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PISA 2022: The impact of school-environment predictors on the performance of Spanish students

PISA 2022. El impacto de los predictores relacionados con el entorno escolar sobre el rendimiento del alumnado español

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Abstract:

The impact of school environment on academic performance has become more important over recent years. However, there are no specific studies of the impact of school environment variables on the performance of secondary school students in the PISA domains of science, reading and mathematics. This article aims to analyse the influence of a set of predictors relating to the school environment (climate, well-being, and bullying) on student performance in all three PISA domains. The sample comprises 28781 Spanish students (14459 male students, 50.24%; 14322 female students, 49.76%) from 935 schools, who participated in PISA 2022. A two-level hierarchical linear model was used: students and schools. The results show that male students score higher than female students in mathematics and science, while female students score higher in reading. Male students have a more favourable opinion of school well-being than female students. Students' economic status is a strong predictor of performance in all three PISA domains. School climate, school well-being, and bullying have more impact on performance in mathematics and science than in reading. Students in private schools perform better than those in public schools. The results of the final models explain more than 21% of the differences between students in performance in the three areas and more than 50% between schools. These findings suggest a need to create an environment that promotes student learning, reinforce students' sense of belonging to the school, and implement anti-bullying measures in schools.

Keywords: bullying, school well-being, school climate, gender differences, economic status, achievement, PISA, multilevel model.

Resumen:

En los últimos años, ha cobrado relevancia el impacto del entorno escolar sobre el rendimiento académico. Sin embargo, no existen estudios específicos sobre el impacto de las variables relacionadas con el entorno escolar sobre el rendimiento del alumnado de educación secundaria en las áreas de PISA: ciencias, lectura y matemáticas. Este artículo

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pretende analizar la influencia de un conjunto de predictores relacionados con el entorno escolar (el clima, el bienestar y el *bullying*) sobre el rendimiento del alumnado en las tres áreas de PISA. La muestra está formada por 28 781 estudiantes españoles (14 459 estudiantes de género masculino, 50.24 %; 14 322 estudiantes de género femenino, 49.76 %) procedentes de 935 centros educativos, quienes han participado en PISA 2022. Se ha utilizado un modelo jerárquico lineal de dos niveles: estudiantes y centros. Los resultados muestran que el alumnado de género masculino obtiene más puntos que el alumnado de género femenino en matemáticas y ciencias, mientras que el alumnado de género femenino destaca en lectura. El alumnado de género masculino tiene una opinión más favorable hacia el bienestar escolar que el alumnado de género femenino. El entorno económico del alumnado es un fuerte predictor del rendimiento en las tres áreas de PISA. El clima de aula, el bienestar escolar y el *bullying* tienen más impacto en el rendimiento en matemáticas y ciencias que en lectura. Los estudiantes de centros privados obtienen mejor rendimiento que los de centros públicos. Los resultados de los modelos definitivos explican más del 21 % de las diferencias de rendimiento en las tres áreas entre los estudiantes y más del 50 % entre centros educativos. Estos resultados sugieren la necesidad de crear un entorno que promueva el aprendizaje de los estudiantes, de reforzar el sentido de pertenencia del alumnado al centro y de implementar medidas en los centros educativos contra el acoso escolar.

Palabras clave: acoso escolar, bienestar escolar, clima de aula, diferencias de género, entorno económico, rendimiento, PISA, modelo multinivel.

1. Introduction

The Programme for International Student Assessment (PISA) assesses the competences of students aged 15-16 who are completing Obligatory Secondary Education (OSE) in three core areas (science, reading, and mathematics). Such competences represent the knowledge they should have so they can face situations in the academic, work, and personal worlds (Ministerio de Educación, Formación Profesional y Deportes, 2023).

The study by Huang et al. (2024) aims to understand the relationship between these predictors and the school environment (school climate, school well-being, and bullying) in the PISA 2018 study. The results show that school climate and school well-being both reduce the effects of bullying on academic performance. This specific study lays the foundations for an in-depth examination of the influence of predictors relating to school environment on performance in the core areas of PISA: gender, economic status, the school climate, school well-being, bullying, and school ownership.

