revista de EDUCACIÓN
Nº 380 ABRIL-JUNIO 2018

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GOBIERNO DE ESPAÑA
MINISTERIO DE EDUCACIÓN, CULTURA Y DEPORTE

Calidad de Revistas Científicas Españolas
FECYT | FUNDACIÓN ESPAÑOLA PARA LA CIENCIA Y LA TECNOLOGÍA | 2016

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DOI: 10.4438/1988-592X-RE-2017-380-373

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Abstract

Given the increasing expansion and use of the results of PISA studies on the evaluation of the scientific, mathematical and linguistic competences of the students, this paper aims to analyse the effect of a set of predictors of performance in Science in Spanish students participating in PISA 2015. For the study, a sample of 32,330 15-year-olds from 17 Autonomous Communities has been taken and hierarchical-linear models have been used that allow the analysis of the possible effect of the different predictors contemplating the nesting of the data at different levels (Students, School Centre and Autonomous Community). 64 predictors were selected as independent variables, some of them included in the questionnaires of PISA 2015 students and centres and the database provided by the Ministry of Education, Culture and Sport (2016a), such as *anxiety of the student, teacher-student relationship, sports habits, interest in science, resources of the centres*, *percentage of foreign students* and *number of students per teacher* in each Autonomous Community, among others. In addition, variables considered as "classic" were included in this type of studies (*gender, academic level of the parents, ownership* and *size of the centre*, *economic investment* by Autonomous Community, etc.). Among the main results we found that 27 variables (24 of Student and 3 of Centre and none of Autonomous Community) were significant predictors of Science performance, analysing the explained variance. The paper concludes with the discussion based on other coincident studies or with contrary results on the variables that have been significant and not significant in the proposed model.

Received: 09-05-2017 Accepted: 12-01-2017

Keywords: PISA, Compulsory Education, Predictive study, Competency in Science, Hierarchical-Linear Models.

Resumen

Dada la creciente expansión y uso de los resultados de los estudios de PISA sobre la evaluación de los alumnos en sus competencias científicas, matemáticas y lingüísticas, el presente trabajo tiene como objetivo analizar el efecto de un conjunto de predictores del rendimiento en Ciencias en los alumnos españoles participantes en PISA 2015. Para el estudio se ha tomado una muestra de 32.330 alumnos de 15 años de 17 Comunidades Autónomas y se han utilizado modelos jerárquico-lineales que permiten el análisis del posible efecto de los distintos predictores, contemplando el anidamiento de los datos en distintos niveles (Alumnos, Centro y Comunidad Autónoma). Como variables independientes se han seleccionado 64 predictores, algunos de ellos incluidos en los cuestionarios de alumnos y de centros de PISA 2015 y de la base de datos facilitada por el Ministerio de Educación, Cultura y Deporte (2016a), como *ansiedad del alumno*, *relación profesor-alumno*, *hábitos deportivos, interés hacia la ciencia, recursos de los centros*, *porcentaje de alumnos extranjeros* y *cantidad de alumnos por profesor* en cada Comunidad Autónoma, entre otros. Además, se incluyeron variables consideradas como “clásicas” en este tipo de estudios (*sexo, nivel académico de los padres, titularidad* y *tamaño* del centro, *inversión económica* por Comunidad Autónoma, etc.). Entre los principales resultados encontramos que 27 variables (24 de Alumno y 3 de Centro y ninguna de Comunidad Autónoma) resultaron predictores significativos del rendimiento en Ciencias, analizando la varianza explicada. El trabajo concluye con la discusión fundamentada en otros estudios coincidentes o con resultados contrarios sobre las variables que han resultado significativas y no significativas en el modelo propuesto.

Palabras clave: PISA, Educación Obligatoria, Estudio Predictivo, Competencia en Ciencias, Modelos Jerárquico-Lineales.

Introduction

The concern for quality is an increasingly evident fact in the world of education, both at national and international levels. In the last few decades, assessment in the field of education has been a priority for all education authorities around the world, and it has become a useful tool to guide education policy, a mechanism for accountability and a means to advance in the search for academic excellence.

Received: 09-05-2017 Accepted: 12-01-2017

PISA (Programme for International Student Assessment) is an OECD (Organization for Economic Cooperation and Development) study conducted every three years which evaluates what 15-year-old students can do with what they have learnt, weighing their choices and making decisions, in the areas of Reading, Mathematics and Science, as well as an innovation area (the 2015 edition assessed the skill Collaborative Problem Solving). Likewise, each edition examines an area of knowledge in detail, and in 2015 it was Science (OECD, 2016).

