as it was previously deduced from the descriptive analysis. This result was also obtained by Baker *et al*. (2004) and Woessmann (2010). This analysis of the base model was replicated by the use of OLS (adding AACC controls) and we obtained a different result: weekly instruction time seems to positively affect academic achievement. The reason behind this result may be that, when using OLS, there is an omission of relevant variables that can potentially explain academic achievement –observable and unobservable variables which are accounted for in the fixed effects model, as they are the same between subjects–, so that instruction time is gathering their effect. Consequently, from now on, the comments of the rest of this section will be focused on fixed effects results.

In Table 3 the differential effect of weekly instruction time by AACC is checked by adding to the base model an interaction of weekly instruction time with each one of the AACC dummy variables. Although the general effect for Spain of weekly instruction time is not significant for the student fixed effects model, it seems that it has a positive effect for Galicia, increasing academic achievement by 0.001 SD per weekly minute of instruction –compared to Andalusia– and decreasing it by 0.001 SD per weekly minute in Aragon –compared with Andalusia–. Nevertheless, when putting these figures into the PISA scale –in which scores have a mean of 500 and standard deviation of 100– this effect does not seem very high: e.g., an increase of one hour of instruction per week in Galicia would mean an increase of 0.06 SD in comparison with Andalusia in PISA 2009. Hence, from the results obtained in Tables 2 and 3, it could be concluded that instruction time per week may not have a relevant effect on academic achievement for the Spanish AACC under analysis[28,29].

Table 2
ESTIMATED EFFECT OF INSTRUCTIONAL TIME ON TEST SCORES

Variables	OLS	Student FE
Weekly minutes of instructional time	0.001***	0.000
	(0.000)	(0.000)
Subject: Reading (Ref.: Science)	0.082***	0.025*
	(0.018)	(0.014)
Subject: Maths (Ref.: Science)	0.061***	0.015
	(0.017)	(0.015)
Aragon (Ref.: Andalusia)	0.414***	
	(0.060)	
Asturias (Ref.: Andalusia)	0.322***	
	(0.071)	
Balearic Islands (Ref.: Andalusia)	-0.010	
	(0.067)	
Canary Islands (Ref.: Andalusia)	-0.205***	
	(0.062)	
Cantabria (Ref.: Andalusia)	0.316***	
	(0.067)	
Castile and Leon (Ref.: Andalusia)	0.494***	
	(0.068)	
Catalonia (Ref.: Andalusia)	0.236***	
	(0.083)	
Galicia (Ref.: Andalusia)	0.378***	
	(0.063)	
La Rioja (Ref.: Andalusia)	0.505***	
	(0.059)	
Madrid (Ref.: Andalusia)	0.448***	
	(0.063)	
Murcia (Ref.: Andalusia)	0.148**	
	(0.068)	

(*Continued*)

Variables	OLS	Student FE
Navarre (Ref.: Andalusia)	0.412***	
	(0.053)	
Basque Country (Ref.: Andalusia)	0.264***	
	(0.052)	
Ceuta and Melilla (Ref.: Andalusia)	-0.351***	
	(0.051)	
Constant	-0.073	0.430***
	(0.088)	(0.047)
Observations	36,669	36,669
R-squared	0.076	0.874

Notes: Standard errors in parentheses. The procedures suggested by PISA (OECD, 2009) to deal with its data have been applied. In the OLS estimation AACC controls have been included.
Estimation method: OLS and student fixed effects.
Dependent variable: Standardised scores in reading, mathematics and science in PISA 2009.
*Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.*
Source: Authors' own calculations.

Table 3
ESTIMATED EFFECT OF INSTRUCTIONAL TIME ON TEST SCORES BY AACC

Variables	OLS	Student FE
Weekly minutes of instructional time	0.001*	-0.000
	(0.001)	(0.000)
Subject: Reading (Ref.: Science)	0.076***	0.025*
	(0.020)	(0.014)
Subject: Maths (Ref.: Science)	0.067***	0.018
	(0.017)	(0.015)
Aragon (Ref.: Andalusia)	0.401*	
	(0.214)	
Asturias (Ref.: Andalusia)	0.031	
	(0.230)	
Balearic Islands (Ref.: Andalusia)	0.090	
	(0.215)	
Canary Islands (Ref.: Andalusia)	-0.820*	
	(0.436)	
Cantabria (Ref.: Andalusia)	0.025	
	(0.195)	
Castile and Leon (Ref.: Andalusia)	0.422**	
	(0.215)	

(*Continued*)

Variables	OLS	Student FE
Catalonia (Ref.: Andalusia)	0.235	
	(0.218)	
Galicia (Ref.: Andalusia)	0.254*	
	(0.139)	
La Rioja (Ref.: Andalusia)	0.272	
	(0.197)	
Madrid (Ref.: Andalusia)	0.145	
	(0.184)	
Murcia (Ref.: Andalusia)	-0.019	
	(0.258)	
Navarre (Ref.: Andalusia)	-0.010	
	(0.179)	
Basque Country (Ref.: Andalusia)	0.484***	
	(0.169)	
Ceuta and Melilla (Ref.: Andalusia)	-1.744***	
	(0.302)	
Interactions with "Weekly minutes of instructional time"		
Aragon (Ref.: Andalusia)	0.000	-0.001***
	(0.001)	(0.001)
Asturias (Ref.: Andalusia)	0.001	0.000
	(0.001)	(0.001)
Balearic Islands (Ref.: Andalusia)	-0.001	-0.000
	(0.001)	(0.001)
Canary Islands (Ref.: Andalusia)	0.003	0.000
	(0.002)	(0.001)
Cantabria (Ref.: Andalusia)	0.001	-0.000
	(0.001)	(0.001)
Castile and Leon (Ref.: Andalusia)	0.000	0.000
	(0.001)	(0.001)
Catalonia (Ref.: Andalusia)	-0.000	0.000
	(0.001)	(0.001)
Galicia (Ref.: Andalusia)	0.001	0.001**
	(0.001)	(0.000)
La Rioja (Ref.: Andalusia)	0.001	-0.000
	(0.001)	(0.000)
Madrid (Ref.: Andalusia)	0.001*	0.001
	(0.001)	(0.000)

