Influence of bullying on mathematics achievement

Influencia del acoso escolar sobre el rendimiento en matemáticas

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Abstract

The educational system must guarantee the well-being of students in their school environment through adequate training that makes academic success possible while promoting equal opportunities through integration in scenarios of diversity. Bullying is a global problem that negatively affects adolescents, with consequences that can be long-lasting. The aim of this research is to analyze the factors that increase bullying and examine how bullying affects the academic performance of Spanish students in mathematics. The analysis is done at the national and regional levels by Autonomous Communities. For this purpose, PISA 2018 data for Spain are used. In this study, descriptive and inferential statistics and regression analysis are used to examine the relationships between the variables and estimate the impact of bullying on mathematics proficiency scores, controlling for the influence of other variables related to the characteristics of the student (socioeconomic factors) and the high school. The results

for Spain show that people who suffer bullying have a lower average score in mathematics. Specifically, the regional analysis shows that the effect of bullying on scores is negative and significant in six of them: Catalonia, the Valencian Community, Galicia, the Balearic Islands, the Basque Country, and the Region of Murcia. Excepting the last case, these are regions with two official languages and where the incidence of bullying exceeds the national average. The results of this study provide knowledge about the type of variables that have a greater impact on bullying, whiRch may be useful for promoting educational inclusion. Thus, these results point to the importance of considering linguistic diversity in intervention programs against bullying, along with other factors that increase the heterogeneity of the student body.

Keywords: bullying, mathematics achievement, regression, PISA, educational policy.

Resumen

El sistema educativo debe garantizar el bienestar del alumnado en su entorno escolar, mediante una formación adecuada que posibilite el éxito académico, promoviendo, además, la igualdad de oportunidades a través de la integración en escenarios de diversidad. El acoso escolar es un problema global que afecta negativamente a los adolescentes y cuyas consecuencias pueden ser duraderas. El objetivo de esta investigación es analizar los factores que elevan el *bullying* y examinar cómo el acoso escolar afecta al rendimiento en matemáticas de los estudiantes españoles. El análisis se hace a nivel nacional y a nivel regional, por comunidades autónomas (CCAA). Para ello se utilizan los datos de PISA 2018 para España. En este estudio se hace uso de la estadística descriptiva e inferencial y del análisis de regresión para examinar la relación entre las variables y estimar el impacto del *bullying* sobre la puntuación en la competencia matemática controlando por la influencia de otras variables relativas a características del alumnado (factores socioeconómicos) y del centro educativo. Los resultados obtenidos para España reflejan que las personas que sufren *bullying* tienen una puntuación media inferior en matemáticas. En concreto, el análisis regional muestra que el efecto del acoso escolar sobre las puntuaciones es negativo y significativo en seis de ellas: Cataluña, Comunidad Valenciana, Galicia, Islas Baleares, País Vasco y Región de Murcia. Salvo en el último caso, se trata de CCAA con dos lenguas oficiales y donde la incidencia del *bullying* supera la media nacional. Los resultados de este trabajo aportan conocimiento sobre el tipo de variables que inciden en mayor medida en el *bullying*, pudiendo ser de utilidad para promover la inclusión educativa. Así, estos resultados apuntan a la importancia de considerar la diversidad idiomática en los programas de intervención frente al acoso, junto con otros factores que elevan la heterogeneidad del alumnado.

Palabras clave: acoso escolar, rendimiento en matemáticas, regresión, PISA, política educativa.

Introduction

One of the principal objectives of the educational system is to promote students' well-being in their school environment, not only by offering them teaching that will lead to their academic success but also by integrating and satisfying the needs of all students. This is closely related to the concept of school climate, which refers to the quality of relationships among the participants in the educational system. Although this term is difficult to define and measure, a positive school climate is easy to recognize (Ministerio de Educación y Formación Profesional [MEFP], 2019; OECD, 2019; Schleicher, 2019). Students notice a school environment where they feel integrated and their relationships with other students and teachers are respectful.

Concerning school conviviality, Rodríguez-Muñiz et al. (2022) states the following:

"The study of the relational climate in schools has increased due to the ever more frequent situations and behaviors contrary to conviviality, which add to greater social sensitivity and the increased interest of educational administrations and institutions in providing solutions to these problems." (p. 2).

Although Spain has a solid regulatory and documental base addressing bullying and conviviality in schools, it does not have any specific regulation to tackle this issue (Cerezo and Rubio, 2017). Law 8/2021, which aims to visualize and correct these types of behaviors, has been an advance in that it establishes the obligation for every school to implement a conviviality plan, accompanied by action protocols to identify and address situations of harassment, abuse, bullying, cyberbullying, and other inappropriate treatment.

Bullying is a problem that affects every country, producing serious consequences for the students who have been bullied. According to Olweus (1994) and Olweus et al. (2019), a pioneer in research on bullying, a person is being bullied when they are repeatedly subjected to negative actions by one or more people, as long as the actions are intentional and there is an imbalance of power between the person who is bullying and their victim. This problem dates back in time, although systematic studies did not begin until the beginning of the seventies. The analysis was initiated in Scandinavia, and

in the following decade, academic and social interest increased in other countries such as Australia, the United States, Japan, and the United Kingdom.