The spread and impact of this assessment has been such that several countries have carried out education reforms based on their results in the PISA tests (Pongratz, 2013). Over 500,000 students from more than 70 countries participated in PISA 2015, with Singapore (556), Japan (538), Estonia (534) and Finland (531) getting the best results in Science. Spain obtained a medium score in Science of 493, the same as the OECD average (493) and 2 points below the European Union average (495).

By Spanish Autonomous Community, Castilla y León (519), Community of Madrid (516), Navarre (512) and Galicia (512) had the highest scores in Science. The Canary Islands (475), Extremadura (474) and Andalusia (473) obtained the lowest scores (Ministry of Education, Culture and Sports, 2016b) (Table I).

The existence of these differences between the various Autonomous Communities is nothing new in the 2015 edition, and it has motivated numerous studies since Spain participated in the first edition of 2000, applying diverse statistical techniques for analysis, including different variables in the studies (Villar, 2013; Wheater, 2013; Stacey, 2015). Yet we must not only consider and analyse the differences between the Autonomous Communities. We should bear in mind that students, the ultimate unit in the study, are embedded or clustered in schools which, in turn, are clustered in Autonomous Communities. Given the hierarchical structure of the data, one of the most appropriate techniques for this type of studies is the one applied here, hierarchical-linear modelling.

This type of assessments (such as PISA, TIMSS- Trends in International Mathematics and Science Study-, and PIRLS -Progress in International Reading Literacy Study-, etc.) have both defenders and detractors. Some people justify the usefulness of these studies given the motivation generated by the ensuing comparisons (necessary to assess one's own situation) or because they allow conducting studies that go beyond the more limited and less representative local scope (Ministry of Education, Culture and Sports, 2016b; Fernández-Díaz, Rodríguez-Mantilla, & Martínez-Zarzuelo, 2016). Others consider that these assessments and, in particular PISA, have no value to guide teachers or improve schools (Carabaña, 2017). The intention, therefore, is to give them their fair due, without either denying their usefulness or trying to turn them into a means to eclipse the political debate on education (Jover, Prats & Villamor, 2017). The objective of this paper was not to delve into these arguments, but rather to try to analyse the effect which several predictors (Student, School and Autonomous Community variables) have on Science performance.

TABLE I. Science Results by Autonomous Community

	SCIENCE	
	Mean	**SD**
Castilla y León	519.69	79.13
Madrid	516.42	81.55
Navarre	512.41	79.78
Galicia	512.24	82.64
Aragon	508.39	81.23
Catalonia	504.71	84.38
Asturias	501.79	83.64
La Rioja	498.51	87.20
Castilla-La Mancha	497.09	80.90
Cantabria	496.21	80.06
Community of Valencia	494.37	76.47
SPAIN	**493.35**	**83.09**
Balearic Islands	485.71	82.36
Murcia	484.06	82.76
Basque Country	483.38	80.74
Canary Islands	475.13	83.99
Extremadura	474.60	83.83
Andalusia	473.27	84.22

Source: Ministry of Education, Culture and Sports (2016b)

Received: 09-05-2017 Accepted: 12-01-2017

Based on the data provided by the Ministry of Education, Culture and Sports (2016a) and the questionnaires administered to students and school headmasters in PISA 2015, the aim was to study the possible effect on Science performance of Autonomous Community characteristics (*GDP per capita, public expenditure on education,* etc.), school characteristics (*ownership, location, number of students and teachers,* etc.) and personal and family Student features (*sex, parents' level of education, absenteeism,* etc.). These are all "classic" variables included in the majority of multilevel education studies. However, this paper paid special attention to other Student, School and Autonomous Community variables.

Among the Student variables, we wanted to include *student anxiety about assessments* as a predictor, understood as the concern about delivering a lower performance than expected and the possible consequences thereof. According to Furlan (2013), anxiety can lead students to reach negative conclusions regarding their failure, which could lower their self-esteem, generate feelings of incompetence, and lead them to drop out of school. As a result, the student's *motivation towards achievement* may disappear, which could cause dissatisfaction with life or frustration (Lens, Matos, & Vansteenkiste, 2008).

An element related to motivation is student *interest*. Many studies have shown the relationship between school performance and interest in the subject, stating that interest is the true driver that generates the necessary engagement to achieve adequate performance (National Institute for Education Evaluation, 2013; Klug, Krause, Schober, Finsterwald, & Spiel, 2014).