(*Continued*)

Variables	OLS	Student FE
Murcia (Ref.: Andalusia)	0.001	-0.000
	(0.001)	(0.001)
Navarre (Ref.: Andalusia)	0.002**	-0.001
	(0.001)	(0.001)
Basque Country (Ref.: Andalusia)	-0.001	-0.000
	(0.001)	(0.000)
Ceuta and Melilla (Ref.: Andalusia)	0.007***	0.001
	(0.001)	(0.001)
Constant	0.003	0.436***
	(0.120)	(0.044)
Observations	36,669	36,669
R-squared	0.080	0.874

Notes: Standard errors in parentheses. The procedures suggested by PISA (OECD, 2009) to deal with its data have been applied. In the OLS estimation AACC controls have been included.
Estimation method: OLS and student fixed effects.
Dependent variable: Standardised scores in reading, mathematics and science in PISA 2009.
*Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.*
Source: Authors' own calculations.

5.2. Robustness checks

Once obtained the main conclusions of this research, the robustness of these results is checked. In this sense, the lack of effect of weekly instruction time may be conditioned by the socio-economic status of students, which could be averaging the effects of instruction time of low and high socio-economic status to get a neutral effect. Because of that, we have replicated in Table 4 the base model by dividing the sample according to the socio-economic status of students. In order to do that, we have made use of the index of economic, social and cultural status (ESCS) provided by PISA 2009 and divided it in three quantiles (terciles), estimating one specification for each one. The results obtained show that the lack of effect of weekly instruction time is the same for the three ESCS terciles, confirming the robustness of our main results.

The next robustness check consisted of dividing the sample into three groups of AACC according to the relative –in relation to the AACC under analysis– at risk of poverty rate they had in 2009 –following each AACC at poverty risk rate provided by INE (2017) for this year– in order to check if the effect of weekly instruction time on academic achievement is different depending on the relative at risk of poverty group in which the AACC is located, so considering all the AACC under analysis in the same regression could be compensating its different effects in each group. The results of this checking are presented in Table 5. As it can be appreciated, the absence of effect still appears in the three at risk of poverty groups, what confirms again the robustness of this lack of effect of weekly instruction time on academic achievement.

Table 4
ESTIMATED EFFECT OF INSTRUCTIONAL TIME ON TEST SCORES BY ESCS TERCILE

Variables	Low ESCS Student FE	Medium ESCS Student FE	High ESC Student FE
Weekly minutes of instructional time	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Subject: Reading (Ref.: Science)	0.054**	0.022	-0.008
	(0.022)	(0.021)	(0.023)
Subject: Maths (Ref.: Science)	0.050*	-0.005	-0.006
	(0.026)	(0.020)	(0.022)
Constant	0.188***	0.422***	0.722***
	(0.068)	(0.067)	(0.075)
Observations	12,237	12,216	12,216
R-squared	0.870	0.859	0.865

Notes: Standard errors in parentheses. The procedures suggested by PISA (OECD, 2009) to deal with its data have been applied.
Estimation method: Student fixed effects.
Dependent variable: Standardised scores in reading, mathematics and science in PISA 2009.
*Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.*
Source: Authors' own calculations.

Table 5
ESTIMATED EFFECT OF INSTRUCTIONAL TIME ON TEST SCORES BY AACC RELATIVE AT RISK OF POVERTY GROUP

Variables	Higher relative at risk of poverty group Student FE	Medium relative at risk of poverty group Student FE	Lower relative at risk of poverty group Student FE
Weekly minutes of instructional time	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)
Subject: Reading (Ref.: Science)	-0.016	0.069***	0.020
	(0.027)	(0.026)	(0.013)
Subject: Maths (Ref.: Science)	-0.041	0.030	0.142***
	(0.027)	(0.027)	(0.015)
Constant	0.364***	0.459***	0.549***
	(0.079)	(0.090)	(0.047)

(*Continued*)

Variables	Higher relative at risk of poverty group Student FE	Medium relative at risk of poverty group Student FE	Lower relative at risk of poverty group Student FE
Observations	9,693	8,799	18,177
R-squared	0.875	0.871	0.871

Notes: Standard errors in parentheses. The procedures suggested by PISA (OECD, 2009) to deal with its data have been applied. Higher relative at risk of poverty group: Ceuta and Melilla, Canary Islands, Murcia, Andalusia, Galicia; Medium relative at risk of poverty group: Castile and Leon; Balearic Islands, La Rioja, Madrid, Catalonia; Lower relative at risk of poverty group: Cantabria, Asturias, Aragon, Basque Country and Navarre.
Estimation method: Student fixed effects.
Dependent variable: Standardised scores in reading, mathematics and science in PISA 2009.
*Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.*
Source: Authors' own calculations.