The literature exploring the adverse effects of bullying and the factors that foster it is scarce. In the international context, Ponzo (2013) can be mentioned for Italian students, using data from PIRLS 2006 and TIMSS 2007[1] reports. This author concludes that the benefits of preventing bullying do not only influence educational levels but also equal opportunities since students with lower socioeconomic levels or of different nationalities tend to be victims of bullying more frequently. Ammermueller (2012), using data from TIMSS 2003 for 11 European countries, shows that the student's gender and social and migratory origin influence bullying, and being a victim has a significant negative effect on present and future school performance. Kibriya et al. (2017) use data from the TIMSS 2011 report on students in Ghana, one of the countries with the poorest population and the worst academic performance in the world. Their results show that students who are victims of bullying score lower than their classmates in standardized mathematics tests.

Recently, Yu and Zhao (2021), using PISA data belonging to students from 51 countries and different models, estimated the direct consequences of bullying on academic literacy and social integration. Their results indicate a negative relationship between being a victim of bullying and mathematics achievement.

Among the studies carried out in Spain, García-Continente et al. (2010) use a sample of 2727 students from 66 high schools in Barcelona to examine bullying, considering factors such as age, adverse emotional state, and addictive substance consumption, among others. In their analysis, they explain that boys show slightly higher levels of bullying than girls. They also find a positive relationship between being a victim of bullying and alcohol and tobacco consumption.

The study by Rusteholz et al. (2023) focuses on students from schools in the Community of Madrid. Their results, based on aptitude tests given in 2017, show an increased probability of lower achievement in environments where bullying occurs.

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[1] PIRLS: Progress in International Reading Literacy Study and TIMSS: Trends in International Mathematics and Science Study.

Therefore, this is a research line of great relevance. It is necessary to explore the characteristics of the students who are victims of bullying and its repercussions for mathematic performance in order to propose mechanisms and strategies for its prevention and actions to respond to its occurrence. This study focuses on this line. We use data from PISA 2018 for this research. The main objective of this study is to analyze the causal relationship between bullying and the academic performance of 15- and 16-year-old Spanish students (generally in their fourth year of ESO in Spain, which corresponds to the second year of high school in the US). We consider the students' socioeconomic factors that could also influence their performance and other characteristics relevant to their school. The analysis focuses on the scores obtained in mathematics due to its connection to STEM degrees and the significance these have for the students' future job opportunities and economic development. The results for Spain as a whole are compared with those for the country's regions (Autonomous Communities), centering predominantly on three: Catalonia, the Basque Country, and the Region of Murcia. The first two are among the regions with the highest rates of bullying in Spain. The Region of Murcia was selected because it has one of the lowest rates of bullying and also because of its particular characteristics, such as its large immigrant population and the low socioeconomic levels of its students (MEFP, 2019). The analysis also aims to identify the factors related to bullying, which is relevant when planning proposals to reduce its occurrence. The research questions of this study are:

- What is the profile of students most likely to suffer from bullying?
- How does bullying affect students' mathematics achievement?
- Are there differences among regions in the incidence of bullying? Are there differences in the effects of bullying on mathematics achievement?

Methodology

The methodology used is quantitative, descriptive, transversal, and based on information taken from the seventh round of the Program for International Student Assessment (PISA). PISA is a triennial study comparing education worldwide that was first conducted in the year 2000. Its main objective is to discover the abilities and skills of 15- and 16-year-old students, focusing on the assessment of three competences: Reading, Mathematics, and Science. The analysis of this study centers on the mathematics abilities of Spanish students based on the PISA 2018 data.

Variables and sample characteristics

In the seventh round of PISA, 79 countries and 600000 students participated, representing a total of 32 million. In the case of Spain, the sample comprised 35943 students belonging to 1089 high schools distributed among the different regions[2]. In this study, we have considered the sample for Spain and 17 sub-samples corresponding to each of the Spanish regions.

The variables used in this analysis are the mathematics scores (SCORE)[3], indicators of bullying, and variables related to the characteristics of the student (socioeconomic factors) and the high school. A particularity of the PISA assessment is that the scores are a relative measure that depends on the results of all the participants. There are no maximum or minimum scores; the results are scaled to a normal distribution, with a mean of 500 points and a standard deviation of 100 points, using the sample of the OECD countries in the year 2000 as a reference (MEFP, 2019).

Different contextual questionnaires directed toward students, families, high schools, and educators are also included in the PISA evaluations. The questionnaire given to the students is quite broad, collecting information about the student's socioeconomic characteristics. PISA began addressing the

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2 The sample used in this study does not include all the students who participated in the PISA assessment in Spain in 2018 since many of them (around 9,100) chose not to reveal if they had been victims of bullying.

3 The results of the PISA assessment do not consist of one value. For each student, 10 "plausible values" are calculated based on the distribution of the score values the students received. This occurs because, in PISA, students only respond to some of the questions on the test, not to all of them, and it is necessary to estimate how they would have responded to all the questions.

issue of bullying in its questionnaires in 2015, evaluating the frequency, type of bullying, and environment in which it takes place.