1.1. Theoretical framework

Regarding the first predictor, students' gender, research has found significant differences in performance in the three areas of PISA. The work by Torppa et al. (2018) analyses gender differences in Finnish students who participated in PISA. The results reveal that female students score higher than male students in reading, as they display a more positive attitude towards reading. The work by Manu et al. (2023) shows that parents' economic status affects boys' reading performance more than that of girls. The work by Eriksson et al. (2020) analyses differences in performance by gender in the editions of PISA between 2000 and 2015. The results indicate that male students perform lower than female students in reading, while performing higher than them in mathematics and science. In this respect, the work by Stoet and Geary (2022) finds that this difference is because boys' professional aspirations are oriented towards the sphere of mathematics and science more than those of girls, owing to the gender stereotypes associated with careers in the STEM field (science, technology, engineering, and

mathematics) (Bottazzi & Lusardi, 2021). The work by Sortkaer and Reimer (2018) explains that the gender differences in the PISA 2012 study are because of a correlation between school well-being and performance, that is stronger in male students than in female ones.

With regards to the second predictor, economic status, research has shown its impact on students' academic performance (Xie & Ma, 2019). The work by Eriksson et al. (2022) notes the influence of context on the performance of students participating in the 2018 edition of PISA, so that in the societies with the widest performance gap, the ESCS (index of economic, social, and cultural status) represents 31% of the variance in mathematics and science and 29% in reading. Accordingly, economic status explains the difference in performance between students who are located in the top and bottom quartiles that PISA establishes (Hanushek et al., 2022). The work by Yeung et al. (2022) finds that economic status is a strong predictor of student performance, as parents' educational level influences their children's academic expectations (Gamazo & Martínez-Abad, 2020). The work by Kang and Cogan (2020) finds that students with a low economic status have fewer learning resources in the home, which results in them facing greater difficulties than students with a high status when applying their knowledge to problem solving.

In connection with the third predictor, school climate, this can be defined as surroundings that foster learning based on the quality of relations between students and teachers (Ministerio de Educación, Formación Profesional y Deportes, 2023). Research has shown the impact of a positive school climate on student performance (Izaguirre et al., 2023; Ramazan et al., 2023). The work by Gómez and Suárez (2020) points out that school climate is a variable that influences the performance of students who participated in the 2015 edition of PISA, underlining the importance of the relationship between teachers and students to promote learning (Zysberg & Schwabsky, 2021), as well as the opinion of students on teaching quality (Rohatgi & Scherer, 2020). The work by Teng (2020) reveals that school climate has a more significant influence on the performance of students with a low economic status than on those with a high economic status, underlining the impact of school climate when reducing the gap in performance by economic status (Trinidad, 2020). Several studies find significant differences in favour of female students in perception of the school climate by gender (Alshammari et al., 2022; González-Moreno & Molero, 2023).

In relation to the fourth predictor, school well-being, this can be understood as the conditions that foster students' sense of belonging to the school and promote their integral development in the physical, psychological, and social dimensions (Ministerio de Educación, Formación Profesional y Deportes, 2023). Research shows its impact on student performance, with a more positive attitude towards learning among students who have a sense of belonging to the school (Burns et al., 2020; Haw & King, 2023; Tan et al., 2022). The work by Kiuru et al. (2020) finds that school well-being affects students' academic performance. This is explained by the sense of integration and good relations with their peers in the school (Craggs & Kelly, 2018; Korpershoek et al., 2020). In this sense, the work by Arslan (2021) reflects that students with a higher school well-being index display a lower level of bullying and better academic performance. Various studies find significant differences in favour of female students in school well-being by gender (Hernández et al., 2017; Jiang et al., 2024).

The fifth predictor, bullying, can be defined as a type of behaviour in which a person or group of people deliberately and repeatedly causes harm to and upsets another. Bullying can be physical (hitting), verbal (insults), and relational (spreading lies) (Ministerio de Educación, Formación Profesional y Deportes, 2023). Research shows the negative influence of bullying on students' academic performance (Karakus et al., 2022; Molina-Muñoz et al., 2023; Ozyldirim & Karadağ, 2024), owing to worse school well-being (González-Gallardo et al., 2021; Murphy et al., 2022). Giménez et al. (2024) reveal that bullying had a negative influence on performance in science, reading, and mathematics in the 2018 edition of PISA, with a particular impact on male students' scores in mathematics. Various studies find significant differences in bullying by gender, with female students experiencing more bullying than male students, which has a stronger effect on reducing the academic performance of girls than that of boys (Riffle et al., 2021; Zhou et al., 2024).

With regards to the sixth predictor, ownership of the school, the study by Aparicio et al. (2017) points out that students from private schools perform better than ones from public schools, owing to the effect on performance of the economic status of the students who attend a given school (Le Donné, 2014). However, other studies (Larsen et al., 2023; Pivovarova & Powers, 2019) conclude that, after adjusting for economic status, students being educated in public or private schools does not explain differences in their performance.