Furthermore, the ability grouping of students by schools may be conditioning the results obtained, so not distinguishing sorted students from those who are not may be causing the compensation of the effect of weekly instruction time and, hence, providing its neutral effect. Concretely, students whose schools sort them following an ability criterion may be offering different amounts of instruction time per week to each of the ability groups, in order to provide more advantaged students with more instruction time or, on the contrary, providing less ability students with more instruction time. Because of that, we have replicated the base model by dividing the sample of Spanish students according to the grouping policies applied in their schools: grouping students by ability into different classes, grouping by ability within their classes or not grouping students by ability. Results are presented in Table 6. A simple descriptive analysis shows that, regardless of their grouping, students report approximately 190 minutes per week of instruction time in reading, 200 in mathematics and almost 240 in science. From the view of these figures we may expect that this grouping does not influence the obtained lack of effect of weekly instruction time on academic achievement, but –nevertheless– we performed the corresponding estimations to check this hypothesis.

Moreover, in these estimations –reported in Table 6– weekly instruction time was included as self-reported by students, instead of using the school average of these answers, so we can account for the fact that the differences in students' self-reported weekly instruction time within the same school may be caused by their attendance to different ability classes. Results show that the effect of weekly instruction time is not significant for the three grouping options, so ability grouping differences in weekly instruction time do not seem to condition the conclusions obtained for the whole sample. We can also conclude that averaging weekly instruction time by schools is not biasing the obtained results, what lets us avoid the potential bias due to students not remembering instruction time per week properly or due to their absenteeism –although we cannot check for the latter due to limitations of the data, as previously mentioned, this should not be a problem, as the attendance to tenth grade is compulsory in Spain–.

Table 6
ESTIMATED EFFECT OF INSTRUCTIONAL TIME ON TEST SCORES CONDITIONED ON SCHOOL GROUPING BY ABILITY

Variables	Grouping by ability into different classes Student FE	Grouping by ability within classes Student FE	Not grouped by ability Student FE
Weekly minutes of instructional time	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Subject: Reading (Ref.: Science)	0.017	0.041*	0.021
	(0.021)	(0.024)	(0.018)
Subject: Maths (Ref.: Science)	0.020	0.036	-0.004
	(0.025)	(0.031)	(0.022)
Constant	0.370***	0.387***	0.469***
	(0.056)	(0.057)	(0.035)
Observations	13,254	11,589	16,890
R-squared	0.869	0.875	0.874

Notes: Standard errors in parentheses. The procedures suggested by PISA (OECD, 2009) to deal with its data have been applied. The sum of the number of observations of all specifications differs from the total amount of observations because schools can use more than one ability grouping criterion, and this grouping variable also has missing observations. The variable "weekly minutes of instruction time" has been included as self-reported by students, rather than as school average of students' answers.
Estimation method: Student fixed effects.
Dependent variable: Standardised scores in reading, mathematics and science in PISA 2009.
*Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.*
Source: Authors' own calculations.

The null effect of weekly instruction time on academic achievement may also be due to a specification error as consequence of using a linear equation, so we have checked –in Table 7– whether results change when including weekly instruction time in four different non-linear forms to check if students' decreasing attention affects this lack of effect (Bunce *et al*., 2010): as a squared term, dividing its distribution in three similar shares, dividing it into complete hours and, finally, decomposing it in the number of lessons per week and minutes per lesson –using the school average for them–. The results obtained show the lack of effect of weekly instruction time on academic achievement for all these specifications.

Finally, school quality may be conditioning the effect of instruction time per week on academic achievement, as the quantity of instruction time per week may be less relevant than its quality (Baker *et al*., 2004; Mullis *et al*., 2012; OECD, 2013; Gromada and Shewbridge, 2016). Because of that, we have made use of three quality-related indexes which OECD elaborate from school principals' answers to school questionnaires. These indexes are "quality of the school educational resources", "student-related aspects of school climate" –which we will call "student behaviour"– and "teacher-related factors affecting school climate" –which we will call "teacher behaviour"–[30]. These indexes have been interacted with weekly instruction time in order to get their effect on this variable. Although controlling for the proportion of teachers with ISCED 5a level of studies in the school could be interesting –which is provided by school principals in PISA–, in the case of Spain all teachers have this level, and we do not have information about whether they have ISCED 6 or not, so we cannot control the quality of teachers in this additional way.

