More class time, better achievement?

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Abstract

Spanish press has widely criticized the fact that students spend almost their whole day at school, a practice rooted in the common belief that higher instruction time enhances students' learning. However, in spite of this high amount of instruction time that Spanish students are receiving, their results do not seem to outstand in comparison with other countries with similar or lower instruction time.

In this context, this research intends to accomplish two main objectives: the first one is to check if the amount of instruction time received by 15 year-old Spanish students actually affects their academic achievement. The second one intends to analyse if this potential influence of instruction time may be affecting Spanish Autonomous Communities in different ways, as each one is responsible for setting instruction time in its own region. In order to accomplish these objectives, the methodology employed let us isolate the effect of instruction time from other covariates by using students' fixed effects by subject, using PISA 2009 and 2012 data. Results have shown that there is not any effect of instruction time on academic achievement, being this conclusion extended to every Autonomous Community in Spain. Further checks have corroborated the robustness of these results and have also highlighted that the effect of instruction time is a question of quality more than quantity, as students' engagement and the classroom climate during lessons may be causing differences in academic achievement, rather than the amount of instruction time *per se*.

Keywords instruction time; student fixed effects; secondary education; Autonomous Communities; Spain.

JEL Codes I20; I21; I28

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1. Introduction

The high amount of instruction time that Spanish students are receiving each course has been widely criticised by the Spanish press during the last years. The idea behind this high number of instruction hours is based on the common belief that a higher amount of them will be directly translated 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 does not seem to happen in the case of Spanish students in relation to students of other countries. According to OECD (2011a), 15 year-old Spanish students received a total of 1,050 hours of instruction time in 2009 and got a score of 481 in reading, 483 in mathematics and 488 in science in PISA 2009 (OECD, 2010). Nevertheless, there are numerous cases of countries whose students have a lower amount of instruction hours per year but they outperform Spanish students in the competences evaluated by PISA, e.g., Finland, with a total of 856 hours of instruction for 15 year-old students in 2009 and scores of 536, 541 and 554 in PISA 2009 –for reading, mathematics and science, respectively– or Australia, with 964 hours of instruction in 2009 and scores of 515, 514 and 527 in PISA 2009 –in reading, mathematics and science, respectively–.

In spite of these differences between countries, there are research works which have stated the existence of an influence of instruction time on students' academic achievement. Lavy (2015) stated that higher instructional time had a positive effect on students' achievement in PISA 2006 for over 50 countries. Cattaneo, Oggenfuss, and Wolter (2016) 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. This result was also found by Rivkin and Schiman (2015) for 72 countries in PISA 2009 and Andersen, Humlum, and Nandrup (2016) for the United States. Walberg, Niemiec, and Frederick (1994) reviewed more than 100 studies and found that 88% indicated the existence of a positive relationship between instruction time and academic achievement. 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. 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– but it was stated that an increase in instruction time would not be the solution to low performance: it would be increasing the quality of lessons and teachers. Mullis, Martin, Foy, and Drucker (2012) also remarked the positive effect of instruction time and the importance of its effective use.

However, another strand of the literature indicates that instruction time does not have any effect on academic achievement, and that the later depends on other factors, like the quality of this instruction time. Baker, Fabrega, Galindo, and Mishook (2004) analysed almost 40 countries in PISA and TIMSS and found that there is low evidence of an increase of marginal 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. In this argument of the quality of instruction time Gromada and Shewbridge (2016) stated that, due to the high costs of increasing instruction time, one of the main priorities when increasing it is to assure that it is not lost and it is used effectively, by an improvement of teaching quality and classroom management, so instruction time can be translated into engaged time. 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. Woessmann (2010) studied education systems of 16 different states in Germany for three years and three subjects, applying a methodology which made unobserved factors related to the country to be erased. He found that instruction time does not have influence on academic achievement.

Thus, the relationship between instruction time and academic achievement may not be as obvious as it seems, what may be motivated to the great difficulty to isolate the effect of

instruction time from other characteristics which may be conditioning the conclusions obtained from its analysis, e.g. the quality of the curriculum, teacher quality and knowledge of the subject or school climate. Furthermore, instruction time may present non-linear effects on academic achievement, as e.g. decreasing marginal effects.

In this context, the objective of this research is twofold: firstly, we intend to analyse the potential effect –or absence of it– of the amount of instruction time on the academic achievement of 15 year-old Spanish students, using PISA 2009 and 2012 data. Secondly, we want to check whether the capacity that Spanish Autonomous Communities (AACC) have to set the amount of instruction time in their region, due to the transference of all the educative competences to them by the Spanish government, may be causing a differential effect –depending on the AACC– of this potential influence of instruction time on academic achievement. In this sense, according to the Autonomy Statute of Spanish AACC "It is the full competence of the Autonomous Community –name of the Autonomous Community– to regulate and manage education in all its extension, levels and grades, modalities and specialities, without detriment of that stablished 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"[3]. Hence, what this legal text indicates is that each Autonomous Community in Spain has the competence to set the number of hours of instruction for each subject that students have to take in the academic year.

To perform this research we have made use of the differences in instruction time by subject using student fixed effects, for three different subjects analysed by PISA (Programme for International Student Assessment): reading, mathematics and science. This procedure let us obtain the effect of instruction time on academic achievement considering the rest of variables constant across subjects, so results will not be influenced by other confounding factors which could bias the conclusions obtained.

The results of this research have shown that instruction time does not seem to affect 15 year-old Spanish students' academic achievement. What is more, this conclusion seems to be general for all the Spanish Autonomous Communities under analysis, as a similar absence of influence of instruction time on academic achievement is found for all of them. Further robustness checks have given strength to these conclusions and have also highlighted that it seems that it is not the quantity of this instruction time, but the quality, in terms of students' engagement and classroom climate, what determines the way students perform. This would lead to policy interventions related to assuring the quality of the instruction time offered by schools.

This research is structured as follows: in section 2 we present the data employed, in section 3 the methodology and identification strategy are commented, section 4 shows the main results of the analysis and section 5 concludes.

2. Data

In this research main dataset employed is that of PISA 2009. PISA main intention is to measure students' competences in reading, mathematics and science –which are the principal ones– of 15 year-old students, 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

[3] Legal text literally translated by authors from the general text of the Autonomy Statute of all Spanish AACC.

reading, mathematics and science[4], being this the main variable to employ in this analysis. However, as PISA 2009 is not the most recent cycle publicly accessible, we are going to cross-check our results by the use of PISA 2012, which contains a similar question about instruction time. However, its use has the drawback that, due to the rotation procedure used for students' questionnaire (OECD, 2014), only two-thirds of the sample answered the question related to instruction time. Because of that, our main results are based on PISA 2009 data, but we also used PISA 2012 as a robustness check to see if results are kept in more recent years. As in both years the same educative legislation was applicable "*Ley Orgánica de Educación*" (LOE) of 2006 (BOE, 2006), potential changes in the effect of instruction time may not be related to changes in the education legislation in Spain. Another positive fact of using PISA 2009 and 2012 is that it lets us obtain a continuous measure of instruction time in minutes –e.g., Lavy (2015) used PISA 2006 but the data on instruction time was categorised and not continuous, due to the structure of the question in PISA 2006; PISA 2003 contained a question on instruction time in minutes only for mathematics and PISA 2000 did not contain any question in minutes about it–. In PISA 2009 there are a total of 25,887 students in 889 schools and in PISA 2012 there are 25,313 students in 902 schools. These students are attending tenth grade, which is equivalent to the fourth and 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 including repeater students may affect the results obtained, as they may have different minutes of instruction due to their attendance to a different course –PISA is focused on students in 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 this), while in PISA 2012 they are 28.51% of the sample (0.79% do not have information about this).

For both datasets non-repeater students who had missing values for any of the minutes of instruction in 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 hours of instruction in reading and mathematics were also dropped from the analysis –as these are compulsory subjects in Spain (BOE, 2006), so this missing information would be the consequence of a reporting error–, together with those students who reported zero hours of instruction in sciences[5]. Students who were eliminated according to these two criteria of the instruction time variable were 22.77% in PISA 2009 and 49.59% in PISA 2012 –this high amount of eliminations is due to only two-thirds of the sample answering the question about instruction time–.