Another interesting variable is *sports and healthy habits*. Since there are so many studies evidencing the effect which sports have on student cognitive and academic development (Rodríguez, Delgado, & Bakieva, 2011; González & Portolés, 2014; Ruiz-Ariza, Ruiz, de la Torre-Cruz, Latorre-Román, & Martínez-López, 2016), it was deemed appropriate to include it in the study.

Regarding *science lessons* and *teacher-student relationships*, Rodríguez Mantilla and Fernández Díaz (2015) pointed out the importance of paying attention to elements such as classroom climate, the way teachers treat students or the clarity of their presentations, among others, so that the learning process is successful. That is, aside from correct teaching practices by teachers, it is necessary to take care of the affective environment in the classroom.

In relation to the School variables, we paid attention, first, to the *amount of resources* and *equipment* as possible predictors, since not all specialised literature agrees on the effect which these variables have on academic performance (Cordero, Manchón, & Simancas, 2012; Flores, 2014; Mediavilla & Escardíbul, 2015; Fernández-Cruz, 2016). Second, having underscored the importance for learning of certain features such as motivation and interest, we deemed it necessary to include variables in the study related to *activities organised by the school* (competitions and sports, music and science activities, etc.) as elements that could be beneficial (Lieury & Fenouillet, 2016).

Among the Autonomous Community variables, aside from the financial ones listed above, we aimed to study the possible effect of the *percentage of students lagging behind in primary education*, of *foreign students* or the *average number of students per teacher*.

Therefore, the general objective of this paper was to analyse the simultaneous effect of a set of predictors on Science performance of the Spanish students who participated in PISA 2015, for each data aggregation level (Level 1: Student, Level 2: School, and Level 3: Autonomous Community), by using hierarchical-linear modelling.

Method

Design and Methodology

This paper's research methodology is quantitative, with a non-experimental design, along the lines of ex-post-facto studies.

Sample

For this study we used the databases provided by the OECD on the PISA 2015 assessment, taking only data from Spain. The total sample was made up of 32,330 students, in 976 schools of the 17 Autonomous Communities (Table II), of which 50.4% were male and 49.6% female. 66.2% of the participating schools were public, 28.4% private with state subsidies, and 5.4% private.

Received: 09-05-2017 Accepted: 12-01-2017

TABLE II. Sample composition

Autonomous Communities	Schools	Students
Andalusia	54	1,813
Aragon	53	1,798
Asturias	54	1,790
Cantabria	56	1,924
Castilla-La Mancha	55	1,889
Castilla y León	57	1,858
Catalonia	52	1,769
Community of Valencia	53	1,625
Extremadura	53	1,809
Galicia	59	1,865
Balearic Islands	54	1,797
Canary Islands	54	1,842
La Rioja	47	1,461
Madrid	51	1,808
Murcia	53	1,796
Navarre	52	1,874
Basque Country	119	3,612
Total	**976**	**32,330**

Source: Compiled by the authors

Variables

The dependent variable we used was scientific literacy, an area examined in greater detail in the 2015 edition of PISA, understood as the ability to explain phenomena scientifically; evaluate and design scientific enquiry; and interpret data and evidence scientifically (OECD, 2016).

The data of the dependent variable were scaled with the Rasch model and expressed by assigning ten plausible values (OECD, 2016), shown on a continuous scale where the OECD country average equalled 500 points and standard deviation was 100 points (Ministry of Education, Culture and Sports, 2016b).

Regarding independent variables, for Level 1: Student, we used as predictors 35 of the items comprising the questionnaire administered to the PISA 2015 students, whose dimensions and evaluated features are shown in Table III. The values of each variable were recoded for their proper inclusion in the model.