Table 7
ESTIMATED EFFECT OF INSTRUCTIONAL TIME ON TEST SCORES CONDITIONED ON SCHOOL GROUPING BY ABILITY

Variables	Specification (I) Student FE	Specification (II) Student FE	Specification (III) Student FE	Specification (IV) Student FE
Weekly minutes of instructional time	-0.000 (0.001)			
Squared weekly minutes of instructional time	0.000 (0.000)			
Weekly minutes of instructional time (distribution)				
More than 198 to 218 (Ref.: 198 or less)		-0.011 (0.017)		
More than 218 (Ref.: 198 or less)		-0.005 (0.018)		
Weekly minutes of instructional time (complete hours)				
181 to 240 (Ref.: 180 or less)			0.018 (0.016)	
241 or more (Ref.: 180 or less)			0.005 (0.027)	
Number of lessons per week				0.007 (0.011)
Minutes per lesson				-0.005 (0.011)
Subject: Reading (Ref.: Science)	0.024* (0.014)	0.020 (0.014)	0.018 (0.013)	0.025* (0.014)
Subject: Maths (Ref.: Science)	0.015 (0.015)	0.011 (0.015)	0.008 (0.015)	0.016 (0.015)
Constant	0.450*** (0.126)	0.459*** (0.025)	0.444*** (0.028)	0.676 (0.621)

(*Continued*)

Variables	Specification (I) Student FE	Specification (II) Student FE	Specification (III) Student FE	Specification (IV) Student FE
Observations	36,669	36,669	36,669	36,669
R-squared	0.874	0.874	0.874	0.874

Notes: Standard errors in parentheses. The procedures suggested by PISA (OECD, 2009) to deal with its data have been applied.
Estimation method: Student fixed effects.
Dependent variable: Standardised scores in reading, mathematics and science in PISA 2009.
*Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.*
Source: Authors' own calculations.

The results for the estimations controlling by school quality are presented in Table 8. It can be appreciated that only the interaction of weekly instruction time with the index of student behaviour –specification II– has a significant and positive effect on academic achievement, but this effect is almost zero, so none of the school quality controls seem to interact with weekly instruction time in a relevant way. When including these three indexes together in the same specification –specification IV– we obtained the same results and conclusions as when included alternatively, what can be taken as proof of the absence of multicollinearity problems between them. These results could be highlighting that the quality of this instruction time –in terms of the available control variables– does not influence the lack of effect of weekly instruction time on academic achievement.

Table 8
ESTIMATED EFFECT OF INSTRUCTIONAL TIME ON TEST SCORES IN RELATION WITH SCHOOL QUALITY

Variables	Specification (I) Student FE	Specification (II) Student FE	Specification (III) Student FE	Specification (IV) Student FE
Weekly minutes of instructional time	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
(Weekly minutes of instructional time)x(Index of the quality of the school educational resources)	0.000 (0.000)			0.000 (0.000)
(Weekly minutes of instructional time)x(Index of student behaviour)		0.000* (0.000)		0.000** (0.000)
(Weekly minutes of instructional time)x(Index of teacher behaviour)			-0.000 (0.000)	-0.000 (0.000)
Subject: Reading (Ref.: Science)	0.026* (0.014)	0.025* (0.014)	0.025* (0.014)	0.027* (0.014)
Subject: Maths (Ref.: Science)	0.016 (0.015)	0.016 (0.015)	0.015 (0.015)	0.017 (0.015)

(*Continued*)

Variables	Specification (I) Student FE	Specification (II) Student FE	Specification (III) Student FE	Specification (IV) Student FE
Constant	0.427*** (0.048)	0.427*** (0.046)	0.428*** (0.047)	0.414*** (0.046)
Observations	36,555	36,669	36,669	36,555
R-squared	0.873	0.874	0.874	0.873

Notes: Standard errors in parentheses. The procedures suggested by PISA (OECD, 2009) to deal with its data have been applied. The number of observations in specifications I and IV differs from the total due to missing observations of the additional variables included.
Estimation method: Student fixed effects.
Dependent variable: Standardised scores in reading, mathematics and science in PISA 2009.
*Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.*
Source: Authors' own calculations.

Furthermore, robustness checks analysing the effect of weekly instruction time on students' academic achievement dividing the sample according to students' sex, father's level of education and mother's level of education, alternatively, have been performed, and our results hold. These estimations are available from authors upon request.

6. Conclusions

Education has been found to widely affect the economic behaviour of households and, then, the aggregate economy, being crucial to sustain the welfare state (Abío *et al.*, 2017). However little is known on the causal impact of some key characteristics of the education system on the performance of Spanish students. This is the case of the potential effect of instruction time, which has received very scarce attention in the context of the Spanish educational system.

This research attempts to overcome this by using the heterogeneity in the amount of weekly instruction time of three subjects to accomplish a twofold aim: to check whether or not instructional time has an effect on 15 year-old Spanish students' academic achievement and if this potential effect could be different depending on the Autonomous Community under analysis. The use of student fixed effects has let us isolate the effect of weekly instruction time on students' academic achievement. Results have shown that weekly instruction time does not have influence on academic achievement in Spain and that this conclusion holds for all the Spanish AACC under analysis. Many robustness checks have been performed and results remain the same, what reinforces the conclusions obtained.