Finally, we focused this analysis on those Autonomous Communities which had an extended sample for the corresponding cycle of PISA. In this sense, in PISA 2009 Castile-La Mancha, Valencia and Extremadura did not extend their sample (MECD, 2010), while in PISA 2012, Castile-La Mancha, Ceuta and Melilla, Canary Islands and Valencia did not extend their

[4] 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. In the case of PISA 2012: ST69 (Q1-Q3) "How many minutes, on average, are there in a <class period> for the following subjects?" and ST70 (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. This combination of two questions let to obtain the variables "lmins", "mmins" and "smins" –provided by PISA–, which indicate the minutes of instruction that students report for the current course, being this the main variable of our analysis.

[5] OECD (2011b) reported that in many countries, including Spain, science is not a compulsory subject for 15 year-old students. This is due to the optional character that sciences had in the Spanish education legislation –LOE in 2009 and 2012 (BOE, 2006)–, being likely that this is the reason why there are some students who reported 0 hours 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 of instruction in science and results about instruction time did not change. These estimations will be provided from authors upon request.

sample (MECD, 2013). Because of that, we performed the estimations using those Autonomous Communities with extended sample which are common to both cycles, i.e., we did not include Castile-La Mancha, Ceuta and Melilla, Canary Islands, Valencia and Extremadura[6]. Hence, the final list of included Autonomous Communities is formed by Andalusia, Aragon, Asturias, Balearic Islands, Cantabria, Castile and Leon, Catalonia, Galicia, La Rioja, Madrid, Murcia, Navarre and Basque Country. This left us with a sample of 13,774 non-repeater students for PISA 2009 and 9,021 for PISA 2012.

3. Methodology and identification strategy

As previously stated, the aim in this research is twofold: firstly, it intends to analyse the potential effect –or the absence of it– of instruction time on students' academic achievement by using information about it in three different subjects for each student –reading, mathematics and science–, while the second one is to check whether this potential effect is different in each of the Spanish Autonomous Communities. To accomplish these aims student fixed effects by subjects have been employed. Basically, the identification strategy stablishes that student and school characteristics are the same for the three subjects under analysis, so the potential differences in academic achievement between these subjects may be due to their uneven instructional time. Hence, these differences in academic achievement would not be due to heterogeneity in ability, socio-economic background, study habits or school environment and quality, remaining only those subject related factors associated with instruction time. This identification strategy also avoids the potential bias which could cause the fact that students can be sorted according their ability and, thus, receive a quantity of instruction time according to this sorting –this will be checked in section 4.2.–. Furthermore, we have replicated these estimations by OLS in order to check whether the effect of 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 and the five plausible values[7]– have been applied in order to obtain reliable estimations[8].

The first aim has been studied by the estimation of the following student fixed effects model, which will be our base model from now on:

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

where Y_{ikjc} is the achievement of the i^{th} student in the k^{th} subject of the j^{th} school in the c^{th} Spanish Autonomous Community; T_{kjc} is the school average of students' self-reported

[6] Estimations have been replicated for 2009 and 2012 separately including only those Autonomous Communities which extended their sample that year –without eliminating those which did not in the other cycle–. The results obtained for the base model were similar and are available from authors upon request.

[7] Estimations have been replicated without using OECD (2009) procedures –being the average of the five plausible values the dependent variable– and results have not changed; concretely, those related to the effect of instruction time are similar. These results are available from authors upon request.

[8] There are many researchers who have used student fixed effects by subject to analyse the effect of instruction time on students' academic achievement for PISA (Lavy, 2015; Rivkin & Schiman, 2015; Cattaneo, Oggenfuss, & Wolter, 2016). However, they did not made use of PISA recommended practices when dealing with its data.

instruction time in minutes[9] for the k^{th} subject in the j^{th} school of the c^{th} Spanish Autonomous Community; S_k identifies the k^{th} subject; $AACC_c$ is the c^{th} –for $c = 1, \dots, p$– Spanish Autonomous Community with extended sample both in PISA 2009 and 2012; X_{ijc} are the observable student characteristics of the i^{th} student of the j^{th} school in the c^{th} Spanish Autonomous Community which are constant across subjects, e.g., socio-economic background; SCH_{jc} are the observable school characteristics of the j^{th} school in the c^{th} Spanish Autonomous Community which are constant across subjects; α_i is the student fixed effect, which represents student's ability and other unobservable characteristics of the student; σ_j represents the unobserved characteristics of the school, ψ_k those of the subject and μ_c those of the country; ε_{ijkc} is the unobserved error term.

One of the main identification strategies of this analysis is that the production function for reading, mathematics and science is the same, so the effect of one hour 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, we have analysed whether this assumption holds in our research or not by using a similar procedure to that of Cattaneo, Oggenfuss, and Wolter (2016), who replicated it from Metzler and Woessmann (2012) –who used it to check whether the influence of teachers' knowledge was the same across reading and mathematics subjects–. To do this, we define the unobservable student fixed effect α_i as:

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

where the φ_k coefficient which accompanies T_{kjc} –for $k = 1, \dots, 3$, 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 due to students' unobservables –like ability– on the k^{th} subject, for the j^{th} school of the c^{th} Spanish Autonomous Community; X_{ijc} are the unobservable characteristics of the i^{th} student of the j^{th} school in the c^{th} Spanish Autonomous Community which are constant across subjects; SCH_{jc} are the unobservable characteristics of the j^{th} school in the c^{th} Spanish Autonomous Community which are constant across subjects; θ_i is the remaining student fixed effects unobserved term and it is uncorrelated with the other independent variables.

When substituting equation (2) in (1) we obtain:

$$Y_{ikjc} = \varphi_1 T_{1jc} + \varphi_2 T_{2jc} + \varphi_3 T_{3jc} + \tau X_{ijc} + \omega SCH_{jc} + \theta_i + \beta T_{kjc} + \gamma S_k + \sum_{c=1}^{p} \delta AACC_c + \rho X_{ijc} + \lambda SCH_{jc} + \sigma_j + \psi_k + \mu_c + \varepsilon_{ijkc} \qquad (3)$$

Rearranging terms and defining $s = 1,2,3$ specifications for equation (3), one for each of the $k = 1,2,3$ subjects:

$$Y_{isjc} = (\beta_s + \varphi_s) T_{sjc} + \sum_{k \neq s} \varphi_k T_{kjc} + \gamma S_s + \sum_{c=1}^{p} \delta AACC_c + (\rho + \tau) X_{ijc} + (\lambda + \omega) SCH_{jc} + \theta_i + \sigma_j + \psi_s + \mu_c + \varepsilon_{ijsc} \qquad (4)$$

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 instruction time on the s^{th} subject academic achievement; φ_s is the unobserved subject-specific

[9] We have calculated the average by school of the self-reported instruction time by students as Lavy (2015), Rivkin and Schiman (2015) –the later also aggregate students' achievement to the school level, by grade and subject– or Cattaneo, Oggenfuss and Wolter (2016) do, because the use of self-reported instruction time may be subject to problems, like the difficulty for students to recall the number of weekly lessons or instruction time per lesson, more than due to absenteeism or other reasons. Unfortunately, we can not control by absenteeism because, although PISA 2012 –not PISA 2009– contains a question about skipping classes, it is only available for two-thirds of the sample and it is not very reliable, as it is asked to the student. Moreover, as students are attending compulsory education, it is not legal that they skip classes. Cattaneo, Oggenfuss and Wolter (2016) used the school average of students' self-reported and official instruction time, showing the last one lower a coefficient for the effect of instruction time on academic achievement. However, they could not choose which of the two measures of instruction time was better, because the first one may be subject to measurement errors and recall bias, while the later may not show the reality in schools. Estimations in the base model of our research were replicated by the use of the self-reported instruction time by students and results about instruction time did not change, so the use of the school average of self-reported students' answers may not be biasing the results. These specifications will be provided upon request to the authors.

effect of instruction time on the s^{th} subject due to students' unobservables –like ability– on the s^{th} subject, i.e., it shows their ability to take advantage of instruction time in that s^{th} particular subject; φ_k is the unobserved subject-specific effect of instruction time on s^{th} subject due to students' unobservables –like ability– on the k^{th} subject, being $k \neq s$, i.e., it shows their ability to take advantage of the instruction time on other subject different from s which affects their academic achievement on the s^{th} subject. Hence, we have to check two main hypothesis: the first assumption that $\varphi_1 = \varphi_2 = \varphi_3$ holds, so that the effect instruction time in the subject due to student-specific unobservables –ability– on the subject is the same for the three subjects[10]; the second assumption that β_s of the three specifications are the same, i.e., $\beta_1 = \beta_2 = \beta_3$, so that the effect of β of the base model in equation (1) would not be biased[11], i.e., instruction time affects academic achievement in the same way for all subjects. The results of these tests are presented in Table 1 and the estimations for each of the subjects are displayed in Table A1 (Appendix). It can be appreciated that both hypothesis are accepted for PISA 2009, but not for PISA 2012. This may be the effect of having only two-thirds of the sample in this last cycle, so this could warn us about its inadequacy to perform the analysis that we want to accomplish, so the results for PISA 2012 have to be interpreted with more caution than those of PISA 2009.