The literature review underlines the need to progress in knowledge of the influence of the cited predictors on the three core areas of PISA (science, reading, and mathematics). There are four reasons that justify this research. Firstly, it uses a solid sample that is representative at a national level in the in the PISA 2022 study. Secondly, it uses a multilevel model with 2 levels (students and schools) in Spain. Thirdly, it includes both the influence and the effect size of the three variables relating to school environment that have the most impact on the areas of PISA, namely, school climate, school well-being, and bullying. Fourthly, this work provides political leaders with knowledge of the variables relating to the school environment that have the biggest influence on student performance so that they can take measures to improve performance in science, reading, and mathematics at the level of educational policy; and it provides teachers with knowledge of didactic actions that strengthen the school climate and school well-being.

Therefore, the first objective of this work is to identify significant differences by gender in the variables relating to the school environment. Drawing on this objective, the following hypotheses are proposed:

- Hypothesis 1. There are significant gender differences in perception of the school climate.
- Hypothesis 2. There are significant gender differences in school well-being.
- Hypothesis 3. There are significant gender differences in bullying.

The second objective is to analyse the influence of a set of predictors on school environment in performance in science, reading, and mathematics by the Spanish students who participated in PISA 2022. From this objective, the following hypotheses are proposed:

- Hypothesis 4. Students' gender is a significant predictor of performance in the three core areas of PISA.
- Hypothesis 5. Economic status predicts student performance.
- Hypothesis 6. School climate has a significant effect on performance.
- Hypothesis 7. School well-being has a significant effect on performance.
- Hypothesis 8. Bullying has a significant effect on performance.
- Hypothesis 9. The ownership of the school predicts the performance of the students.

2. Method

2.1. Research design

This research is a non-experimental *ex post facto* investigation. There is no direct control of independent variables and participants cannot be assigned at random to the experimental groups as the phenomenon has already happened (Kerlinger & Lee, 2002).

2.2. Participants

In the 2022 edition of PISA, 30 800 Spanish students aged between 15 and 16 years participated (15 561 male students, 50.52%; 15 239 female students, 49.48%) from 966 schools.

The majority were in the 4th year of OSE (Obligatory Secondary Education) (Ministerio de Educación, Formación Profesional y Deportes, 2023).

The sample was selected through multi-stage sampling with a 95% confidence interval and a 5% sampling error (OECD, 2023). In the first stage, the schools in each autonomous region that 15-year-old students could be enrolled in were sampled, taking into account the ownership of the schools. These schools were systematically sampled with selection likelihoods in proportion with the estimated size of the population of 15-year-olds. In the second stage, back-up schools for each sampled school were identified in case a school decided not to participate in PISA.

In the third stage, samples of the students were taken within the schools included in the sample. Once the schools had been selected, a list of students aged 15 years in each school in the sample was prepared.

In the fourth stage, based on this list, 42 students were selected at random, a target figure established by the OECD for all of the countries that participated in the PISA study.

The real sample comprises 28781 Spanish students (14459 male students, 50.24%; 14322 female students, 49.76%), from de 935 schools (63.2% public, 36.8% private). In the configuration of the final sample, 2019 students were excluded as they did not report complete information for all of the variables.

Table 1. Details of the PISA 2022 sample in Spain.

Autonomous region / Autonomous city	***n***	**Schools**
Andalusia	1610	51
Aragon	1359	44
Asturias	1560	49
Cantabria	1646	52
Castile-La Mancha	1453	51
Castile and León	1687	54
Catalonia	1501	50
Extremadura	1655	54
Galicia	1715	57
Balearic Islands	1492	51
Canary Islands	1419	52
La Rioja	1361	47
Madrid	1726	52
Murcia	1605	52
Navarra	1741	52
Basque Country	3115	94
Valencia	1532	51
Ceuta	345	12
Melilla	259	10
Spain	28781	935

2.3. Tools

This study analyses variables included in the following instruments of the PISA 2022 study (Ministerio de Educación, Formación Profesional y Deportes, 2023):