Building on these results, the relevance of weekly instruction time has been studied not only in the sense of its quantity, but in that of its quality, concretely, in relation to some school quality indexes; nevertheless, we found that none of them interacted in a relevant way with weekly instruction time. However, although this research may be some kind of replication of Cattaneo *et al*. (2017), but for the Spanish case and its Autonomous Communities, the obtained results are far more different to theirs. In this sense, this lack of effect of weekly instruction time that we have found seems to contradict their results and those obtained by other researchers using PISA data and student fixed effects (Lavy, 2015; Rivkin and Schiman, 2015) as they found a positive effect of instruction time on academic achievement. Hence, we have to bear in mind that the focus of the current research is different from that in these researches (and thus, where it novelty lies): the casuistry of the Spanish education system. Because of that, the obtained conclusions in this kind of research cannot be generalised to other countries. This also warns about the performance of this kind of analysis for a pooled group of countries, alerting about the relevance of controlling by country in order to get non-biased results. These results are of special relevance for Spain in terms of Public Economics and Education legislation as, e.g., for the implementation of education laws as the new Spanish education law *Ley Orgánica para la Mejora de la Calidad Educativa* (LOMCE; BOE, 2013), which changed the distribution of instruction time in different subjects; particularly, this law increased the instruction time on supposedly "important" subjects (i.e., reading, mathematics and science, which have been the focus of the current research) and reduced the time on the "distracting" ones[31]. Our results hence highlight the need to make a previous evaluation before the implementation of education laws; otherwise, these laws can suppose an expense of money, time and effort, without potential impact on students' academic achievement, as it seems it would happen when increasing the instruction time in these "important" subjects. Nevertheless, education laws as LOMCE can also modify other aspects of education, besides from weekly instruction time (Fernández-Santos *et al*., 2013), as e.g. evaluation methods, the content of the subjects, academic track options, etc., which can potentially affect students' academic achievement. Because of that, it is necessary to be cautious and evaluate these and many other aspects of education laws before implementing some kind of policy based on the results obtained in the current research.

Furthermore, our results can be taken as indicative that the common practice in Spain of providing students with a high amount of instructional time during their school-day may not be profitable for their learning. This has relevance in terms of Public Economics to the extent that, following PISA 2009, 69.1% of secondary education Spanish schools are publicly funded, 25.7% are semi-private and only 5.2% are private, so most of the policy interventions derived from the current research have to be funded by the Spanish public sector. In this sense, regarding to the allocation of public education resources, to the extent that the increase of instruction time per week supposes an increase in the public costs of education in pecuniary terms (Gromada and Shewbridge, 2016) this would mean a waste of public resources. Besides, this would also mean a waste of resources in terms of time as, e.g., due to the trade-off between the amount of instruction time per week devoted to different relevant subjects or students' trade-off in their use of free time for study or for leisure.

Additionally, one plausible explanation for this null effect of instruction time can derive some Public Economic implications. This likely explanation is that this null effect might be rooted in the way that students are receiving their learning: basically, PISA measures students' skills and competences in the subjects under analysis, whereas Spanish education seems to be more content-based knowledge as, e.g., pure memorization of contents, low real-life applicability of the lessons' knowledge, etc. (Ananiadou and Claro, 2009; INEM, 2009; Pamies *et al*., 2015). This means that, besides from the weekly instruction time conclusions derived from the current research, Spanish public education sector has a high responsibility in investing and increasing the funding in improving teachers' formation on competence-teaching and turning the curriculum to a more competence-focused. What is more, these competences are not only necessary for the population's daily-life, but they are also demanded and required in the labour market (Pamies *et al*., 2015).

However, in spite of the high amount of class time that Spanish students are receiving nowadays, many working parents find this useful as they avoid their children being alone while they are working (Belle, 1999). According to our results, this higher amount of weekly instruction time which serves as a "kindergarten service" for parents does not seem to benefit students' academic achievement, so a better offer of extracurricular activities by schools may be an alternative for this higher class time. As students will not benefit from extracurricular activities related to the subjects they are coursing –to the extent that this supposes higher weekly instruction time on them–, these activities could be oriented to improve their competences in other fields which are not –usually– taught at school.

Another relevant conclusion of this research is to alert about the use of PISA 2012 for this kind analysis due to only two-thirds of the students' sample answering the questions related to weekly instruction time. This could also be extended to analyses which use any other student variable of the rotated part of the questionnaire.

To conclude, as it has been indicated, although PISA is the best source of information we can get to analyse this issue for Spain, this data is not free of limitations. As previously highlighted, the use of self-reported weekly instruction time presents some problems, which have been addressed and shown that they do not seem to meaningfully affect our results. Furthermore, the lack of availability of more precise school or teacher variables does not let go deeper in the determinants of this lack of effect of weekly instruction time and the role that some aspects of education quality could have as, e.g., teachers' practices in lessons.

Finally, it is important to have into account that all the results presented in this research are applicable to Spain, so these results may substantially vary depending on the country –or countries– under analysis. All in all, the results presented here provide an empirical evidence of something that Spanish media has highlighted: in the case of instruction time, the more not always means the better.