Table 1. Check of the equality of students' unobserved subject-specific effect of instruction time due to students' ability on the subject and the equality of the effect of instruction time on academic achievement of all subjects

	PISA 2009		PISA 2012	
	Chi-square	P-value	Chi-square	P-value
$\varphi_2 = \varphi_3$	0.04	0.85	7.00	0.01
$\varphi_1 = \varphi_3$	0.94	0.33	13.93	0.00
$\varphi_1 = \varphi_2$	0.01	0.91	0.09	0.76
$\beta_1 = \beta_2 = \beta_3$	2.34	0.31	22.80	0.00

Note: Tests based on the estimations in Table A1 (Appendix).
Source: Author's own calculation.

The second aim of this research, related to a different effect of instruction time depending on the AACC, has been checked by introducing in the base model in (1) an interaction of instruction time with each one of the AACC.

Once analysed these two aims, we performed some robustness checks to see whether our results hold conditioned on certain factors. One of these analyses is to check whether the effect of instruction time could be conditioned by the socio-economic status of the student or by the ability grouping that some schools perform –which may suppose different amounts of instruction time–. The later analysis supposes another argument in favour of the use of PISA 2009, as it contains information on whether students are grouped according to their ability within the class or into different classes, so that we can check if the differences of the instruction time reported by the student 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 instruction time by school level may be a good representation of students' real instruction time. Additionally to these estimations, we analysed the potential existence of non-linearities in instruction time by including it as a squared term and as a categorical variable, in alternative specifications.

[10] To contrast this second 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 confirm by transitivity that $\varphi_1 = \varphi_2 = \varphi_3 = \varphi$.

[11] 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 $\vartheta_s = \beta_s + \varphi_s$, this is done by subtracting from each of the s^{th} ϑ_s coefficients the effect of the correspondent φ_s from each $k \neq s$ specifications. In this sense, for $s = 1$ we obtain β_1 by subtracting from ϑ_1 the coefficient of φ_1 in specification $s = 2$ and φ_1 in specification $s = 3$; for $s = 2$ we obtain β_2 by subtracting from ϑ_2 the coefficient of φ_2 in specification $s = 1$ and φ_2 in specification $s = 3$; for $s = 3$ we obtain β_3 by subtracting from ϑ_3 the coefficient of φ_3 in specification $s = 1$ and φ_3 in specification $s = 2$. Once these three hypothesis have been accepted we can confirm that $\beta_1 = \beta_2 = \beta_3 = \beta$.

In addition, the potential effect of instruction time on academic achievement may be due to its quality more than its quantity, as previously argued in the section 1. 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 can not check for classroom peer effects because the sampling procedure used by PISA obtains 15 year-old students randomly from the school, so it is not possible to know the classroom of the student.

4. Results

4.1. Main results

Descriptive statistics for the sample under analysis are presented in Table 2A (Appendix) by Autonomous Communities. The first thing that may call our attention is the high number of observations that the Autonomous Community, Basque Country, possesses. However, this may not be an issue as we are making use of the weighting procedures recommended by the OECD. The information in these statistics is presented in Figures 1 and 2 (Appendix) for PISA 2009 and 2012, respectively. From the view of these graphics it does not seem that there is a clear relationship between academic achievement and instruction time. Most of the AACC are located in the range between 210 and 230 minutes of instruction time –in the case of science in PISA 2009 this band is located between 230 and 250 minutes–, but they present different levels of academic achievement, what could be advancing the result that academic achievement may not be dependent on instruction time for the case of the Spanish AACC. Furthermore, the case of Andalusia in mathematics and science in PISA 2009 and 2012 is relevant, as it shows a high amount of instruction time but low academic performance.

In order to check these results from the descriptive analysis, the base model of equation (1) has been estimated and presented in Table 2. From the results obtained for the student fixed effects model we can infer that instruction time may not be conditioning academic achievement of Spanish students, as it was deduced from the descriptive analysis. This result was also obtained by Baker, Fabrega, Galindo, and Mishook (2004) and Woessmann (2010). This analysis was replicated by the use of OLS and we obtained a different result: instruction time seems to positively affect academic achievement. The reason behind this result may be that there is an omission of relevant variables –which are observable and unobservable and are accounted in the fixed effects model, as they are constant across subjects– that can potentially explain academic achievement, so that instruction time is gathering their effect. Hence, building in this result, the use of students' fixed effects to perform such an analysis is essential. In addition, the AACC with the lowest academic achievement are Balearic Islands and Andalusia, as it was expected from the descriptive analysis.

Table 2. Estimated effect of instructional time on test scores

	PISA 2009		PISA 2012	
Variables	OLS	Student FE	OLS	Student FE
Minutes of instructional time	0.108***	0.008	0.148***	0.002
	(0.030)	(0.018)	(0.052)	(0.026)
Subject: Reading (Ref.: Science)	0.199	-4.853***	0.046	-3.492***
	(1.683)	(1.333)	(1.762)	(1.325)
Subject: Maths (Ref.: Science)	3.698**	-0.407	-1.965	-4.013***
	(1.479)	(1.382)	(1.619)	(1.243)
Aragon (Ref.: Andalusia)	37.148***		24.000***	
	(5.174)		(7.371)	
Asturias (Ref.: Andalusia)	28.542***		22.754***	
	(6.208)		(6.186)	
Balearic Islands (Ref.: Andalusia)	1.136		2.559	
	(5.236)		(7.064)	
Cantabria (Ref.: Andalusia)	27.481***		9.344*	
	(5.871)		(5.605)	
Castile and Leon (Ref.: Andalusia)	43.977***		27.603***	
	(5.635)		(5.918)	
Catalonia (Ref.: Andalusia)	20.387***		4.505	
	(7.051)		(7.257)	

Galicia (Ref.: Andalusia)	32.204***		20.115***	
	(5.669)		(5.921)	
La Rioja (Ref.: Andalusia)	43.563***		23.969***	
	(5.084)		(5.698)	
Madrid (Ref.: Andalusia)	39.304***		26.984***	
	(5.021)		(7.485)	
Murcia (Ref.: Andalusia)	14.534**		0.340	
	(5.925)		(8.386)	
Navarre (Ref.: Andalusia)	36.815***		28.379***	
	(4.708)		(6.890)	
Basque Country (Ref.: Andalusia)	22.087***		10.729**	
	(4.451)		(5.047)	
Constant	480.956***	527.070***	493.684***	538.023***
	(8.273)	(4.220)	(12.020)	(5.785)
Observations	36,180	36,180	24,456	24,456

Notes: Standard errors in parentheses are clustered at the school level. The sample contains only non-repeater students of those AACC which have an extended sample in PISA 2009 and 2012.
Estimation method: OLS and student fixed effects.
Dependent variable: Competence in reading, mathematics and sciences.
Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.
Source: Author's own calculation.

In Table 3 the differential effect of instruction time by ACC is checked. Although the general effect for Spain of instruction time is still not significant for the student fixed effects model, it seems that for PISA 2009 it has a positive effect for Galicia, increasing academic achievement by 0.105 points per minute of instruction compared with Andalusia and decreasing it by 0.115 per minute in Aragon compared with Andalusia. In the case of PISA 2012, a negative effect of instruction time in comparison with Andalusia can be appreciated in Cantabria, La Rioja, and with an especially high amount of it, in Catalonia. Nevertheless, when putting these figures into the PISA scale –where 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 in Galicia would mean an increase of its scores in 6.3 points in comparison with Andalusia. Because of that, together with the low reliability that PISA 2012 results may have as indicated by the tests performed in section 3, it could be concluded that instruction time does not have a relevant effect on academic achievement for all AACC in Spain.