Due to the diversity of the information on intimidation and school violence and their different conceptualizations, we have considered various variables to measure bullying. Violent attitudes can be manifested as physical contact (hitting, kicking, etc.), verbal aggression (taunts, threats, and insults), or relational (being excluded from activities, spreading defamatory rumors, etc.). To explore this distinction, we have considered three binary variables, PHYSICAL, VERBAL, and RELATIONAL, which indicate whether each of these three types of bullying has occurred. These variables are generated from the information collected in the questionnaires the students have answered.

These three types of bullying have been combined into a single index (BEINGBULLIED) constructed by the OECD, which reports on students' degree of exposure to bullying. This index has also been taken into account in this study. The index has a mean of 0 and a standard deviation of 1 for the OECD average in the year 2000. When the index shows positive (negative) values, it indicates a higher (lower) rate of bullying than the average of the OECD countries (MEFP, 2019).

In addition to the variables related to bullying, other variables reflecting socioeconomic characteristics are included in the descriptive and econometric analysis. Table I lists and describes all the variables used in the analysis, distinguishing among the socioeconomic characteristics of the student, the characteristics of the high school, and diverse indicators of bullying.

TABLE I. Definition of the variables used in the study

Socioeconomic characteristics of the student	
FEMALE	1= Female, 2= Male.
REPEAT	1= Repeated a grade, 0= Did not repeat a grade.
ESCS	Index of the student's economic, social, and cultural status. It has a mean of 0 and a standard deviation of 1 for the OECD average in the year 2000. Positive values indicate a higher-than-average socioeconomic level.
IMMIGRANT	1=Native, 2= 2nd Generation, 3 = 1st Generation.
ABSENTEE-ISM	Entire days absent from high school in the last two weeks: 1= None, 2= One or two, 3= Three or four, 4= Five or more.
LANGUAGE	Language generally spoken at home: 0= The same as the test, 1= Another.
High school characteristics	
PUBLIC	0= Private and Semi-private, 1= Public
LOCATION	Location of high school determined by population: 1= Rural (fewer than 3000 inhabitants), 2= Town (from 3000 to 14999), 3= Small city (from 15000 to 99999), 4= Medium-sized city (from 100000 to 1000000), 5= Big city (more than 1000000 inhabitants)
Indicators of bullying	
VERBAL	Reflects whether the student has been verbally bullied in the last 12 months: 0= Has not been bullied, 1= Has been bullied.
PHYSICAL	Reflects whether the student has been physically bullied in the last 12 months: 0= Has not been bullied, 1= Has been bullied.
RELATIONAL	Reflects whether the student has been relationally bullied in the last 12 months: 0= Has not been bullied, 1= Has been bullied.
BEINGBUL-LIED	Index of exposure to bullying. It includes the frequency, during the 12 months previous to the PISA test, with which students had the following experiences at school: Other students "intentionally excluded me"; "made fun of me"; "threatened me"; "took or destroyed my things"; "hit or pushed me"; and "spread malicious rumors about me."

Source: Compiled by the authors based on PISA 2018 data. (https://www.oecd.org/pisa/data/2018database/).

Bullying by regions

Spain is a country with a low rate of bullying, obtaining a value of -0.21 on the bullying index (BEINGBULLIED), which is well below the OECD average. Specifically, it occupies the fourth-lowest position, higher only than the

Netherlands (-0.30), Japan (-0.28), and Portugal (-0.25). In contrast, the highest values belong to New Zealand (0.40), Latvia (0.37), Malta (0.33), and Australia (0.33), MEFP (2019, p. 155).

Figure I shows the average values of the bullying index (BEINGBUL-LIED) by region. As can be seen, among the regions above the Spanish average, those that have a second official language stand out, such as: Catalonia, the Basque Country, the Valencian Community, the Balearic Islands, and Galicia, in addition to others like Andalusia and the Canary Islands.

**FIGURE I**. Mean values of the bullying index by region
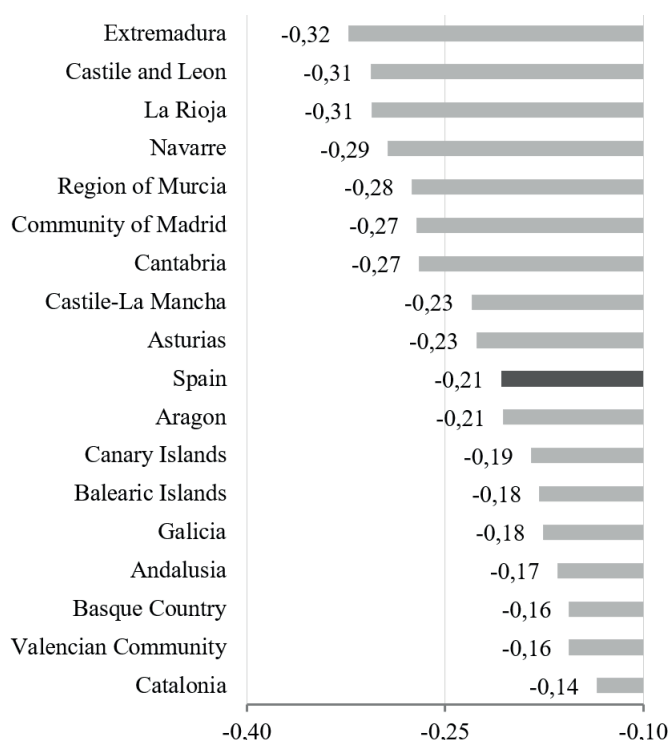
Source: Compiled by the authors

As previously mentioned, bullying can manifest in different ways. Therefore, three types of bullying have been differentiated. Figure II shows the percentages of students subjected to each type of bullying by region. In all

three, Catalonia and the Basque Country exceed the Spanish average, while the Region of Murcia is below the average.