TABLE III. Variables of Level 1: Student

<table>
<tr><th>Dimension</th><th>Item</th><th>Name</th><th>Recoded values</th></tr>
<tr><td rowspan="10">Personal, school and family characteristics</td><td>1^{-}</td><td>Sex</td><td>0=Male 1=-Female</td></tr>
<tr><td rowspan="2">2^{+}</td><td rowspan="2">Education level completed by your mother</td><td>0=Primary Education</td></tr>
<tr><td>1= Lower Secondary Education</td></tr>
<tr><td rowspan="2">3^{+}</td><td rowspan="2">Education level completed by your father</td><td>2=Intermediate level VET</td></tr>
<tr><td>3=Upper Secondary Education</td></tr>
<tr><td rowspan="3">4^{-}</td><td rowspan="3">Number of school changes</td><td>0=No change</td></tr>
<tr><td>1=1 Change</td></tr>
<tr><td>2=2 or more</td></tr>
<tr><td>5^{-}</td><td>In the last two weeks, school absences</td><td>0=None
1=1 or 2
2=3 or 4
3=5 or more</td></tr>
<tr><td rowspan="6">In your home, there is:</td><td>6</td><td>A room of your own</td><td rowspan="4">0=No
1=Yes</td></tr>
<tr><td>7</td><td>A quiet place to study</td></tr>
<tr><td>8^{+}</td><td>A computer you can use for school work</td></tr>
<tr><td>9^{+}</td><td>A link to the Internet</td></tr>
<tr><td>10^{-}</td><td>Television sets</td><td>0=None 1=1
2=2 3=3 or more</td></tr>
<tr><td>11</td><td>Books</td><td>0=0-10 1=11-25
2=26-100 3=101-200
4=201-500 5=More than 500</td></tr>
<tr><td rowspan="3">Anxiety and Achievement</td><td>12^{-}</td><td>Even when I am well prepared for an exam, I feel very nervous</td><td rowspan="3">0=Totally disagree
1=Disagree
2=Agree
3=Totally agree</td></tr>
<tr><td>13^{-}</td><td>I feel very tense when I study for an exam</td></tr>
<tr><td>14^{+}</td><td>I want to be one of the best students in class</td></tr>
</table>

Relationship with teachers	15-	Teachers give me the impression they think I am less intelligent than I am	0=Never/almost never 1=A few times a year 2=A few times a month 3=Once a week or more
	16-	Teachers have punished me more harshly than others	
	17	Teachers have made fun of me in front of others	
	18-	Teachers have insulted me in front of others	
Sports practice	19	How many days a week do you go to physical education classes?	0-7 (days)
	20	After school I do exercise	0=No 1=Yes
	21-	Before school I do exercise	
	22+	In the last week, outside school, I have done moderate physical activities	0-7 (days)
	23	In the last week, outside school, I have done intense physical activities	
	24+	I have breakfast before going to school	0=No 1=Yes
Science Lessons	25+	Number of lessons per week	Sample mean-centred
	26	Additional hours per week	
	27-	It is noisy and disorderly	0=Never/almost never 1=In some classes 2=In most classes 3=In all classes
	28	Students can express their ideas	
	29	We spend time in the laboratory doing experiments	
	30+	The teacher clearly explains the importance of science concepts for life	
	31	We do research to prove certain concepts	
Interest in science and technology	32+	I watch science programmes on television	0=Never/almost never 1=Sometimes 2=Regularly 3=Very often
	33+	I visit science websites	
	34+	I read science journals or articles	
	35+	I like to use digital devices	

Source: Compiled by the authors. *Note*: -Items which have shown a significant negative effect. +Items which have shown a significant positive effect

For Level 2: School, we took 21 of the items comprising the questionnaire administered in PISA 2015 to headmasters. The dimensions, evaluated aspects and recoded values are shown in Table IV.

TABLE IV. Variables of Level 2: School

Dimension	Item	Name	Recoded values
Ownership and location	36-	Type of school	0=Private 1=Private with state subsidies 2=Public
	37	Location	0=Rural Area rural (less than 3,000 people) 1=Small town (3,000-15,000 people) 2=Town (15,000-100,000 people) 3=City (100,000-1,000,000 people) 4=Large city (over 1,000,000)
Number of Students	38	Total number of students	Sample mean-centred
	39	Number of boys	
	40	Number of girls	
Number of teachers	41	Number of full-time teachers	
	42	Number of part-time teachers	
ICT resources	43	Total number of digital whiteboards	
	44	Total number of projectors	
	45	Number of computers with Internet for teachers	
Activities offered	46	Musical band, orchestra or choir	0=No 1=Yes
	47	Computing/Technology	
	48	Sports	
	49+	Science Competitions	
Science Classes	50+	There is enough laboratory equipment	
	51	There is additional laboratory support staff for science classes	
	52	The school spends additional money on updating equipment	
Student assessments	53	Standardised tests are used	
	54	Tests prepared by teachers are used	
Evaluation of school for improvement	55	We conduct internal evaluations or self-evaluations	0=No 1=Yes, on our own initiative 2=Yes, on a mandatory basis
	56	External evaluations are conducted	

Source: Compiled by the authors. *Note*: -Items which have shown a significant negative effect. +Items which have shown a significant positive effect

Received: 09-05-2017 Accepted: 12-01-2017

For Level 3: Autonomous Community, we took the 8 variables (Table V) (data provided by the Ministry of Education, Culture and Sports, 2016a). In order to facilitate interpretation of results, these variables were sample mean-centred.