Table 3. Estimated effect of instructional time on test scores by AACC

	PISA 2009		PISA 2012	
Variables	OLS	Student FE	OLS	Student FE
Minutes of instructional time	0.073*	-0.006	0.245***	0.061
	(0.041)	(0.029)	(0.092)	(0.042)
Subject: Reading (Ref.: Science)	-0.142	-4.795***	-0.485	-4.189***
	(1.796)	(1.375)	(1.865)	(1.451)
Subject: Maths (Ref.: Science)	4.545***	-0.065	-3.206*	-5.182***
	(1.590)	(1.422)	(1.732)	(1.318)
Aragon (Ref.: Andalusia)	32.313*		28.778	
	(18.083)		(53.236)	
Asturias (Ref.: Andalusia)	-4.265		38.584	
	(19.559)		(34.993)	
Balearic Islands (Ref.: Andalusia)	1.265		22.051	
	(16.642)		(25.971)	
Cantabria (Ref.: Andalusia)	0.221		70.889*	
	(17.683)		(37.371)	
Castile and Leon (Ref.: Andalusia)	35.138**		37.896	
	(16.975)		(29.885)	
Catalonia (Ref.: Andalusia)	19.676		69.244**	
	(20.306)		(27.094)	
Galicia (Ref.: Andalusia)	16.981		41.938*	
	(12.267)		(23.233)	
La Rioja (Ref.: Andalusia)	23.017		56.806**	
	(15.740)		(26.119)	
Madrid (Ref.: Andalusia)	9.590		49.212	
	(14.961)		(30.252)	
Murcia (Ref.: Andalusia)	-10.007		19.702	
	(20.586)		(40.920)	
Navarre (Ref.: Andalusia)	1.251		40.301	
	(16.404)		(39.244)	

Basque Country (Ref.: Andalusia)	38.121***		33.329	
	(13.783)		(20.551)	
Interactions with "Minutes of instructional time"				
Aragon (Ref.: Andalusia)	0.020	-0.115***	-0.015	-0.015
	(0.077)	(0.043)	(0.269)	(0.114)
Asturias (Ref.: Andalusia)	0.158	0.020	-0.068	-0.021
	(0.103)	(0.049)	(0.177)	(0.081)
Balearic Islands (Ref.: Andalusia)	-0.003	-0.007	-0.086	-0.026
	(0.066)	(0.041)	(0.137)	(0.105)
Cantabria (Ref.: Andalusia)	0.125	-0.037	-0.289	-0.161*
	(0.078)	(0.062)	(0.183)	(0.094)
Castile and Leon (Ref.: Andalusia)	0.039	0.025	-0.044	0.033
	(0.073)	(0.043)	(0.140)	(0.106)
Catalonia (Ref.: Andalusia)	-0.002	0.020	-0.322**	-0.318***
	(0.097)	(0.054)	(0.142)	(0.074)
Galicia (Ref.: Andalusia)	0.077	0.105**	-0.098	0.094
	(0.061)	(0.042)	(0.125)	(0.085)
La Rioja (Ref.: Andalusia)	0.093	-0.040	-0.150	-0.146**
	(0.070)	(0.040)	(0.126)	(0.071)
Madrid (Ref.: Andalusia)	0.135**	0.042	-0.100	-0.021
	(0.061)	(0.041)	(0.148)	(0.065)
Murcia (Ref.: Andalusia)	0.108	0.008	-0.087	0.001
	(0.083)	(0.073)	(0.192)	(0.094)
Navarre (Ref.: Andalusia)	0.158**	-0.044	-0.053	-0.157
	(0.069)	(0.051)	(0.184)	(0.101)
Basque Country (Ref.: Andalusia)	-0.081	-0.012	-0.102	-0.016
	(0.061)	(0.042)	(0.104)	(0.054)
Constant	488.662***	527.125***	472.690***	541.223***
	(10.011)	(4.174)	(18.835)	(6.117)
Observations	36,180	36,180	24,456	24,456

Notes: Standard errors in parentheses are clustered at the school level. The sample contains only non-repeater students of those AACC which have an extended sample in PISA 2009 and 2012.
Estimation method: OLS and student fixed effects.
Dependent variable: Competence in reading, mathematics and sciences.
Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.
Source: Author's own calculation.

4.2. 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 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 of equation (1) 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 both PISA 2009 and 2012 and divided it in three quantiles (terciles), estimating one specification for each one. The results obtained show that the lack of effect of instruction time is the same for the three ESCS terciles, providing robustness to our main results.

Table 4. Estimated effect of instructional time on test scores by ESCS tercile

	PISA 2009					
	Low ESCS		Medium ESCS		High ESCS	
Variables	OLS	Student FE	OLS	Student FE	OLS	Student FE
Minutes of instructional time	0.094*	-0.015	0.068**	0.015	0.079**	0.029
	(0.055)	(0.027)	(0.033)	(0.024)	(0.036)	(0.031)
Subject: Reading (Ref.: Science)	2.270	-3.322	-2.499	-4.965***	-3.507	-6.231***
	(2.818)	(2.179)	(2.262)	(1.887)	(2.714)	(2.178)
Subject: Maths (Ref.: Science)	6.215**	2.067	-0.391	-2.483	1.501	-0.834
	(2.530)	(2.431)	(2.072)	(1.817)	(2.614)	(2.061)
AACC Dummies	✓	✓	✓	✓	✓	✓
Constant	462.771***	507.750***	498.653***	527.944***	515.686***	546.782***
	(14.103)	(6.559)	(9.193)	(5.850)	(10.557)	(6.949)
Observations	11,775		12,114		12,153	
	PISA 2012					
Minutes of instructional time	0.106*	-0.028	0.128*	0.012	0.134*	0.022
	(0.061)	(0.036)	(0.067)	(0.030)	(0.074)	(0.036)

Subject: Reading (Ref.: Science)	0.053	-2.637	-1.318	-4.089**	-0.333	-3.499
	(2.100)	(1.730)	(2.350)	(1.855)	(2.849)	(2.270)
Subject: Maths (Ref.: Science)	-4.484**	-5.766***	-3.731*	-5.325***	1.299	-0.771
	(2.268)	(1.978)	(2.212)	(1.680)	(2.160)	(1.950)
AACC Dummies	✓	✓	✓	✓	✓	✓
Constant	483.572***	523.536***	497.410***	534.244***	524.875***	555.507***
	(13.740)	(8.470)	(15.577)	(6.975)	(17.498)	(8.285)
Observations	7,974		8,211		8,235	

Notes: Standard errors in parentheses are clustered at the school level. The sample contains only those AACC which have an extended sample in PISA 2009 and 2012. The sum of the number of observations of all ESCS terciles differs from the total amount of observations due to missing observations in the ESCS variable. The tick (✓) indicates that it has been controlled by an AACC dummy for each included AACC (reference: Andalusia).
Estimation method: OLS and student fixed effects.
Dependent variable: Competence in reading, mathematics and sciences.
Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.
Source: Author's own calculation.

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 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 to each of the ability groups, in order to provide more advantaged students with more instruction time or, on the contrary, providing those students of less ability 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 5. Unfortunately, we can only perform this robustness check for PISA 2009, as PISA 2012 contains this information only for the mathematics' class. A simple descriptive analysis shows that students grouped by ability into different classes report an average of 190 minutes of instruction time in reading, 201 minutes in mathematics and 241 minutes in sciences; students grouped by ability within their classes show a mean of 189 minutes in reading, 200 minutes in mathematics and 240 in sciences; students who are not grouped by ability present 196 minutes in reading, 205 in mathematics and 247 in sciences. From the view of these results, it seems that there is not a high difference on instruction time for the different ability grouping criteria, so we may expect that this grouping does not influence the effect of instruction time on academic achievement.

Moreover, in the estimations of Table 5 instruction time was included as self-reported by students, instead of using the school average of these answers, so we can check whether or not the differences in students' self-reported instruction time within the same school may be conditioned by their attendance to different ability classes. Results show that the effect of instruction time is not significant for the three grouping options, so ability group differences in instruction time do not seem to condition the conclusions obtained for the whole sample. We can also conclude that averaging instruction time by schools is not biasing the results obtained, what lets us avoid the potential bias due to students not remembering instruction time properly or due to their absenteeism –although we can not check the later in a deeper way due to limitations of the data, as previously indicated–.