In Spain, the most frequent types of bullying are relational and verbal, with physical bullying occurring slightly less often. This pattern is repeated in the regions, where Catalonia shows the highest incidence of relational bullying. The Valencian Community has the highest rate of verbal bullying, and the Basque Country has the largest percentage of students subjected to physical bullying. In contrast, the Region of Murcia is where physical bullying is the least frequent.

FIGURE II. Percentage of students experiencing bullying by region
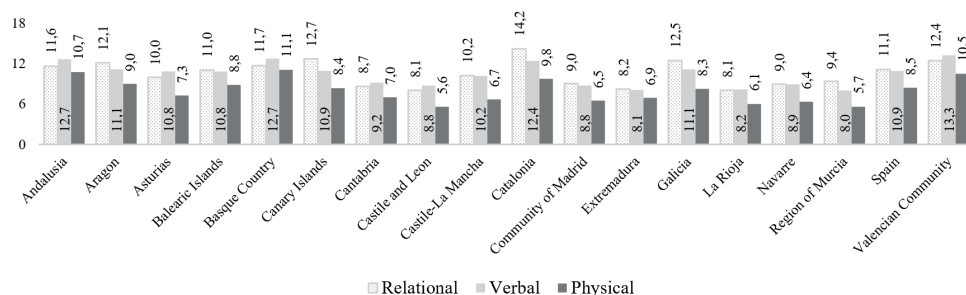
Source: Compiled by the authors

Data Analysis

This study focuses on the data obtained for Spain and three regions in particular: Catalonia, the Basque Country, and the Region of Murcia. The first two are among the regions with the highest rates of bullying, while Murcia has the lowest incidence of physical bullying and is one of the regions with the lowest rates of bullying. Table II summarizes the principal characteristics of the sample. As can be seen, Catalonia and the Basque Country are two highly "developed" regions with positive values for Economic, Social, and Cultural Status (ESCS) that are well above the Spanish average, while the Region of Murcia has an ESCS index rating well below the average (in 2018, it was the

region with the lowest level of "well-being"). Murcia also has a larger proportion of immigrants. Catalan and Basque students obtain an average score in mathematics above the national average, while Murcian students' scores are below average.

TABLE II. Sample characteristics

		Catalonia	Basque Country	Region of Murcia	Spain
Students	Number	1690	3605	1682	35943
	Percentage	4.70	10.03	4.67	100
Score in Mathematics		489.9	499.2	473.6	481.4
Economic, Social, and Cultural Status (ESCS)		0.09	0.08	-0.41	-0.12
% immigrant students	2nd Generation	6.7	3.1	7.9	4.9
	1st Generation	7.3	7.2	7.6	7.3
% students who speak a language different than that of the test at home		62.8	13.1	20.6	6.8
% students who have been absent at least one day		34.8	26.0	29.6	33.7
% students who are repeating a grade		15.1	20.0	34.6	28.7
Index of bullying		-0.14	-0.16	-0.28	-0.21

Source: Compiled by the authors

The data analysis has been performed using the RStudio software package Intsvy (Caro and Biecek, 2017)[4]. The first part of the analysis uses descriptive and inferential statistics to calculate the means of the variables for the different groups of individuals. The objective is to compare the mathematics scores of the students who have been bullied (relational, verbal, or physical) with those who have not. We also examine the relationship between bullying and each of the factors that influence it. Ammermueller (2012) and Yu and Zhao (2021) show that among the factors affecting bullying are aspects such as the student's gender, socioeconomic status, absenteeism rate,

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[4]   This package facilitates a data analysis considering the design of the PISA sample (with replicate weights) and the 10 "plausible values" that are used to measure the achievement of each student.

having repeated a grade, and being an immigrant or a descendant of immigrants. These factors are analyzed in this study.

The second part uses a multiple regression analysis to examine the effects of bullying on mathematics scores, considering the characteristics of the student and the high school. The equation, estimated using Ordinary Least Squares (OLS), is the following (1):

$$\text{SCORE}_i = \beta_0 + \beta_1\text{BEINGBULLIED}_i + \beta_2\text{ESCS}_i + \beta_3\text{REPEAT}_i + \beta_4\text{IMMIGRANT}_i + \beta_5\text{LANGUAGE}_i + \beta_6\text{FEMALE}_i + \beta_7\text{ABSENTEEISM}_i + \beta_8\text{PUBLIC}_i + \beta_9\text{LOCATION}_i + \varepsilon_i \quad (1)$$

where the subscript i refers to each student, and SCORE is the PISA 2018 mathematics score. The regressors of the model are the bullying index (BEINGBULLIED) and the control variables defined in Table I. Following previous studies, variables referring to the student and high school have been chosen as control variables (Ponzo, 2013; Kibriya et al., 2017). These variables are the socioeconomic level (ESCS), repeating a grade (REPEAT), the country of birth (IMMIGRANT), the language spoken at home (LANGUAGE), gender (FEMALE), the rate of absenteeism (ABSENTEEISM), whether the high school is private or public (PUBLIC) and the location of the high school (LOCATION).