APPENDIX

Table A1
ESTIMATED EFFECT OF INSTRUCTIONAL TIME ON TEST SCORES CONDITIONED ON SCHOOL GROUPING BY ABILITY

Variables	Reading	Mathematics	Science
Weekly minutes of instructional time in reading	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)
Weekly minutes of instructional time in mathematics	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)
Weekly minutes of instructional time in science	0.001***	0.001**	0.001**
	(0.000)	(0.000)	(0.000)
Aragon (Ref.: Andalusia)	0.311***	0.442***	0.336***
	(0.060)	(0.073)	(0.075)
Asturias (Ref.: Andalusia)	0.271***	0.257***	0.298***
	(0.090)	(0.090)	(0.113)
Balearic Islands (Ref.: Andalusia)	-0.017	0.049	-0.067
	(0.074)	(0.085)	(0.083)
Canary Islands (Ref.: Andalusia)	-0.004	-0.233***	-0.053
	(0.074)	(0.078)	(0.084)
Cantabria (Ref.: Andalusia)	0.197***	0.290***	0.290***
	(0.069)	(0.075)	(0.080)
Castile and Leon (Ref.: Andalusia)	0.356***	0.494***	0.414***
	(0.065)	(0.078)	(0.078)
Catalonia (Ref.: Andalusia)	0.292***	0.257***	0.264***
	(0.066)	(0.078)	(0.090)
Galicia (Ref.: Andalusia)	0.394***	0.390***	0.571***
	(0.077)	(0.093)	(0.104)
La Rioja (Ref.: Andalusia)	0.411***	0.493***	0.444***
	(0.070)	(0.080)	(0.087)
Madrid (Ref.: Andalusia)	0.406***	0.338***	0.402***
	(0.078)	(0.088)	(0.105)
Murcia (Ref.: Andalusia)	0.186***	0.164**	0.142**
	(0.060)	(0.066)	(0.070)
Navarre (Ref.: Andalusia)	0.228***	0.440***	0.323***
	(0.068)	(0.074)	(0.087)
Basque Country (Ref.: Andalusia)	0.175***	0.364***	0.087
	(0.055)	(0.068)	(0.068)
Ceuta and Melilla (Ref.: Andalusia)	-0.340***	-0.328***	-0.351**
	(0.118)	(0.113)	(0.144)

(*Continued*)

Variables	Reading	Mathematics	Science
Female student (Ref.: Male student)	0.224***	-0.293***	-0.210***
	(0.020)	(0.021)	(0.023)
First generation immigrant student (Ref.: Native student)	-0.436***	-0.483***	-0.466***
	(0.055)	(0.064)	(0.062)
Second generation immigrant student (Ref.: Native student)	-0.210	-0.102	-0.247*
	(0.138)	(0.130)	(0.144)
Index of Economic, Social and Cultural Status (ESCS) of the student	0.124***	0.142***	0.171***
	(0.012)	(0.012)	(0.013)
Public school (Ref.: Private school)	-0.043	0.054	-0.000
	(0.074)	(0.080)	(0.083)
Private government-dependent (Ref.: Private school)	-0.032	-0.024	-0.029
	(0.077)	(0.084)	(0.086)
School Index of Economic, Social and Cultural Status (ESCS)	0.165***	0.122***	0.126***
	(0.033)	(0.043)	(0.040)
Constant	-0.400*	-0.173	-0.289
	(0.238)	(0.288)	(0.304)
Observations	12,223	12,223	12,223
R-squared	0.186	0.209	0.194

Notes: Standard errors in parentheses. Estimations have been weighted and standard errors are clustered by school.
Estimation method: Seemingly unrelated regression (SURE).
Dependent variable: Standardised average scores of the five plausible values for the corresponding competence in PISA 2009: reading, mathematics and science.
*Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.*
Source: Authors' own calculations.

Table A2

DESCRIPTIVE STATISTICS OF SCORES AND WEEKLY INSTRUCTION TIME FOR PISA 2009 BY AUTONOMOUS COMMUNITY FOR THE SAMPLE UNDER ANALYSIS

Autonomous Community	Obs.	Scores in						Weekly minutes of instruction in					
		Reading		Mathematics		Science		Reading		Mathematics		Science	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Andalusia	673	504.79	3.98	507.76	4.40	511.01	4.88	186.63	2.25	229.98	1.08	271.28	10.04
Aragon	799	535.60	3.41	550.66	5.59	542.94	4.01	207.38	1.37	206.61	1.27	232.78	10.17
Asturias	898	528.71	5.32	533.70	4.88	537.24	5.55	216.71	1.67	171.74	1.62	216.18	6.82
Balearic Islands	490	503.04	6.94	508.70	5.04	502.52	5.84	166.20	0.87	216.62	1.55	244.60	10.95
Canary Islands	561	492.59	4.63	476.87	4.73	494.91	4.34	216.51	1.76	216.37	1.69	216.53	5.47
Cantabria	841	525.98	4.48	537.19	5.13	539.52	4.69	209.48	1.95	207.29	2.21	227.81	7.71
Castile and Leon	723	542.06	5.16	557.89	5.59	552.15	5.32	206.73	1.42	206.93	1.55	249.71	7.35
Catalonia	540	525.30	5.75	523.95	7.24	526.28	6.85	174.79	1.28	185.12	4.07	234.47	10.58
Galicia	853	528.21	4.07	529.88	3.63	545.76	4.41	153.34	1.66	157.07	1.26	201.60	7.66
La Rioja	570	543.93	3.59	556.27	4.10	553.31	3.80	207.01	0.28	208.27	0.32	234.18	1.48
Madrid	610	546.37	4.50	541.62	5.16	549.01	5.01	210.83	2.11	185.42	3.82	244.18	8.01
Murcia	567	518.55	4.87	521.59	4.71	521.23	4.81	215.41	0.75	214.86	0.65	243.56	9.03
Navarre	716	529.97	3.14	554.84	2.62	545.95	3.57	214.57	0.92	209.68	1.82	239.65	4.98
Basque Country	2,805	523.52	2.46	541.99	2.28	521.11	2.11	195.42	1.66	210.64	1.73	214.80	3.03
Ceuta and Melilla	577	470.37	3.42	475.11	3.68	475.50	3.83	205.05	0.19	207.26	0.23	190.59	0.76
Spain	**12,223**	**522.53**	**1.80**	**525.66**	**1.99**	**527.97**	**2.06**	**192.55**	**0.87**	**202.47**	**1.03**	**241.45**	**3.28**

Notes: The procedures suggested by PISA (OECD, 2009) to deal with its data have been applied. Weekly instruction time has been calculated by using average instruction time per week by school. "Obs." stands for Observations and "SE" stands for "Standard error".