Table 5. Estimated effect of instructional time on test scores conditioned on school grouping by ability

	PISA 2009					
	Grouping by ability into different classes		Grouping by ability within classes		Not grouped by ability	
Variables	OLS	Student FE	OLS	Student FE	OLS	Student FE
Minutes of instructional time	0.115***	0.002	0.120***	0.012	0.139***	0.013
	(0.020)	(0.013)	(0.023)	(0.013)	(0.022)	(0.010)
Subject: Reading (Ref.: Science)	-0.336	-5.971***	2.308	-3.172	0.527	-5.955***
	(2.070)	(1.897)	(2.183)	(2.036)	(2.059)	(1.541)
Subject: Maths (Ref.: Science)	3.343	-1.109	6.047***	1.771	2.468	-2.851

	(2.205)	(2.303)	(2.315)	(2.554)	(2.561)	(1.965)
AACC Dummies	✓	✓	✓	✓	✓	✓
Constant	475.638***	522.964***	480.664***	523.220***	475.708***	531.479***
	(8.855)	(4.490)	(8.985)	(4.699)	(8.589)	(3.037)
Observations	12,936		11,169		16,080	

Notes: Standard errors in parentheses are clustered at the school level. The sample contains only those AACC which have an extended sample in PISA 2009 and 2012. 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 tick (✓) indicates that it has been controlled by a AACC dummy for each included AACC (reference: Andalusia). The variable of minutes of instruction time has been included as self-reported by students, rather than as school average of students' answers.
Estimation method: OLS and student fixed effects.
Dependent variable: Competence in reading, mathematics and sciences.
Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.
Source: Author's own calculation.

The null effect of instruction time on academic achievement may be also due to a specification error of using a linear equation, so we have checked in Table 6 whether results change when including instruction time in two different non-linear forms: as a squared term and dividing its distribution in three similar parts[12]. Results for PISA 2009 show that results hold for the effect of instruction time on academic achievement, although it is not the case for PISA 2012, in which instruction time has a negative effect on academic achievement which is compensated –although to a low extent in the case of the squared term and without any compensation for the categorical division of instruction time– by high amounts of instruction time. However, these results for PISA 2012 may be the effect of the previously indicated problems related to this sample: the number of students who answered the questions related to instruction time, what did not let us verify the two tests proposed in section 3.

Table 6. Estimated non-linear effect of instructional time on test scores

	PISA 2009			
	Specification (I)		Specification (II)	
Variables	OLS	Student FE	OLS	Student FE
Minutes of instructional time	0.151	-0.057		
	(0.131)	(0.080)		
Squared minutes of instructional time	-0.000	0.000		
	(0.000)	(0.000)		
200 or more to less than 220 (Ref.: 200 or less)			10.938***	-1.237
			(3.396)	(1.639)
220 or more (Ref.: 200 or less)			6.962***	-1.988
			(2.505)	(1.836)
Subject: Reading (Ref.: Science)	0.314	-5.036***	-3.125**	-6.100***
	(1.658)	(1.346)	(1.561)	(1.365)
Subject: Maths (Ref.: Science)	3.729**	-0.462	0.322	-1.182
	(1.479)	(1.373)	(1.465)	(1.358)
AACC Dummies	✓	✓	✓	✓
Constant	475.529***	535.135***	502.548***	530.474***
	(16.867)	(10.644)	(4.268)	(2.225)
Observations	36,180		36,180	
	PISA 2012			
Minutes of instructional time	-0.359	-0.379***		
	(0.324)	(0.144)		
Squared minutes of instructional time	0.001	0.001***		
	(0.001)	(0.000)		
195 or more to less than 220 (Ref.: less than 195)			-2.377	-3.316**
			(2.341)	(1.347)
220 or more (Ref.: less than 195)			5.410	-1.925
			(3.456)	(1.937)
Subject: Reading (Ref.: Science)	0.131	-3.404***	-1.854	-3.766***
	(1.797)	(1.320)	(1.615)	(1.356)
Subject: Maths (Ref.: Science)	-1.508	-3.655***	-3.497***	-4.108***

[12] This later division does not coincide in PISA 2009 and 2012 because the distribution of instruction time frequencies is different for each cycle.

	(1.675)	(1.269)	(1.293)	(1.193)
AACC Dummies	✓	✓	✓	✓
Constant	549.875***	579.852***	525.145***	540.047***
	(37.454)	(16.539)	(5.516)	(1.839)
Observations	24,456		24,456	

Notes: Standard errors in parentheses are clustered at the school level. The sample contains only non-repeater students of those AACC which have an extended sample in PISA 2009 and 2012. The tick (✓) indicates that it has been controlled by an AACC dummy for each included AACC (reference: Andalusia).
Estimation method: OLS and student fixed effects.
Dependent variable: Competence in reading, mathematics and sciences.
Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.
Source: Author's own calculation.

Finally, school quality may be conditioning the effect of instruction time on academic achievement, as the quantity of instruction time may be less relevant than its quality (Baker, Fabrega, Galindo, & Mishook, 2004; Mullis, Martin, Foy, & Drucker, 2012; OECD, 2013; Gromada & Shewbridge, 2016). Because of that, we have made use of three quality-related indexes which OECD elaborate from the answers of school principals to school questionnaires. These indexes are "quality of the school educational resources", "student behaviour" ("student-related factors affecting school climate" in PISA 2012) and "teacher behaviour" ("teacher related factors affecting school climate" in PISA 2012)[13]. These indexes have been interacted with instruction time in order to get their effect on this variable. Although controlling for the proportion of teachers with ISCED 5a level of studies 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 can not control the quality of teachers by this additional way.

The results for this estimation of school quality are presented in Table 7. It can be appreciated that only the interaction of instruction time with the index of student behaviour –specification II– has a significant and positive effect on academic achievement in PISA 2009. This result may be denoting that the classroom environment where students are receiving their lessons is a relevant element, as all students may be able to be more engaged during the duration of the lesson when there is a proper discipline in the classroom. Furthermore, these results could also be remarking that the ability of teachers taking advantage of instruction time is almost the same around Spain, what may be related to their homogeneous level of studies and similar formation. Moreover, the availability of school resources seems to be an irrelevant factor when taking advantage of instruction time. When including these three indexes together

[13] Following OECD (2012) for PISA 2009 and OECD (2014) for PISA 2012, these indexes have been created by the OECD using school principals' answers about their agreement –in four levels, i.e., "Not at all", "Very little", "To some extent" and "A lot"– with some statements. The statements used to create each of the indexes for PISA 2009 are: a) Quality of the school educational resources index: Shortage or inadequacy of science laboratory equipment; Shortage or inadequacy of instructional materials (e.g. textbooks); Shortage or inadequacy of computers for instruction; Lack or inadequacy of Internet connectivity; Shortage or inadequacy of computer software for instruction; Shortage or inadequacy of library materials and Shortage or inadequacy of audio-visual resources**.** b) Student Behaviour index**:** Student absenteeism; Disruption of classes by students; Students skipping classes; Students lacking respect for teachers; Student use of alcohol or illegal drugs; Students intimidating or bullying other students**.** c) Teacher Behaviour index**:** Teachers' low expectations of students; Poor student-teacher relations; Teachers not meeting individual students' needs; Teacher absenteeism; Staff resisting change; Teachers being too strict with students; Students not being encouraged to achieve their full potential. In the case of PISA 2012: a) Quality of the school educational resources index: Shortage or inadequacy of science laboratory equipment; Shortage or inadequacy of instructional materials (e.g. textbooks); Shortage or inadequacy of computers for instruction; Lack or inadequacy of Internet connectivity; Shortage or inadequacy of computer software for instruction; Shortage or inadequacy of library materials. b) Student-related factors affecting school climate index: Student truancy; Students skipping classes; Students arriving late for school; Students not attending compulsory school events (e.g. sports day) or excursions; Students lacking respect for teachers; Disruption of classes by students; Student use of alcohol or illegal drugs; Students intimidating or bullying other students. c) Teacher-related factors affecting school climate index: Students not being encouraged to achieve their full potential; Poor student-teacher relations; Teachers having to teach students of heterogeneous ability levels within the same class; Teachers having to teach students of diverse ethnic backgrounds (i.e. language, culture) within the same class; Teachers' low expectations of students; Teachers not meeting individual students' needs; Teacher absenteeism; Staff resisting change; Teachers being too strict with students; Teachers being late for classes; Teachers not being well prepared for classes.

in the same specification –specification IV– we obtained the same results and conclusions as when included alternatively.