Results

Statistical analysis

Before analyzing the influence of bullying on achievement, it is useful to examine the correlation between bullying and other pertinent factors related to students[5].

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[5] The relationship between bullying and high school characteristics (PUBLIC and LOCATION) was also examined. The results show very little relationship among these variables. These results are available upon request.

Factors influencing bullying

Examining the incidence of bullying in terms of gender (Figure III), it can be seen that boys are more often implicated in situations of bullying than girls. Therefore, the difference or gap between them is always positive. This could be due to the fact that women tend to prioritize prosocial behavior over antisocial behavior more than men do.

In general, gender inequality in all the types of bullying is lower in the Region of Murcia, while the Basque Country shows a larger difference between women and men, especially in physical bullying.

FIGURE III. Percentage of students experiencing any type of bullying by gender and GAP
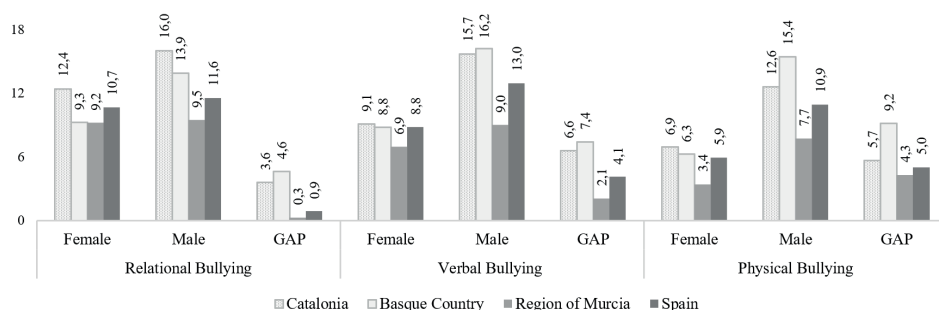
Source: Compiled by the authors

Among the female students, there is always a preponderance of relational bullying. In contrast, no uniform pattern is observed among male students, showing more variability. This is reflected in less gender inequality in relational bullying. In fact, in the Region of Murcia and the national average, men and women show values that are practically the same. However, this gap is greater in the case of physical bullying.

Another aspect that can be relevant in bullying is the student's social, economic, and cultural context. To address this question, Table III shows the mean values of the socioeconomic index (ESCS) for students who have been bullied (relational, verbal, or physical) and those who have not.

TABLE III. Mean values of the ESCS index by type of bullying

		Catalonia	Basque Country	Region of Murcia	Spain
RELATIONAL BUL-LYING	Not bullied	0.18	0.10	-0.36	-0.06
	Bullied	-0.03	-0.06	-0.68	-0.25
VERBAL BULLYING	Not bullied	0.21	0.08	-0.38	-0.06
	Bullied	-0.22	0.10	-0.49	-0.27
PHYSICAL BULLY-ING	Not bullied	0.18	0.08	-0.37	-0.07
	Bullied	-0.16	0.08	-0.79	-0.25

Source: Compiled by the authors

Table III indicates that being a victim of bullying is related to students' socioeconomic context, which means that young people in less advantaged economic situations are more at risk of being intimidated. Spain, Catalonia, and the Region of Murcia show considerably lower values of the ESCS index for the group of students experiencing any type of bullying. The case of the Basque Country is noteworthy since there is no distinction in the ESCS index in the cases of verbal and physical bullying.

The rest of this section centers on the bullying index (BEINGBUL-LIED). We analyze its relationship to other student characteristics (immigration and repeating a grade, absenteeism, and language spoken at home). Table IV shows that there is a relationship between these individual student characteristics and the frequency with which they are exposed to bullying.

As can be seen, students who are immigrants are more exposed to bullying than native students. Both second- and first-generation immigrants have indexes with values close to 0. For Spain and the Region of Murcia, first-generation immigrants (born outside of Spain) are the most affected. However, in Catalonia and the Basque Country, second-generation immigrants (born in Spain to immigrant parents) are more vulnerable to bullying.

Another important factor related to immigration is the influence of the language students speak at home on bullying. Linguistic differences have an effect on bullying since students who speak a different language at home than

that of the achievement test experience greater intimidation. Table IV shows that the causal effect is notable since the index for the average in Spain varies from -0.24 to 0.06, a value close to the OECD average. In the case of the Region of Murcia, this difference is even greater since it goes from the region with the lowest incidence of bullying among the students who speak the same language at home as the test (Castellano) to receiving the highest value (0.11) among students who speak a different language at home. However, these differences are not so pronounced in Catalonia, where the language used for the PISA test is Catalan, the co-official language, since the language spoken at home can be Castellano[6].

The rate of absenteeism and repeating a grade are two other aspects related to bullying (Table IV). Students who are absent from class more often and those who repeat a grade show higher values in the bullying index.