TABLE V. Variables of Level 3: Autonomous Community

Dimension	Item	Name
Economic	57	GDP per capita (euro)
	58	Public expenditure per public and subsidised student (euro)
	59	Public expenditure per public student (euro)
Proportion of public schools	60	% of public schools
Students	61	% of students who lagged behind in Primary Education
	62	% of foreign students
	63	Average number of students per teacher
	64	% of students participating in integrated content and foreign language learning experiences in Lower Secondary Education

Source: Compiled by the authors

Data Analysis

To achieve the study objective set, we used hierarchical-linear modelling as this allows collecting the embedded data structure at various levels (in this case: Student, School and Autonomous Community). The use of this methodology helps distinguish more precisely the effects due to each one of the levels above. To analyse the data, we used the software MLwin 2.36.

Results

Below is part of the modelling process for the multilevel analysis: the null model and the definite model, upon which the final interpretation was based.

Estimate of null model

The null model (Table VI) helps evaluate appropriateness of using multilevel models. The fixed parameter indicates the intercept value (mean performance in Science for all the subjects in the sample = 489,967).

TABLE VI. Estimate of null model

FIXED PART	
Parameter	**Estimate (Standard Error)**
Constant	489.967(3.083)
RANDOM PART	
Level 1: Student	
Science Variance	6,225.496(45.068)
Level 2: School	
Science Variance	590.640(35.754)
Level 3: Autonomous Community	
Science Variance	154.936(56.966)
Likelihood Ratio	**453,611.400**
Number of parameters	**4**
N	**32,330**

Source: Compiled by the authors

The random part of the model showed variances in the residuals at the three levels. The parameters obtained were statistically significant in the different levels considered[1], and therefore Students differed in Science performance (6,225.496/45.068 > 1.96). Schools and Autonomous Communities also differed in their mean performance (590,640/35,754 and 154,936/56,966, respectively, are higher than 1.96). The significance of these parameters indicates there is unexplained variance in the three levels, which justified continuing expansion of the model to explain the

(1) In accordance with Gaviria and Castro (2004), the criterion we followed to decide whether a parameter was significant or not (for alpha=0.05) was if the quotient between the parameter estimate and its standard error was higher than 1.96

greatest amount of variance possible. Therefore, we included first, second and third level predictors in the fixed and random parts of the model.

The Likelihood Ratio had a value of 453,611.400 for a model with 4 parameters, a value to be compared with the one obtained in the definite model, which allows evaluating the adjustment of the final model.

Expanded model

First, we entered the first level variables (included in Table III) in the fixed and the random parts of the model, discarding any with no significant parameters. The procedure was repeated for the second and third level variables (included in Tables IV and V). 24 first level variables, 3 second level ones and none in the third level, showed significant parameters (see Table VII).

TABLE VII. Definite model

FIXED PART	
Parameter	**Estimate (Standard Error)**
Constant	446.326(4.895)
Item	
1	- 12.104(0.915)
2	6.669(0.505)
3	6.665(0.460)
4	- 16.202(0.726)
5	- 12.242(0.792)
8	13.199(1.917)
9	12.271(2.745)
10	- 4.185(0.620)
12	- 7.956(0.498)
13	- 7.199(0.533)
14	12.083(0.500)
15	- 4.314(0.502)
16	- 4.604(0.603)

Received: 09-05-2017 Accepted: 12-01-2017

18	- 2.882(0.762)
21	- 31.953(0.931)
22	2.242(0.180)
24	4.383(1.266)
25	8.037(0.247)
27	- 3.517(0.502)
30	2.905(0.485)
32	3.317(0.676)
33	8.319(0.702)
34	3.055(0.740)
35	10.150(0.660)
36	- 3.868(0.923)
49	5.981(1.146)
50	3.334(1.111)
RANDOM PART	
Level 1: Student	
Science Variance	3,552.683(37.049)
Level 2: School	
Science Variance	205.196(47.906)
Item	
3	22.696(7.641)
5	49.189(16.192)
25	4.162(1.045)
33	49.784(11.109)
Level 3: Autonomous Community	
Science Variance	72.403(26.526)
Likelihood Ratio	**236,126.100**
Number of parameters	**35**
N	**32,330**

Source: Compiled by the authors

Considering the fixed part of the model, average performance in Science has dropped to 446.326. This value refers to the average estimated performance of *male* students whose *parents completed Primary Education*, without *changing school* throughout their school life,

Received: 09-05-2017 Accepted: 12-01-2017

without having been absent from school in the last two weeks, without *a computer* at home, without *Internet connection* and without *a television set* at home. Likewise, this average corresponds to students who *do not feel nervous* or *tense* when studying for an exam, who *want to be one of the best in class*, who do not suffer any *contempt*, *harsh punishments* or *insults* from their teachers; who *have breakfast* and practice *sports moderately before going to school*; with a number of Science lessons per week equal to the sample average (3), who belong to classes which are *orderly* but where *teachers do not explain clearly the importance of scientific concepts applied to everyday life;* these are students who *show no interest in science and technology*, and who belong to *private* schools where there are no *science competitions* nor enough *laboratory equipment*.