Table 7. Estimated effect of instructional time on test scores in relation with school quality

	PISA 2009							
	Specification (I)		Specification (II)		Specification (III)		Specification (IV)	
Variables	OLS	Student FE	OLS	Student FE	OLS	Student FE	OLS	Student FE
Minutes of instructional time	0.115***	0.009	0.092***	0.003	0.100***	0.008	0.101***	0.008
	(0.027)	(0.019)	(0.029)	(0.017)	(0.030)	(0.018)	(0.028)	(0.018)
(Minutes of instructional time)x(Index of the quality of the school educational resources)	0.022**	0.008					0.017*	0.008
	(0.010)	(0.012)					(0.009)	(0.013)
(Minutes of instructional time)x(Index of student behavior)			0.038***	0.033**			0.040***	0.039**
			(0.009)	(0.016)			(0.011)	(0.018)
(Minutes of instructional time)x(Index of teacher behavior)					0.017*	-0.002	-0.010	-0.019
					(0.009)	(0.017)	(0.012)	(0.019)
Subject: Reading (Ref.: Science)	0.274	-5.065***	-0.472	-5.060***	-0.278	-5.142***	-0.113	-4.948***
	(1.648)	(1.358)	(1.699)	(1.321)	(1.686)	(1.335)	(1.657)	(1.335)
Subject: Maths (Ref.: Science)	3.438**	-0.821	2.875*	-0.811	2.987**	-0.896	3.171**	-0.681
	(1.551)	(1.388)	(1.540)	(1.364)	(1.516)	(1.385)	(1.541)	(1.373)
AACC Dummies	✓	✓	✓	✓	✓	✓	✓	✓
Constant	479.603***	527.102***	485.695***	527.046***	482.099***	527.570***	484.198***	526.176***
	(7.639)	(4.382)	(7.972)	(4.137)	(8.290)	(4.179)	(7.629)	(4.295)
Observations	35,205		35,331		35,331		35,205	
	PISA 2012							
Minutes of instructional time	0.171***	-0.000	0.114***	0.002	0.172***	-0.003	0.101**	-0.003
	(0.047)	(0.026)	(0.043)	(0.027)	(0.049)	(0.026)	(0.042)	(0.026)
(Minutes of instructional time)x(Index of the quality of the school educational resources)	0.008	-0.009					0.005	-0.002
	(0.010)	(0.030)					(0.011)	(0.033)
(Minutes of instructional time)x(Index of student-related factors affecting school climate)			0.032***	-0.010			0.045***	-0.001
			(0.008)	(0.027)			(0.010)	(0.033)
(Minutes of instructional time)x(Index of teacher-related factors affecting school climate)					0.005	-0.014	-0.025**	-0.013
					(0.007)	(0.026)	(0.010)	(0.033)
Subject: Reading (Ref.: Science)	0.746	-3.547***	-0.440	-3.781***	0.560	-3.802***	-0.596	-3.794***
	(1.724)	(1.318)	(1.560)	(1.337)	(1.730)	(1.302)	(1.560)	(1.305)
Subject: Maths (Ref.: Science)	-1.588	-4.133***	-2.431	-4.512***	-1.947	-4.512***	-2.499	-4.511***
	(1.670)	(1.276)	(1.534)	(1.225)	(1.606)	(1.212)	(1.521)	(1.238)
AACC Dummies	✓	✓	✓	✓	✓	✓	✓	✓
Constant	488.117***	539.036***	499.377***	539.727***	488.133***	539.648***	501.729***	539.656***

	(11.093)	(5.734)	(10.165)	(5.697)	(11.123)	(5.701)	(10.282)	(5.721)
Observations	24,183		23,733		23,733		23,649	

Notes: Standard errors in parentheses are clustered at the school level. The sample contains only those AACC which have an extended sample in PISA 2009 and 2012. The number of observations in each specification differs due to missing observations of the additional variables included. The tick (✓) indicates that it has been controlled by an AACC dummy for each included AACC (reference: Andalusia).
Estimation method: OLS and student fixed effects.
Dependent variable: Competence in reading, mathematics and sciences.
Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.
Source: Author's own calculation.

5. Conclusions

The objective of this research has been twofold: 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. Results have shown that instruction time does not have influence on academic achievement and that this conclusion holds for all the AACC in Spain. Several robustness checks for these estimations have been performed and results hold, what reinforces the conclusions obtained. However, the relevance of instruction time has been highlighted not in the sense of its quantity, but in that of its quality, concretely, in relation to the classroom environment and general attitudes that students show in the classroom, more than teachers' attitudes towards students and their teaching or the available resources of the school.

These results can be indicating that the common practice in Spain of providing students with a high amount of instructional time during their school-day may be a useless one. This has relevant policy implications, as the increase of instruction time supposes an increase in the education costs (Gromada & Shewbridge, 2016) in terms of money, e.g. waste of resources or higher salaries for teachers due to additional instruction time, or in terms of time, e.g. the trade-off between the amount of instruction time devoted to different relevant subjects or students' free time to devote to study or leisure. Thus, the target of policy regulations should be placed on relocating these expenses of higher instruction time on improving students' behavior towards learning, schools and teachers, so that all students in the classroom can be engaged all the time that the lesson lasts. This might be achieved by preparing teachers' curriculum to deal with these problems in early ages of students, so that students may be more engaged when they reach higher courses.

Another relevant conclusion is aimed to discouraging the use of PISA 2012 for this kind analysis due to the amount of students who answered the questions related to instruction time –due to the student questionnaire rotation design–, what did not let us verify the equality of the effect of instruction time between subjects, deriving in many cases to results which were very likely biased. This caution with the interpretation of the results can be extended to any other kind of analysis which uses one or more of the questions of the student questionnaire in PISA 2012 which are answered only by two-thirds of the sample.

To conclude, the quality of this instruction time has been highlighted to be more relevant than its quantity, something that seems intuitively logical in most areas, but the empirical evidence provided in this research reinforces the application of this criterion to the education field.

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Appendix

Table A1. Estimations for checking the equality of students' unobserved subject-specific effect of instruction time due to students' ability on the subject and the equality of the effect of instruction time on academic achievement of all subjects