TABLE IV. Mean values of the bullying index by student characteristics

		Catalonia	Basque Country	Region of Murcia	Spain
IMMIGRANT	Native	-0.15	-0.18	-0.31	-0.22
	2nd Generation	-0.01	-0.01	-0.15	-0.12
	1st Generation	-0.11	-0.09	-0.04	-0.07
LANGUAGE	Official language of test	-0.20	-0.18	-0.30	-0.24
	Other	-0.10	0.04	0.11	-0.06
ABSENTEEISM	Never	-0.28	-0.24	-0.32	-0.29
	Once or more times	0.11	0.10	-0.19	-0.03
REPEAT	No	-0.20	-0.19	-0.34	-0.27
	Yes	0.25	-0.02	0.15	-0.03

Source: Compiled by the authors

Bullying and mathematics achievement

After examining the relationship between bullying and different aspects related to students and high schools, we examine whether this problem affects stu-

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6   Basque students can take the PISA test in Euskera or Castellano.

dents' performance in mathematics. To do this, we consider the mathematics scores (SCORE) obtained in PISA 2018. Table V shows the mean and standard deviation (in parentheses), differentiating between students who have experienced bullying (relational, verbal, or physical) and those who have not. We also calculate the t-statistic to compare the equality of the means between the two groups.

TABLE V. Mathematics scores by type of bullying

		Catalonia	Basque Country	Region of Murcia	Spain
RELATIONAL BULLYING	Not bullied	497.44 (89.06)	505.77(84.57)	485.02 (87.33)	491.43 (86.52)
	Bullied	450.39 (85.58)	458.06(90.47)	427.36 (94.03)	446.29 (88.66)
	t-Statistic	5.93***	7.87***	7.21***	25.66***
VERBAL BULLYING	Not bullied	497.23 (88.22)	504.03 (85.16)	482.05 (88.81)	490.37 (86.48)
	Bullied	450.84 (90.63)	475.65 (88.96)	449.54 (94.29)	454.79 (91.89)
	t-Statistic	5.47***	4.90***	3.84***	20.16***
PHYSICAL BULLYING	Not bullied	495.05 (88.78)	504.76 (85.71)	482.81 (88.17)	490.05 (86.69)
	Bullied	453.15(94.45)	460.3 (83.92)	428.91 (92.89)	447.34 (92.35)
	t-Statistic	4.42***	7.16***	5.37***	21.41***

Note: *, **, *** indicate significance at 10%, 5%, and 1%, respectively.

Table V shows that the differences in scores among students who have not been bullied and those who have are significant for the three types of bullying and the four samples. This difference is greater in the cases of relational and physical bullying. These results align with the analysis by Yu and Zhao (2021), who find that verbal bullying has less impact on academic achievement.

Econometric analysis

In this section, we estimate an econometric model to quantify the effect of

bullying on mathematics achievement after controlling for student and school characteristics. We estimate equation (1) using OLS. The dependent variable is the mathematics score (SCORE). To evaluate the impact of bullying, we use the bullying index (BEINGBULLIED) as a continuous treatment variable. The control variables, defined in Table I, refer to both the student and the high school.

This model has been estimated for Spain and each of its regions. Table VI shows the results for Spain and the three selected regions: Catalonia, the Basque Country, and the Region of Murcia. Table VII shows the estimated co-efficient of the variable BEINGBULLIED for the rest of the regions.

The results in Table VI show that bullying has a negative effect on mathematics achievement. Spain and the regions studied obtained a significant (at least 10%) and negative coefficient. This indicates that, *ceteris paribus*, an increase in the bullying index would worsen performance in mathematics. At the national level, maths scores fall by an average of 4.7 points, with Catalonia showing the largest decrease, 10.8 points.

Although the Region of Murcia does not have a high value of BEING-BULLIED (see Figure I), we can see that this variable is relevant for explaining mathematics achievement. This indicates that even though the rate of bullying among Murcian students is relatively low, its impact on maths scores is significant.

With regard to the control variables, the effect of the socioeconomic index (ESCS) is notably positive and highly significant in the three selected regions and in Spain as a whole, where an increase of one standard deviation in the index is associated with an increase of 14.4 points, *ceteris paribus*. This effect is weaker in the Region of Murcia and the Basque Country, while in Catalonia, it is substantially stronger, with an average increase of 22 points.

The rest of the variables related to students' characteristics have a negative impact on mathematics achievement. Repeating a grade (REPEAT) is the variable that has the strongest negative influence on the mean score in mathematics in addition to being highly significant. For Spain, *ceteris paribus*, it causes a decrease of 85.2 points. For the Region of Murcia, the decrease is even greater, 93 points.