In the random part of the model, there is still unexplained variance in Science performance and at the three levels. Nonetheless, the random parameter values have been reduced compared to the initial values of the null model. This aspect is analysed below.

The results showed the significance of some of the predictors. In the variables related to *Personal, family, school and home characteristics*, the Science performance average was 12.104 points less for *girls*. For every higher level of *education completed* by the mother or the father, the student's average performance increased 6.66 points in both cases, and for every *change of school* and *absence from class* the average in Science fell 16.20 and 12.24 points, respectively. Students who had *a computer* at home with which to study, increased their average by 13.19 points, and if they had *Internet*, 12.27 points more. While the number of *books* present in the household showed no significant value in the model, students with *a television set* at home diminished their average by 4.18 points (and double in the case of students with 2 television sets and triple for those with 3 or more).

Regarding *Anxiety and Achievement*, for every degree of increase in the student's level of *tension when studying* and level of *nervousness before an exam,* average performance dropped 7.19 and 7.95 points, respectively. However, for every degree of increase in the student's wish to be *one of the best students in the class*, the average rose 12.08 points.

In the case of *Teacher-student relationship*, the predictors which were most significant have all shown a negative effect. Thus, average Science performance fell 4.31 points for every degree of increase in the students' perception of *having their intelligence underestimated by teachers*; it went down 4.60 points for every level of increase in the students' perception of being *punished more harshly than their peers* and it dropped 2.88 for every degree of increase in the use of *insults* by teachers towards students.

Regarding *Sports practice*, for every day which students did *physical activities moderately outside school*, there was a 2.24 increase in average Science performance (for *intense physical activities* no significant effect was found). However, results show that those who did *exercise before going to school* diminished their average by 31.95 points. On the other hand, we found that those who *had breakfast before going to class* increased their average by 4.83 points.

In relation to *Science Lessons*, for every *additional session* above the sample mean (3 sessions/week), performance rose 8.03 points (with no significant result from the effect of *additional hours* outside school). For every degree of increase in the *noise and disorderliness in the classroom*, the average fell by 3.51 points. In turn, while variables such as the *chance given students to express their ideas, doing practical experiments in the laboratory* and *research* showed no significant values, for every degree of increase in the *clarity with which teachers explain the importance of science concepts for everyday life*, average performance rose 2.90 points.

All predictors related to the *Interest in science and technology* have been significant and with a positive effect. Thus, for every degree of increase in *watching science programmes on television*, *visiting science websites* and *reading science journals or articles*, the average rose 3.31, 8.31 and 3.05, respectively. Likewise, the average went up 10.15 points for every degree of increase in the *use of digital devices*.

Regarding the School variables, we found significance in *Ownership*, with 3.86 points less in the Science average for students from private schools with state subsidies and 7.72 less for those from public schools compared to students from private schools. Students from schools that organised *science competitions* and that *had enough laboratory equipment* obtained 5.98 and 3.33 more average points, respectively. All other school variables (*location, number of students* and *teachers*, *technology resources, type of student assessments conducted*, *school evaluations*, etc.) showed no significant values.

Similarly, none of the Autonomous Community variables *(GDP per capita, public expenditure per student, percentage of public schools*, etc.) have shown to be significant predictors in the model.

To determine adjustment of the definite model compared to the null model, we compared the *Likelihood Ratio* of the two models. The difference showed a drop in the adjustment statistical value in the final model, which indicates a chi-squared difference of 217,485.30 with 31 degrees of freedom, a value which is significant at 0.01, confirming the better adjustment of the definite model compared to the null model.

To understand how much variance of the dependent variable is explained by all the predictor variables of the model and to analyse the proportion of variance associated to each one of the three levels, it was necessary to compare the random parameter values of the definite model and the null model, through the R^2quotient (Snijders & Bosker, 2012). The 27 predictors included in the model help explain nearly 43% of the differences between students (R^2=0.429), 65% of the differences between schools (R^2=0.652) and 53% of the differences between Autonomous Communities (R^2=0.532). While the explained variation in Science performance was 45% (R^2=0.4505).