- **The student questionnaire.** This gathers information about the family, school, and academic environments, as well as specific aspects about anxiety and self-efficacy in mathematics. Its Cronbach's alpha coefficient is .81, which indicates a good level of internal consistency of the items (Hernández-Sampieri & Mendoza, 2018). The following variables from this questionnaire have been taken into account (Ministerio de Educación, Formación Profesional y Deportes, 2023):
  - **Gender.** Dummy variable. (0 = male, 1= female).
  - **Economic status.** Normalised variable. This score is given by the number of books at home (0 = 0-10 books, 1 = 11–25 books, 2 = 26-100 books, 3 = 101-200 books, 4 = 201-500 books, 5 = more than 500 books).
  - **School climate.** Normalised variable. This is an index created from the students' opinions on a set of six items (0 = strongly disagree, 1 = disagree, 2 = agree, 3 = strongly agree).
    - The teachers at my school are respectful towards me (mean = 2.85).
    - If I walked into my classes upset, my teachers would be concerned about me (2.42).
    - If I came back to visit my school three years from now, my teachers would be excited to see me (2.01).
    - When my teachers ask how I am doing, they are really interested in my answer (2.31).
    - The teachers at my school are friendly towards me (2.24).
    - The teachers at my school are interested in students' well-being (2.89).

  The mean of these items is combined to create the school climate index.

  - **School well-being.** Normalised variable. This index is created from students' answers to six items (0 = strongly disagree, 1 = disagree, 2 = agree, 3 = strongly agree).
    - I make friends easily at school (1.61).
    - I feel like I belong at school (2.99).
    - Other students seem to like me (2.17.)
    - I feel like an outsider (or left out of things) at school (1.75).
    - I feel awkward and out of place in my school (2.07).
    - I feel lonely at school (1.61).

  The mean of these items is combined to create the school well-being index.

  - **Bullying.** Normalised variable. This index is created from the frequency with which students experienced some type of bullying during the 12 months prior to the test, reflected in a set of nine items (0 = never or almost never, 1 = a few times a year, 2 = a few times a month, 3 = once a week or more).
    - Other students left me out of things on purpose (1.21).
    - Other students made fun of me (1.40).
    - I was threatened by other students (1.12).
    - Other students took away or destroyed things that belonged to me (1.23).
    - I got hit or pushed around by other students (1.14).
    - Other students spread nasty rumours about me (1.28).
    - I was in a physical fight on school property (1.13).

- I stayed home from school because I felt unsafe (1.17).
- I gave money to someone at school because they threatened me (1.03).

The mean of these items is combined to create the bullying index.

The reliability and validity of the *economic status* (Cronbach's alpha = .79), *school climate* (Cronbach's alpha = .81; McDonald's omega =.82), *school well-being* (Cronbach's alpha = .85; McDonald's omega = .86), and *bullying* (Cronbach's alpha = .77; McDonald's omega = .78) variables show good levels of internal consistency for the items. These items derive from a process that is divided into three stages.

First, a group of experts in mathematics in each country apply the questionnaire to a sample of 100 students in a small-scale validation test, identifying items that have a negative score and do not measure the aspects they set out to measure. Secondly, modifications and linguistic revisions are made to the items to ensure a translation that is adapted to each country. Finally, a field study is carried out to validate the constructs and measurements before the principal test. The aim is to identify the items from the test that show insufficient validity and reliability of scoring before the large-scale application (OECD, 2023).

- **The school questionnaire.** Directed at the management team, this collects information about the administrative and didactic organisation of the schools and the learning environments. Its Cronbach's alpha coefficient is .90, which indicates an excellent level of internal consistency of the items (Hernández-Sampieri & Mendoza, 2018). From this questionnaire, we have taken into account ownership [dummy variable (0 = public, 1 = private)].

TABLE 2. Description of the variables.

Variable	Type of variable	Response options
Gender	Nominal	0 = male 1 = female
Economic status	Scale	Normalised variable
School climate	Scale	0 = strongly disagree 1 = disagree 2 = agree 3 = strongly agree
School well-being	Scale	0 = strongly disagree 1 = disagree 2 = agree 3 = strongly agree
Bullying	Scale	0 = never or almost never 1 = a few times a year 2 = a few times a month 3 = once a week or more
Ownership of school	Nominal	0 = public 1 = private

2.4. Data analysis

The points that the students have scored in the three central areas [science, reading, and mathematics (dependent variables)] are obtained by means of the Rasch model and are reported through scales, with a mean score of 500 points and a standard deviation of 100 (OECD, 2023).

To calculate students' performance in each area, independent estimates were carried out for each of the ten plausible values and the mean of the scores was calculated (Wu & Adams, 2002).