TABLE VI. Results of the regression analysis

Dependent V.: SCORE Regressors	Catalonia	Basque Country	Region of Murcia	Spain
CONSTANT	514.0***	557.9***	539.8***	536.9***
	(17.5)	(11.7)	(16.8)	(6.1)
BEINGBULLIED	-10.8***	-5.9**	-5.3*	-4.7***
	(3.6)	(2.5)	(2.9)	(1.4)
ESCS	22.0***	12.3***	12.7***	14.4***
	(4.1)	(2.8)	(2.6)	(1.2)
REPEAT	-74.7***	-84.3***	-93.0***	-85.2***
	(12.1)	(7.4)	(6.0)	(3.1)
IMMIGRANT	-3.2	-17.9***	-3.0	-5.8***
	(7.1)	(5.4)	(5.4)	(2.2)
LANGUAGE	-5.0	-3.8	-16.3	-4.5
	(7.5)	(6.7)	(14.1)	(3.2)
FEMALE	-8.0	-9.8*	-20.4***	-16.4***
	(7.1)	(5.5)	(4.1)	(2.2)
ABSENTEEISM	-10.1*	-11.8***	-9.2***	-12.0***
	(5.4)	(3.8)	(3.0)	(1.6)
PUBLIC	-2.2	-7.7	-2.5	-0.6
	(9.9)	(6.5)	(6.6)	(3.0)
LOCATION	3.8	1.4	1.8	2.1*
	(3.5)	(2.7)	(4.1)	(1.1)
R-Square	0.2***	0.3***	0.4***	0.3***
	(0.04)	(0.03)	(0.02)	(0.01)

Note: The standard deviations are in parentheses. *,**,*** indicate significance at 10%, 5%, and 1%, respectively.

The country where the student was born also has a negative repercussions for mathematics scores, although this variable is only relevant for Spain and the Basque Country. The difference in scores between native students and immigrants is greater for the Basque Country. The language students speak at home does not appear significant for explaining mathematics achievement in Spain or the selected regions. This result may be due to the existence of multicollinearity caused by the close relationship between the variables LANGUAGE and IMMIGRANT since most of the students who speak a different language at home than that of the test come from immigrant families. In Spain, only 16% of the native students speak a different language at home than that

of the test, while the percentage rises to 51.6% in the case of 1st generation immigrants.

Another factor that can influence mathematics scores is the gender of the student since, on average, women obtain lower maths scores than men (Tao and Michalopoulos, 2018; Fuentes and Renobell, 2020). In the Region of Murcia, this effect is quite pronounced since the mean score for girls is 20.4 points lower than that of boys, *ceteris paribus*. In the case of Spain, the difference in scores between girls and boys is slightly smaller (16.4 points). In Catalonia, this variable is not significant. Therefore, gender might not affect maths scores among Catalan students.

School absenteeism has a negative and significant coefficient in Spain and in the selected regions. *Ceteris paribus*, Spanish students who are absent more frequently obtain a lower mean score in maths than those who usually go to class. This relationship is clear since students with high absenteeism rates interrupt their learning and miss the opportunity to participate in pedagogic activities, which impedes their learning process.

In contrast, the variables associated with the characteristics of the high school seem not to explain mathematics achievement. As can be seen in Table VI, whether a school is public or private is not significant in Spain or the three selected regions. The variable LOCATION is also not significant for the three regions, while it is significant at 10% for Spain. By showing a positive coefficient, we can say that *ceteris paribus*, as the population grows, the average score in mathematics increases, although this increase is small (2.1 points).

TABLE VII. Estimated coefficient of the bullying index for the other Spanish regions

Andalusia	Aragon	Asturias	Canary Islands	Cantabria	Castile and Leon	Castile-La Mancha
0.08	-3.4	-2.3	-3.0	-0.5	0.4	-2.6
(3.5)	(3.1)	(3.1)	(2.8)	(2.8)	(3.1)	(3.7)
Community of Madrid	Extremadura	Galicia	Balearic Islands	La Rioja	Community of Madrid	Navarre
-6.1*	-5.1	-7.2***	-9.0***	-3.7	-2.7	-4.4
(3.4)	(3.4)	(2.5)	(2.9)	(3.5)	(2.2)	(3.1)

Note: The standard deviations are in parentheses. *,**,*** indicate significance at 10%, 5%, and 1%, respectively.

As previously stated, to determine the effect of bullying in all the regions, we also estimate equation (1) for the remaining regions. The results can be seen in Table VII, which shows an estimated coefficient of BEINGBULLIED for each of them. This coefficient is negative for most of the regions, although it is significant only in the three regions with co-official languages: the Valencian Community, Galicia, and the Balearic Islands. These three regions, along with Catalonia and the Basque Country, are among those with the highest rates of bullying in Spain (see Figure I). It would be advisable to explore this novel result in the academic context and for the appropriate authorities to attempt to remedy this situation.

Discussion and conclusions

The results obtained from the seventh edition of the PISA report show a negative impact of bullying on mathematics achievement for Spanish students. The analysis by Autonomous Communities shows that this negative effect occurs in regions with co-official languages (Catalonia, the Valencian Community, Galicia, the Balearic Islands, and the Basque Country) and the Region of Murcia.

This demonstrates the need to consider linguistic diversity in bullying intervention programs, along with other factors that increase students' heterogeneity. It has also been shown that bullying does not affect students equally. Students with different traits than the majority are generally more likely to become victims of bullying. Thus, in regions with two official languages, the probability of experiencing bullying increases. This is one of the important and novel contributions of this study, which should be further explored.

Álvarez-Sotomayor and Martínez-Cousinou (2020) consider linguistic disadvantage as a key factor in the lower achievement of students with immigrant parents in Spain. Although they recognize that advances have been made in knowledge about the relationship between language competence in the vehicular language (language of teaching) and achievement, they conclude that "the practical absence of studies simultaneously measuring proficiency in the language in which subjects are taught and academic achievement makes it impossible to obtain rigorous empirical knowledge about this relationship" (Álvarez-Sotomayor and Martínez-Cousinou, 2020, p. 1).