Discussion and Conclusions

The main objective of this paper was to produce empirical evidence of Science performance predictors for the Spanish students participating in PISA 2015. To this end, we estimated a multilevel regression model that helped identify a series of factors which, as a whole, showed a significant effect on the attainment of Science literacy.

The final model, made up of 24 variables for Level 1: Student and 3 for Level 2: School, helped explain 43% of the differences between students, 65% of the differences between schools and 53% of the differences between Autonomous Communities, with no significant variable being found for Level 3: Autonomous Community. Although these values were not excessively high, neither were they negligible, since, aside from allowing identification of significant predictors, they allowed ruling out others which could have appeared substantial. Below are the main conclusions drawn from this study.

In relation to Student variables:

- The student's *sex* was a significant predictor for Science performance, with females obtaining a lower average (results which match those of Ruiz de Miguel, 2009, and Rodríguez et al., 2011). In this regard, specialised literature highlights the importance of the variables personality, interests, skills acquired in the years prior to schooling and possible sociocultural limitations, for the performance of boys and girls (Inda-Caro, Rodríguez-Menéndez, & Peña-Calvo, 2010), therefore it is necessary to further examine the factors related to these different results in order to bridge any existing gender gaps in the field of education.

- Although studies such as those by Cordero et al. (2012) show there is no relationship between *parents' education level* and academic performance, this study found a significant effect both in the case of the education level of mothers and fathers. The higher the education level of parents, the higher the student Science performance. Therefore, and given the significant weight of family stimulation and motivation on their children's academic performance (Van Ewijk & Sleegers, 2010; Moledo, Rego & Otero, 2012), while the education level of parents is not an element that can be modified, collaborative and work strategies with the families should be established.
- The *number of school changes*, as well as *absences from class,* showed negative effects. It seems evident that having students change schools (whether for disciplinary reasons, parents' work or other) is detrimental to the Science literacy assessed in PISA, perhaps due to a certain lack of adaptation (Arrebola, 2013). Also, many studies insist on the negative effect of school absenteeism on education (Choi de Mendizábal & Calero Martínez, 2013; Mediavilla & Escardíbul, 2015; Izquierdo, 2016), and thus these are two aspects that need to be considered, essentially, by schools and families.
- As for certain basic home possessions, we found that as the *number of television sets* rose in the household, students' Science performance dropped significantly. On the other hand, having or not *their own room, a quiet place to study* or *the number of books in the house* showed no significant values. This could be an indicator, as pointed out by Cordero et al. (2012), that the family's purchasing level need not condition students' academic performance, even though other authors believe otherwise (Ruiz de Miguel, 2009). However, we found that having a *computer to study with* at home, as well as *Internet connection*, had a positive effect on learning Science (which matches the results of Fernández-Cruz, 2016).

Received: 09-05-2017 Accepted: 12-01-2017

- The feelings of *tension, insecurity* and *anxiety about studying or before an assessment test*, significantly diminished student Science performance, while those students who felt highly *motivated and wished to be one of the best students*, had higher averages. In this sense, student self-image and self-esteem play an obvious role, as they are factors which can help diminish anxiety and nervousness regarding assessments and studying (Alegre, 2013). Therefore, it would appear advisable to develop student strategies to strengthen these traits, through workshops, seminars or other school activities.
- Student perception of *poor relationships with teachers* (underestimating, punishments and insults) diminished Science performance, as well as the perception of *disorderliness in the classroom* (results which match those of Ruiz de Miguel, 2009). In turn, the greater the *clarity in the teachers' explanations* and the more *weekly hours of Science*, the higher the performance. This makes manifest the important role of affective variables (treatment of and respect for students) and teaching variables (control over classroom climate and clear explanations) (Rodríguez Mantilla & Fernández Díaz, 2015; Fernández Díaz, Rodríguez Mantilla, & Fernández Cruz, 2016). These are variables that can be changed to reinforce attainment of Science literacy among students.
- Regarding sports or healthy habits for students, while it struck our attention that those who *do sports before going to school* had significantly lower results, *having breakfast before going to school* and doing *sports moderately outside school* during the week, had a positive effect on Science performance. Along these lines, there are several studies that show the positive effect of doing physical activities on academic performance (Ruiz-Ariza et al., 2016), brain function, concentration (Rodríguez et al., 2011; Ardoy et al., 2014), and on educational motivation and healthy behaviours (González & Portolés, 2014), so it would seem necessary to tend to physical development at school as a factor related to a proper student learning process.
- Students who enjoyed *using technology devices*, who read *articles*, watched *television programmes* and checked *science websites,* obtained better results in Science. If we consider that interest is one of the components of intrinsic motivation and one of the reasons why students enjoy learning (Ministry of Education, Culture and

Sports, 2016b), it makes sense that students with a greater interest in Science achieve higher results. Therefore, the recommendation is for schools to work on developing strategies to strengthen student engagement and motivation (Camacho-Miñano, 2015).