	PISA 2009			PISA 2012		
Variables	Reading	Mathematics	Science	Reading	Mathematics	Science
Minutes of instructional time in reading	0.071*	0.165***	0.107**	-0.097**	-0.193***	-0.111**
	(0.043)	(0.044)	(0.045)	(0.049)	(0.047)	(0.046)
Minutes of instructional time in mathematics	0.077**	0.064	0.126***	-0.087**	-0.069*	-0.057
	(0.038)	(0.040)	(0.040)	(0.042)	(0.041)	(0.040)
Minutes of instructional time in science	0.093***	0.067***	0.066***	0.256***	0.234***	0.279***
	(0.011)	(0.011)	(0.011)	(0.022)	(0.022)	(0.021)
Aragon (Ref.: Andalusia)	28.183***	39.558***	30.212***	20.899***	35.595***	30.782***
	(3.421)	(3.545)	(3.572)	(4.826)	(4.687)	(4.611)
Asturias (Ref.: Andalusia)	24.789***	22.510***	27.442***	21.663***	25.375***	27.827***
	(4.481)	(4.642)	(4.677)	(5.719)	(5.554)	(5.463)
Balearic Islands (Ref.: Andalusia)	-0.460	5.126	-4.508	-2.053	7.751	2.736
	(4.121)	(4.269)	(4.302)	(5.146)	(4.998)	(4.917)
Cantabria (Ref.: Andalusia)	17.887***	25.579***	25.847***	5.518	21.464***	17.663***
	(4.690)	(4.859)	(4.896)	(6.218)	(6.039)	(5.940)
Castile and Leon (Ref.: Andalusia)	31.402***	43.337***	36.344***	20.817***	36.724***	31.068***
	(2.910)	(3.014)	(3.037)	(3.759)	(3.651)	(3.591)
Catalonia (Ref.: Andalusia)	26.386***	23.934***	23.891***	12.892***	9.196***	-4.390
	(2.515)	(2.606)	(2.625)	(2.978)	(2.893)	(2.845)
Galicia (Ref.: Andalusia)	34.095***	36.205***	50.385***	14.659***	8.182*	21.243***
	(3.525)	(3.652)	(3.680)	(4.338)	(4.213)	(4.144)
La Rioja (Ref.: Andalusia)	36.347***	43.333***	38.970***	17.552**	47.126***	33.769***
	(6.849)	(7.096)	(7.150)	(8.523)	(8.278)	(8.142)
Madrid (Ref.: Andalusia)	37.070***	30.243***	36.108***	21.063***	26.489***	24.520***
	(2.869)	(2.972)	(2.995)	(3.182)	(3.090)	(3.040)
Murcia (Ref.: Andalusia)	18.216***	15.082***	14.132***	0.282	15.998***	14.547***
	(3.424)	(3.548)	(3.575)	(4.479)	(4.350)	(4.279)
Navarre (Ref.: Andalusia)	20.923***	38.893***	28.202***	24.827***	45.706***	24.220***
	(4.780)	(4.952)	(4.990)	(5.908)	(5.738)	(5.644)
Basque Country (Ref.: Andalusia)	15.747***	32.748***	8.086***	6.365*	19.750***	8.492**
	(2.707)	(2.805)	(2.826)	(3.452)	(3.352)	(3.298)
Female student (Ref.: Male student)	20.344***	-26.310***	-17.914***	20.303***	-24.165***	-14.345***
	(1.161)	(1.203)	(1.212)	(1.507)	(1.463)	(1.440)
First generation immigrant student (Ref.: Native student)	-45.838***	-50.813***	-49.910***	-36.252***	-44.344***	-40.710***
	(2.763)	(2.862)	(2.884)	(3.286)	(3.192)	(3.140)
Second generation immigrant student (Ref.: Native student)	-17.813***	-8.248	-20.555***	-34.810***	-32.714***	-38.298***
	(6.592)	(6.829)	(6.881)	(7.431)	(7.217)	(7.099)
Index of Economic, Social and Cultural Status (ESCS) of the student	11.179***	12.923***	15.067***	10.890***	12.777***	12.493***
	(0.673)	(0.698)	(0.703)	(0.957)	(0.930)	(0.914)
Public school (Ref.: Private school)	-2.903	5.689**	1.585	5.102*	10.103***	11.532***
	(2.527)	(2.618)	(2.638)	(2.843)	(2.761)	(2.716)
Private government-dependent (Ref.: Private school)	-2.992	-2.369	-2.100	5.056*	8.085***	8.734***
	(2.505)	(2.595)	(2.615)	(2.780)	(2.700)	(2.656)
School Index of Economic, Social and Cultural Status (ESCS)	13.909***	10.320***	10.486***	12.672***	13.610***	9.865***
	(1.266)	(1.311)	(1.321)	(1.867)	(1.813)	(1.783)
Constant	447.761***	460.212***	459.477***	489.212***	521.813***	496.921***
	(10.668)	(11.051)	(11.135)	(11.593)	(11.259)	(11.075)
Observations	11,216	11,216	11,216	7,778	7,778	7,778
R-squared	0.182	0.190	0.187	0.134	0.180	0.164

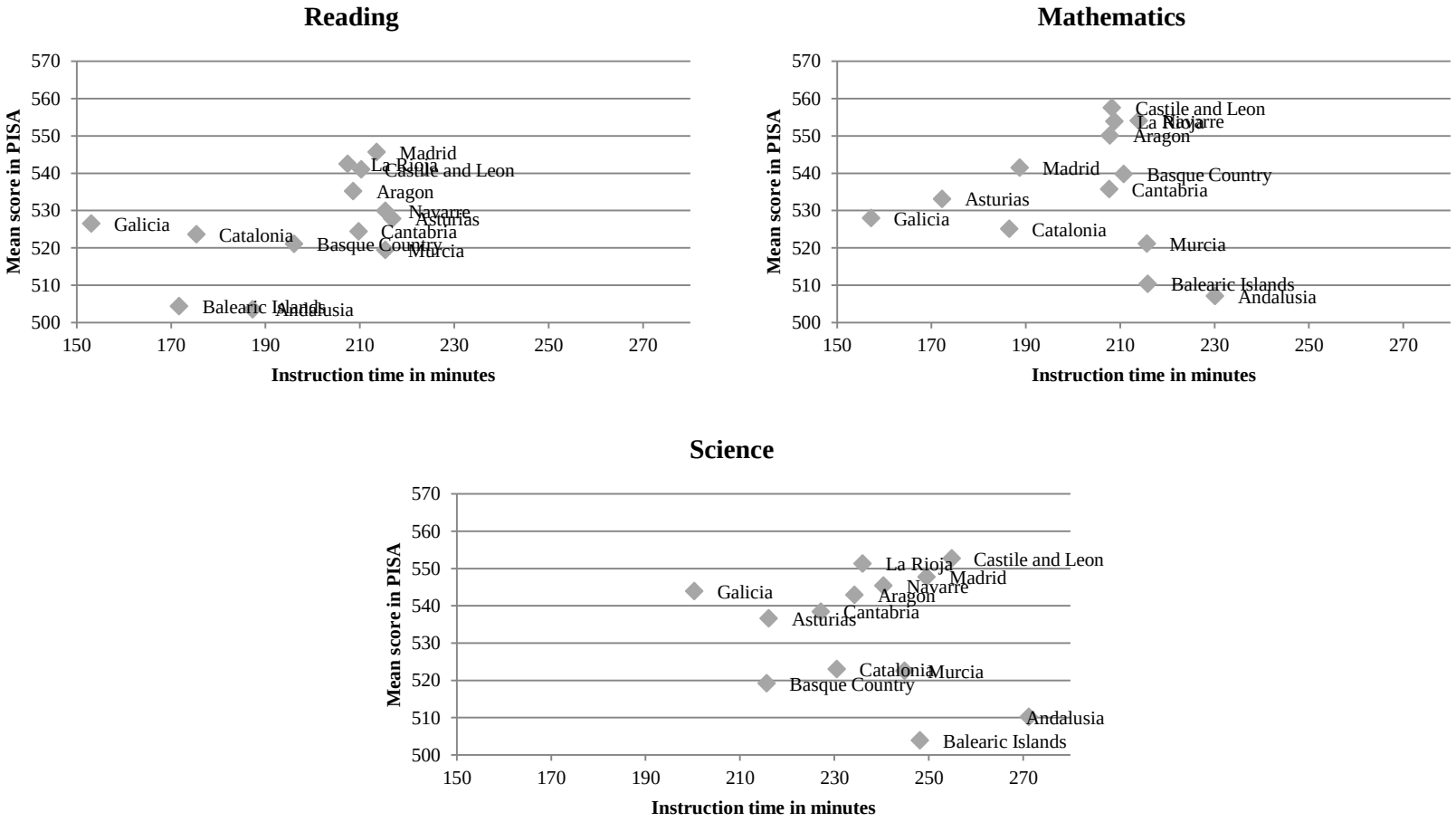
Notes: Standard errors in parentheses are clustered at the school level. The sample contains only non-repeater students of those AACC which have an extended sample in PISA 2009 and 2012. The sum of the number of observations of all specifications for all years differs from the total amount of observations due to missing observations in the additional student and school variables, i.e. sex of the student, immigrant status of the student, ESCS of the student, funding of the school and school ESCS.
Estimation method: Seemingly unrelated regressions (SURE). Estimations have been weighted and clustered by school.
Dependent variable: Average of the five plausible values for the corresponding competence: reading, mathematics and sciences.
Coefficient: ***Significant at 1%, ** significant at 5%, * significant at 10%.
Source: Author's own calculation.