Notes

1. We report the figures of 2009 for consistency with the main PISA year analysed in this research. The discussion on why we consider this our main year of research is explained in the "Methodology and identification strategy" section.
2. This is the average for reading, mathematics and science competencies.
3. Although related to higher education, Rosselló-Villalonga (2017) stated that this decentralization in the provision of education would increase education quality.
4. According to the Autonomy Statute of each Spanish AACC "It is the full competence of the corresponding Autonomous Community to regulate and manage education in all its extension, levels and grades, modalities and specialities, without detriment of that established by the constitutional precepts in this subject, of the Organic Laws which develop them and of the State competences in what refers to the regulation of the conditions of obtaining, expedition and homologation of the academic and professional titles and of the high inspection of the State for its accomplishment and guarantee".
5. In order to analyse this, we have performed a literature review of 5 relevant journals (*Economics of Education Review, The Economic Journal, Education Economics, The Journal of Human Resources* and *Revista de Educación*) searching for published research which employed PISA data for Spain since the year 2005. We found in these journals that only 24 papers dealt with Spanish PISA data and only 4 of them analysed or mentioned the effect of instruction time on students' academic achievement to some extent –although as a control variable and not as the main aim of the research; furthermore, the obtained effect for this instruction time could not be considered as causal–. This literature analysis will be provided upon request to the authors.
6. Concretely, the questions asked in PISA 2009 are: ST28 (Q1-Q3) "How many minutes, on average, are there in a <class period> for the following subjects?" and ST29 (Q1-Q3) "How many <class periods> per week do you typically have for the following subjects?", where students can answer about reading, mathematics and science separately. The combination of these two questions let to obtain the variables "lmins" –for reading–, "mmins" –for mathematics– and "smins" –for science–, which are provided by PISA and indicate the minutes of instruction that students report for the current course, being these derived variables the focus of our analysis.
7. Following Rivkin and Schiman (2015, p. F427) "We focus on mathematics and language arts because the quality of mathematics education is likely to affect performance in the science examination". In order to check for this, we replicated our base model based only on reading and mathematics subjects, and our results hold. These estimations are available upon request to the authors.
8. According to OECD (2014), rotation was firstly introduced in PISA 2012 for students' questionnaire, with the objective of increasing its content coverage without increasing the time of the questionnaire more than the 30 minutes employed in previous cycles of PISA. This rotation means that the students' questionnaire was composed by a common part –answered by all students, which consisted of questions related to gender, language at home, immigrant status and ESCS– and a rotated part –composed by three sets of questions, of which students were randomly assigned to answer two–. This rotation was not used before as it required a previous check on the impact of this procedure and about the continuity of the results.
9. In PISA 2006 the data on instruction time were categorised and not continuous; PISA 2003 contained a question on instruction time in weekly minutes only for mathematics and PISA 2000 did not contain any question in weekly minutes about it.
10. The estimations of the base model have been replicated using both non-repeaters and repeaters and the results did not change. These estimations are available upon request to the authors.
11. OECD (2011b) reported that in many countries, including Spain, science is not a compulsory subject for tenth grade students. This is due to the optional character that sciences had in the Spanish education legislation –LOE (BOE, 2006)–, being likely that this is the reason why there are some students who reported 0 minutes per week of science. This could lead to biased results as the education production function of the later students may be different from that of those students who are attending science subjects. However, the estimations of

the base model have been replicated using those students who have 0 minutes per week of instruction in science and our base model results hold. These estimations are available from authors upon request.