In relation to the School variables, *ownership* was a significant predictor, with private schools obtaining the highest results. There are several studies along these lines (Flores, 2014; Ministry of Education, Culture and Sports, 2016b), while others, such as Cordero et al. (2012), have shown there are no differences between the various types of schools. Authors such as Choi de Mendizábal and Calero Martínez (2013) or Izquierdo (2016) have explained the existence of these differences by relating school ownership to the type of students they admit, their independence to manage resources and budgets, hire teachers and conduct assessments. Regarding these aspects, our study has drawn the following conclusions:

- While Mediavilla and Escardíbul (2015) noted in the PISA 2012 assessment that the ICT (Information and Communication Technology) variables had an impact on attainment of Mathematics (more than on the other competencies assessed: Reading and Science), in this study, the *amount of technology resources* at the school showed no significant effect on Science performance. In this sense, we believe the statement by Fernández-Cruz (2016) is of importance when he asserted that the mere presence of technology resources at schools was not enough to develop various student skills, and rather that it was more important to use said resources properly.
- Students from schools that conduct *Science competitions* and that have *enough laboratory equipment,* significantly increased their performance in scientific literacy assessed in PISA. There is an evident relationship between this variable and undertaking science competitions, as several studies show the benefits of this type of activities for student motivation, learning and interest in the subject (Lieury & Fenouillet, 2016; Arrebola, Barreiro, Gómez, & Chocrón, 2017). Nonetheless, it is striking that incurring *additional expenditure to update equipment* or *having additional laboratory staff* (which explicitly or implicitly entail more financial spending), were not significant. This could indicate, once again, that proper use

of basic resources to deliver Science lessons is more advantageous for student learning than additional financial investments.

- Similarly, there was no significance in the variables related to the school's financial resources, such as *school location* (rural area, small town, city, large city, etc.) or *size* (based on the number of students and teachers), therefore the differences of large, medium or small schools, in rural areas, cities or large cities, are not due to these variables.
- Regarding *the type of assessments* used by the school, results indicate that not using assessments prepared by teachers or standardised assessments are significant factors in Science performance. The topic of assessments has been widely covered in specialised literature and, at times, has generated more controversy than agreement. The OECD (2013) has pointed out that a determining factor for schools to perform better academically is having assessment independence, with advantages in the use of results in external and standardised assessments. Nonetheless, authors such as Hopkins (2008) note that in order for these assessments to be useful, they need to provide relevant and updated information that helps detect the educational response required by each student. Perhaps then we should ask whether the problem lies in the quality of the information provided by these external assessments or in the incorrect use of the information obtained.
- According to INEE [National Institute for Education Evaluation] (2013), one of the factors influencing student performance is the quality and improvement of the school's internal procedures (such as level of independence and efficient management of organisational and educational procedures, among others). To this end, it is necessary to conduct internal evaluations (or self-evaluations) and external ones to determine strengths and weaknesses and thus design continuous improvement plans for the school. In this study, the use of *internal or external evaluations* for this purpose did not show significant values on student Science performance, therefore we should ask whether application of these assessments and improvements plans has a real impact on student academic performance.

Thus, results do not appear to show a clear positive and significant effect on student performance of increasing school resources (findings which match those of Escardíbul and Calero, 2013).

Regarding the Autonomous Community variables, authors such as Martínez, Reverte and Manzano (2016) stated that the existing differences between Spanish Autonomous Communities were related to the sociocultural, economic-labour and educational characteristics of each region. Others, such as Bolívar and López (2009), indicated that the education investment of the various Autonomous Communities was a determining factor for the academic success of their students. However, in this study, none of the variables were significant as predictors of student performance in Science (neither *GDP per capita*, *public expenditure per student, average student-to-teacher ratio*, etc.). These results, in addition to the fact that only the Student and School variables included in the model helped explain more than 53% of the existing variance between Autonomous Communities, show the need for a greater reflection on the real impact which education and economic policies in the area of education have on the student learning process. However, caution should be exercised when interpreting the results found, since we were never able to identify underlying causal relationships as this was a non-experimental study.

Finally, and beyond the above statistical-analytical limitation, we should highlight the contribution of this paper to the specific area of research on school performance and PISA assessments, in general, having, furthermore, provided results that are consistent with previous studies and that point towards new lines of research.

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Received: 09-05-2017 Accepted: 12-01-2017