Table A2. Descriptive statistics of scores and instruction time for PISA 2009 and 2012 by Autonomous Community

	PISA 2009													PISA 2012											
		Scores in						Minutes of instruction in							Scores in						Minutes of instruction in					
		Reading		Mathematics		Sciences		Reading		Mathematics		Sciences			Reading		Mathematics		Sciences		Reading		Mathematics		Sciences	
Autonomous Community	**Obs.**	**Mean**	**S.d.**	**Mean**	**S.d.**	**Mean**	**S.d.**	**Mean**	**S.d.**	**Mean**	**S.d.**	**Mean**	**S.d.**	**Obs.**	**Mean**	**S.d.**	**Mean**	**S.d.**	**Mean**	**S.d.**	**Mean**	**S.d.**	**Mean**	**S.d.**	**Mean**	**S.d.**
Andalusia	679	503.57	3.86	507.13	4.21	510.24	4.81	187.28	2.26	230.14	1.21	271.20	9.93	421	524.37	4.29	522.11	5.78	531.81	5.68	193.54	3.23	233.30	1.58	241.20	5.89
Aragon	862	535.23	3.20	550.13	5.19	542.95	3.94	208.61	1.43	207.84	1.31	234.27	9.97	486	541.38	6.46	548.66	4.99	552.96	5.48	212.53	2.33	211.73	1.94	194.39	4.05
Asturias	906	527.79	5.28	533.12	5.01	536.68	5.52	216.86	1.69	172.30	1.65	216.09	6.84	634	544.58	4.67	539.02	4.28	551.64	4.62	216.62	0.91	174.06	2.73	200.96	3.56
Balearic Islands	662	504.36	5.25	510.38	4.11	503.91	4.93	171.73	2.74	215.88	1.46	248.08	14.73	416	521.84	4.81	526.33	5.20	527.83	4.45	173.44	2.38	216.13	1.19	211.18	4.51
Cantabria	872	524.43	4.47	535.76	4.98	538.45	4.74	209.73	1.90	207.68	2.14	227.14	7.58	583	524.32	3.74	535.17	3.41	540.39	3.81	213.30	1.26	211.63	1.06	199.63	4.04
Castile and Leon	783	541.04	4.98	557.51	5.27	552.69	5.09	210.34	2.03	208.27	1.54	254.84	7.65	537	544.75	4.78	553.98	3.66	557.55	4.47	210.36	1.66	210.59	1.59	214.36	5.14
Catalonia	678	523.61	5.38	525.09	6.80	523.04	6.24	175.38	1.48	186.52	3.94	230.52	9.00	552	533.25	5.23	525.41	5.25	519.46	4.85	180.29	1.98	183.20	2.83	212.27	3.65
Galicia	888	526.50	4.16	527.96	3.85	543.92	4.32	153.11	1.59	157.22	1.22	200.29	7.22	545	537.89	4.73	529.42	2.95	546.50	4.67	154.02	1.02	162.67	2.58	184.16	2.93
La Rioja	638	542.47	3.50	553.91	3.96	551.33	3.67	207.45	0.32	208.79	0.36	235.99	1.46	509	534.42	4.05	556.72	3.91	553.81	3.70	211.08	1.08	212.08	1.06	209.57	3.97
Madrid	737	545.64	4.53	541.47	4.72	547.78	4.57	213.57	1.84	188.76	4.16	249.50	6.76	499	550.94	6.49	550.99	4.65	557.96	4.37	221.38	3.76	215.02	6.48	236.00	5.91
Murcia	609	519.48	4.80	521.13	4.64	522.56	4.73	215.38	0.70	215.70	1.11	244.88	8.95	391	517.60	6.17	525.31	7.35	536.10	7.22	219.03	1.28	217.12	0.94	229.81	6.00
Navarre	759	529.90	3.42	554.04	2.56	545.41	3.66	215.39	1.08	213.96	2.61	240.37	4.74	523	549.42	4.99	560.94	4.48	550.96	5.55	214.90	1.99	210.12	1.67	228.43	4.13
Basque Country	2,987	521.04	2.32	539.79	2.31	519.25	2.01	196.07	1.70	210.76	1.75	215.62	3.06	2,056	530.04	2.57	538.42	2.35	534.85	2.21	196.64	1.70	212.70	1.50	210.42	2.83

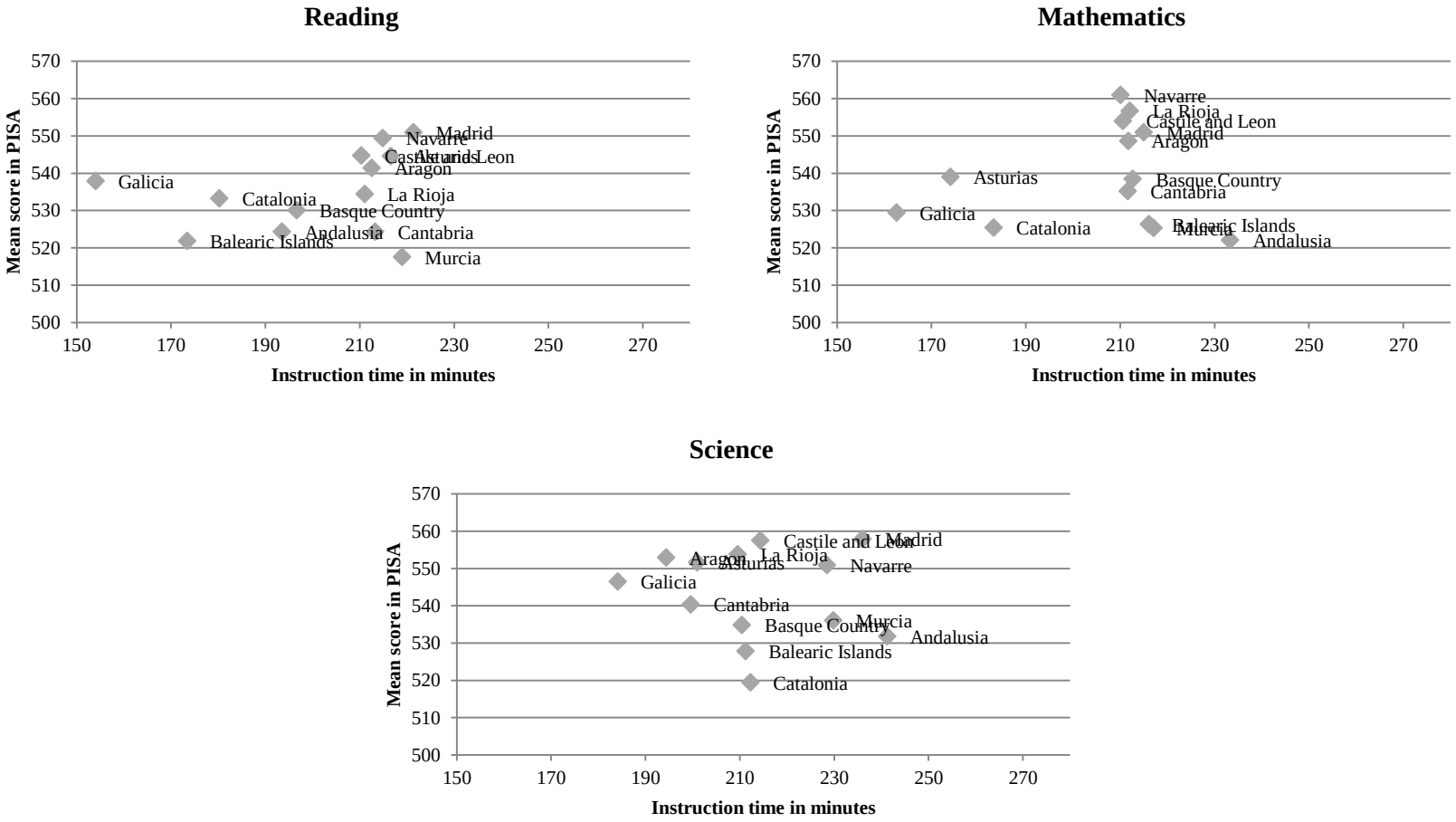
Notes: The sample contains only non-repeater students of those AACC which have an extended sample in PISA 2009 and 2012.
Scores in reading, mathematics and sciences have been obtained using PISA recommended procedures, as the use of the five plausible values, weights and BRR weights. Instruction time has been calculated by using average instruction time by school.
Source: Author's own calculation.

Figure 1. Relationship between instruction time and academic achievement by AACC for PISA 2009



Notes: The sample contains only non-repeater students of those AACC which have an extended sample in PISA 2009 and 2012. Scores in reading, mathematics and sciences have been obtained using PISA recommended procedures, as the use of the five plausible values, weights and BRR weights. Instruction time has been calculated by using average instruction time by school. Horizontal axis: instruction time; vertical axis: mean score in the subject.

Figure 2. Relationship between instruction time and academic achievement by AACC for PISA 2012



Notes: The sample contains only non-repeater students of those AACC which have an extended sample in PISA 2009 and 2012. Scores in reading, mathematics and sciences have been obtained using PISA recommended procedures, as the use of the five plausible values, weights and BRR weights. Instruction time has been calculated by using average instruction time by school. Horizontal axis: instruction time; vertical axis: mean score in the subject.
Source: Author's own calculation.