Calero and Choi (2019) and Doncel-Abad and Cabrera-Álvarez (2020) show that linguistic models may be associated with students' achievements, although they recognize that more research is needed in this area due to the scarcity of robust studies. Specifically, in the first study, the authors find that students who speak Castellano at home and Catalan at school had lower scores in PISA 2015 in science and reading, while the results in mathematics were not clear. This result could be because mathematics uses "a specific formalized language" (Calero and Choi, 2019, p. 43). However, the "language spoken at home, be it co-official or Castellano, does not affect performance in PISA," even though they have different linguistic models, according to Doncel-Abad and Cabrera-Álvarez (2020, p. 182).

After carefully analyzing the various risk factors associated with bullying, we conclude that bullying does not affect men and women in the same way and with the same intensity, with male students having a greater likelihood of being intimated. Different patterns in the way adolescents experience bullying have also been identified. Girls tend to be victims of more indirect types of bullying, such as social exclusion and defamation, which involve psychological aggression intended to damage their social relationships and reputation.

Boys more frequently experience direct expressions of bullying, such as verbal aggression, which is more visible. These findings based on gender align with the results of previous studies (Carrera et al., 2013; López-Hernáez, 2013; Ruiz-Narezo et al., 2020). Some authors also highlight that a country's cultural values can create stereotypes of gender differences, which influence bullying (Hellström and Beckman, 2020; Piñeiro et al., 2022).

Some studies suggest a relationship between economic inequality and bullying (Due et al., 2009). Children of families with low incomes have limited access to resources and emotional support, which increases their isolation and exposure to environments where bullying is more frequent. Our results show that cases of bullying more often occur among students with lower economic and social status.

Immigrant students are more exposed to bullying than native students, which is particularly important among Murcian students. When considering the language spoken at home, the Region of Murcia also shows a higher incidence of bullying among the group of students who do not speak Castellano at home. This region, with a high proportion of immigrant families, has a large number of students whose first language is not Castellano. Specifically, the Region of Murcia is among the regions with the highest proportion of students from immigrant families in Spain, at 15.5% (MEFP, 2019). However, these disparities are not as pronounced in Catalonia and the Basque Country, which could be due to the fact that in these regions, the PISA test is in the co-official language in the first case, namely, in Catalan, and Basque students can do the test in Euskera or Castellano. Thus, students who speak a different language at home are not necessarily immigrants; the language spoken at home could be Castellano.

The results also show high levels of absenteeism and grade repetition among bullied students. This indicates that students who are victims of bullying try to escape the hostile environment created by their aggressor by not attending class. Consequently, their education and social integration are adversely affected, causing them to fall behind and achieve less. This makes them more likely to repeat a grade, which is quite a drastic relationship, as Yu and Zhao (2021) state in their estimations.

Recent studies have confirmed a negative relationship between achieve-

ment and bullying. It is clear that bullying leads to increased absenteeism and less participation, which can result in lower achievement (Juvonen et al., 2011; Méndez and Cerezo, 2018; Sbroglio and Aniceto, 2021). The estimation of our econometric model confirms this negative relationship between test scores and suffering from bullying in Spain, although this result cannot be generalized for all the regions. Analyzing them separately, we find that the relationship is negative for almost all the regions, but it is only significant in six: Catalonia, the Valencian Community, Galicia, the Balearic Islands, the Basque Country, and the Region of Murcia. Excepting the last one, all of these regions have a second official language and bullying indexes above the national average. Although we do not have conclusive information about the causes of this relationship, it is worth asking why some of the "richest" regions, like Catalonia and the Basque Country, which should be more developed, are more affected by bullying than other "poorer" like Andalusia.

The Region of Murcia is a particular case because, without a high bullying index, it does show a considerable negative influence of bullying on average maths scores, which is linked to the presence of a large proportion of immigrant students, who are more likely to be victims of bullying. Therefore, since increased heterogeneity among students leads to a higher risk of bullying, it is essential to facilitate integration when there is personal, economic, linguistic, or cultural diversity in schools to guarantee a stable and safe environment for all students, regardless of their mother tongue.

Finally, according to our results, bullying is an obstacle to education, resulting in poorer performance. The relevance of implementing an effective bullying prevention plan is clear. This could foment solidarity among students, promote prosocial behavior, make students aware of the consequences of the phenomenon, and provide an action protocol. These policies should also be directed toward teachers, parents, and the educational community as a whole since it is essential to visualize this problem and raise social awareness in order to design efficient policies. There will be, without doubt, many difficulties, but it is crucial to achieve an adequately harmonious climate in schools promoting the acceptance of differences in heterogeneous societies.

This study has some limitations, among which is the fact that it only analyzes achievement in mathematics. Future research could investigate reading

and science skills. Other possible developments could involve introducing a temporal perspective or conducting a comparative study among OECD countries to analyze Spain's international position. Moreover, the analysis of cyberbullying has been omitted since its dimension and particular characteristics require a separate study.

Despite these limitations, we feel that the study offers novel and relevant results.

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