The PISA 2022 database provides ten plausible values that PISA assigns to each student. In the area of science, the ten plausible values are 492.92, 490.91, 491.22, 490.06, 490.22, 492.09, 491.16, 491.89, 491.29, and 489.62; in the area of reading, 480.96, 481.06, 482.07, 480.66, 480.07, 481.46, 479.41, 480.73, 480.62, and 481.60; and in the area of mathematics, 480.9, 482.16, 481.82, 482.46, 482.12, 480.82, 482.75, 482.14, 481.34, and 481.98.

This study used a linear hierarchical model in which the influence of a set of predictors on the dependent variables is analysed at two levels: students and schools (Tourón et al., 2023).

The MLwiN 2.36 program was used for data analysis, enabling the estimates to be calculated by the iterative generalised least squares (IGLS) procedure (Goldstein, 2003).

3. Results

The results of Student's *t*-test show significant differences (sig. <.001) in school climate (male students = .15 points; female students = .22 points), school well-being (male students = .42 points; female students = .17 points), and bullying (male students = -.44 points; female students = .40 points). To measure the effect size, the eta-squared coefficient was calculated (Cohen, 1998), which makes it possible to obtain an estimate of the shared variance between each effect and the dependent variable (Tourón et al., 2023), so that three effect sizes are differentiated: small ($p \geq .01$), medium ($p \geq .06$), and large ($p \geq .14$). The results show that school climate has a large effect on performance in science ($p = .24$) and mathematics ($p = .28$), and a medium one on reading ($p = .068$), as well as a large effect of school well-being on performance in science ($p = .21$) and mathematics ($p = .26$), and a medium one on reading ($p = .061$). Likewise, the results indicate a large effect of bullying in all three areas: science ($p = .19$), mathematics ($p = .23$), and reading ($p = .16$) (Tourón et al., 2023).

The modelling process starts by formulating the null model, which does not have predictor variables and so has no explanatory power, but this is essential as it establishes the base line and provides information about the initial variance in the two levels (Tourón et al., 2023).

3.1. Performance in science

Table 3 shows the results of the null model. The fixed parameter indicates the value of the intercept or the mean performance in science for the students who make up the sample.

Table 3. Estimate of the null model for performance in science.

Fixed part	
Parameter	**Estimate (standard error)**
Constant	489.66 (5.12)
Random part (variance in science performance)	
Level 1. Learners	5870.75 (48.05)
Level 2. School	1002.68 (54.82)
-2 restricted likelihood log	356 444.11
Akaike information criterion (AIC)	356 448.11
Schwarz Bayesian criterion (BIC)	356 460.229
Number of parameters	3

The criterion used to establish whether a parameter is significant is that, when working with $\alpha = 0.05$, the quotient between the estimate of the parameter and its standard error is greater than 1.96 (Gaviria & Castro, 2004).

The data in Table 3 show that the mean performance in science is 489.66 points for all students. These data differ from one another at the level of students (5870.75 / 48.05 = 122.18) and of schools (1002.68 / 54.82 = 18.29).

These parameters are greater than 1.96, and so they are significant and indicate the existence of unexplained variance between students and between schools, which justifies calculating the definitive model to explain the greatest possible amount of variance. The likelihood ratio has a value of 356 444.11 for a null model with three parameters, which is compared with the definitive model.

Based on the data from Table 3, the ICC is calculated, which has a value of .1458; this means that 14% of the variance is variance between centres.

ICC = 1002.68 / (5870.75 + 1002.68) = .1458

This value indicates the proportion of the level 2 variance (schools) in the total variance, that is to say, the variance not explained by the predictors that is attributed to the grouping variable in level 2.

Table 4. Definitive model of performance in science.

Fixed part	
Constant	520.81 (3.82)
Gender	-9.17 (.86)
Economic status of the students	12.58 (.97)
School climate	5.62 (.74)
School well-being	2.35 (.53)
Bullying	-8.07 (.45)
Ownership	10.66 (.37)
Random part	
Between students	4531.88 (34.53)
Between schools	484.81 (28.02)
-2 restricted likelihood log	207 563.12
Akaike information criterion (AIC)	207 567.12
Schwarz Bayesian criterion (BIC)	207 579.08
Number of parameters	9

Table 4 displays the results of the fixed part and the random part of the definitive model.

According to the data in Table 4, the value of the constant is 520.81 points, which corresponds with the mean performance in science for male students of average economic status.

The explanatory variables of the random part are significant in performance in science.

Female students' performance is -9.17 points lower, which explains the gender gap in science in favour of male students

Students' economic status is significant in performance in science. For each point increase in students' economic status, their performance increases by 12.58 points.

The school climate is a significant predictor of performance in science. For each point increase in the quality of relations between students and teachers, performance increases by 5.62 points.