12. The estimations of the base model have been replicated including those students who reported zero or missing minutes of weekly instruction time in any of the three subjects –imputing them the average instruction time of their school by subject– and our main results did not change. These estimations are available upon request to the authors.
13. In the case of science, as it gathers many subjects –physics, chemistry, biology, earth and space science, and technology (OECD, 2012)–, a number of lessons higher than 1 per week is not considered an outlier case.
14. For more information on the content of the booklets see OECD (2012, p. 30) for PISA 2009. In OECD (2009) information about the imputation process followed by PISA is available.
15. Nevertheless, as a robustness check, we replicated our base model keeping only those students who took three-subject booklets (reading, mathematics and science) and our results hold. Furthermore, we replicated the current analysis but only for the reading and mathematics subjects and for those students who took the two-subject booklets of reading and mathematics, and our main results also hold. These estimations are available from authors upon request.
16. Out of the 18 AACC in PISA 2009 only Castile-La Mancha, Extremadura and Valencia did not extend their sample [Ministerio de Educación, Cultura y Deporte (MECD), 2010].
17. Following the education law applied from 2006 to 2014 –LOE, Organic Law 2/2006 (BOE, 2006)–, articles 6.4 and 120, Spanish schools have autonomy (subject to certain limitations of the Spanish Government and the Education Administrations about the minimum number of instruction hours) to set the instruction time per week of the subjects taught in their centres. Hence, joined to the heterogeneity in weekly instruction time for each subject of Spanish AACC (due to their education autonomy), this would support the existence of higher heterogeneity due to the differences in instruction time of the schools in each AACC.
18. There are previous research works which have used student fixed effects within-student between-subjects to analyse the effect of instruction time on students' academic achievement for PISA (Cattaneo *et al*., 2017; Lavy, 2015; Rivkin and Schiman, 2015). However, the latter two did not make use of PISA recommended practices when dealing with its data.
19. To estimate student fixed effects, we have appended students' information three times, one per subject. As it could be expected, it is not necessary to control by the variables in equation (1) which are fixed within-student between-subjects when estimating the base model.
20. We have calculated the average by school of the self-reported weekly instruction time by students as Lavy (2015) and Rivkin and Schiman (2015) did, because the use of self-reported weekly instruction time may be subject to problems as, for example, the difficulty for students to recall the number of weekly lessons or instruction time per lesson, more than due to absenteeism (which should not be a problem, as secondary education is compulsory in Spain) or other reasons. Estimations in the base model of our research were replicated by the use of the self-reported weekly instruction time by students and results hold, so the use of the school average of self-reported students' answers may not be biasing the results. The results of estimating these specifications are available from authors upon request.
21. Cattaneo *et al*. (2017) used students' self-reported and official instruction time; however, both raised issues, as the first one may be subject to measurement errors and recall bias, while the latter may not show the reality in schools. Unfortunately, we cannot do a similar analysis, as the Spanish Government stopped publishing each AACC hours of instruction by subject in its annual reports since the change of the education law in 2006 to LOE –the one in which PISA 2009 was conducted– (MECD, 2009, pp. 170). Because of that, PISA information on weekly instruction time is the best one we can get to study the current issue for Spain and its AACC.
22. To contrast this hypothesis it is necessary, for each s^{th} specification, to check whether the $k{\neq}s$ pair of φ_k are equal, i.e., $\varphi_2=\varphi_3$ for equation s=1; $\varphi_1=\varphi_3$ for equation s=2; $\varphi_1=\varphi_2$ for equation s=3. Once these three hypothesis have been accepted, we can accept by transitivity that $\varphi_1=\varphi_2=\varphi_3=\varphi$.
23. This hypothesis is contrasted by obtaining the net effect of β_s from the term $(\beta_s+\varphi_s)$ for each s^{th} subject under analysis. If we call $\theta_s=\beta_s+\varphi_s$, this is done by subtracting from each of the s^{th} θ_s coefficients the effect of the

correspondent φ_s from each one of the k^{th} specifications (being $k \neq s$). For example, for specification s=1, we obtain β_1 by subtracting from θ_1 in this specification the coefficient of φ_1 in specification s=2 and φ_1 in specification s=3, and so on for s=2,3. Once the net effect of each β_s has been obtained we can contrast $\beta_1=\beta_2=\beta_3$.

24. The Balanced Repeated Replication (BRR) weights (to account for students being clustered at school level) were not applied in these estimations as BRR weights are not compatible with seemingly unrelated regression (SURE) methodology. Because of that, we have clustered standard errors by school, which provides similar results to applying BRR weights

25. This may be the effect of having only two-thirds of the sample in PISA 2012 (as previously described). This was warned by OECD (2014, pp. 378-384), as PISA relies in strict sampling procedures which require at least 30 students per school. This sampling reduction would mean less accuracy on the results obtained and an artificial increase in standard deviations, which would be different depending on the country. This issue is so problematic that OECD decided not to impute the values of these one-third variables not answered by students (OECD, 2014, pp. 382-384).

26. It is important to highlight that these statistics differ from those reported in OECD (2010) and MECD (2010) for Spain and Spanish AACC as we have dropped from our sample those students who can potentially bias our results, as indicated in the "Data" section.

27. In PISA 2009 the Spanish mean score in reading was 481 (SD 88); in mathematics 483 (SD 91) and in science 488 (SD 87), OECD (2010).

28. When an interaction of subject and Autonomous Community fixed effect have been included to control for regional policies and practices regarding curriculum which can affect one subject but not the other, our null effect results hold. These estimations are available from authors upon request.

29. Our base model estimations have also been replicated dividing the sample by Autonomous Community and the null effect of weekly instruction time on students' academic achievement holds. These estimations are available from authors upon request.

30. These indexes have been created by the OECD using school principals' answers about their agreement with some statements on each particular subject of the index. Information on the creation of these indexes and the questions used for each one of them in PISA 2009 can be found in PISA 2009 Technical Report (OECD, 2012).

31. Some news on this issue can be found in https://elpais.com/sociedad/2012/09/02/actualidad/1346620941_402605.html or https://elpais.com/sociedad/2012/09/30/actualidad/1349022252_108236.html)

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Resumen

Esta investigación estudia si el tiempo de instrucción semanal recibido por los estudiantes españoles de 15 años realmente afecta a su rendimiento académico y si este efecto difiere por Comunidades Autónomas. Los efectos fijos por estudiante entre asignaturas permiten separar de otras covariables este efecto del tiempo de instrucción. Los resultados muestran que no existe efecto significativo del tiempo de instrucción sobre el rendimiento académico, extendiéndose esto a las Comunidades Autónomas analizadas. Este resultado sugiere que una evaluación previa del tiempo semanal de clase fijado por la ley española de educación de 2013 habría sido necesaria antes de su implementación.

Palabras clave: elección de colegios, experimento de elección discreta, modelo logit mixto.

Clasificación JEL: I20, I21, I28