School well-being has an impact on performance. For each point increase in students' school well-being, their performance increases by 2.35 points.

Bullying has a negative influence on performance. For each point increase in the frequency with which students suffer bullying, their performance falls by -8.07 points.

Ownership of the school is a significant predictor of performance in science. Being enrolled in a private school results in students' performance increasing by 10.66 points compared with a public school.

To establish the goodness of fit, the value of the -2 restricted likelihood log from the null model is compared with the definitive model.

The results show a difference of chi-squared of 148 880.99 with six degrees of freedom which is significant at .01; this confirms the better fit of the definitive model compared with the null model. The results indicate that both the Akaike information criterion (AIC) and the Bayesian criterion (BIC) of the definitive model also reduce with regards to the null model, so that the goodness of fit of the definitive model improves.

The R^2 coefficient expresses the proportion of variance of the dependent variable hat can be explained by the predictors included in the definitive model, after having compared the random parameters of this model with those of the null model (Snijders & Bosker, 2012). The predictors of the definitive model explain 23% of the differences in performance in science between the students (R^2 = .227) and 52% of the variability between schools (R^2 = .5164).

Table 5. Estimation of the null model of reading performance.

Fixed part	
Parameter	**Estimate (standard error)**
Constant	469.19 (4.22)
Random part (variance in reading performance)	
Level 1. Learners	6267.60 (51.30)
Level 2. School	1218.36 (65.33)
-2 restricted likelihood log	358 563.32
Akaike information criterion (AIC)	358 567.32
Schwarz Bayesian criterion (BIC)	358 579.458
Number of parameters	3

3.2. Performance in reading

The data in Table 5 show that the mean performance in reading is 469.19 points for all students. These data differ from one another at the level of students (6267.60 / 51.30 = 122.17) and of schools (1218.36 / 65.33 = 18.64).

These parameters, which are greater than 1.96, are significant and show the existence of unexplained variance between students and schools, which justifies calculating the definitive

model. The likelihood ratio has a value of 358 563.32 for a null model with three parameters, which is compared with the definitive model.

The ICC has a value of .1627, meaning that 16% of the variance is variance between centres.

ICC = 1218.36 / (6267.60 + 1218.36) = .1627

Table 6 displays the results of the fixed part and the random part of the definitive model.

Table 6. Definitive model of performance in reading.

Fixed part	
Constant	500.72 (3.66)
Gender	8.47 (.78)
Economic status of the students	9.11 (.93)
School climate	3.48 (.12)
School well-being	1.06 (.27)
Bullying	-7.29 (.47)
Ownership	10.04 (.19)
Random part	
Between students	4914.68 (39.32)
Between schools	611.62 (22.64)
-2 restricted likelihood log	243 891.17
Akaike information criterion (AIC)	243 895.17
Schwarz Bayesian criterion (BIC)	243 907.02
Number of parameters	9

According to the data in Table 6, the mean reading performance for male students with an average economic status is 500.72 points.

Female students' performance is 8.47 points higher, which explains the gender gap in reading in favour of female students

For each point increase in students' economic status, their performance increases by 9.11 points.

With regards to the school climate, for each point increase in the quality of relations between students and teachers, the performance increases by 3.48 points.

For each point increase in students' school well-being, their performance increases by 1.06 points.

As for bullying, for each point increase in the frequency with which students suffer bullying, their performance in reading drops by -7.29 points.

With regards to the ownership of the school, being enrolled in a private school means that performance in reading increases by 10.04 points compared with a public school.

The results show a difference of chi-squared of 114 672.15 with six degrees of freedom, which is significant at .01, which confirms the better fit of the definitive model compared with the null model. The results reveal that both the AIC and the BIC of the definitive model also decrease with regards to the null model, so that the goodness of fit of the definitive model improves.

The predictors of the definitive model explain 21% of the differences in reading performance between the students (R^2 = .2158) and 50% of the variability between schools (R^2 = .4979).

3.3. Performance in mathematics

Table 7. Estimate of the null model of mathematics performance.

Fixed part	
Parameter	**Estimate (standard error)**
Constant	479.98 (4.19)
Random part (variance in mathematics performance)	
Level 1. Learners	5333.47 (43.66)
Level 2. School	1180.77 (62.20)
-2 restricted likelihood log	353 699.55
Akaike information criterion (AIC)	353 703.55
Schwarz Bayesian criterion (BIC)	353 715.671
Number of parameters	3

The data in Table 7 show that the mean performance in mathematics is 479.98 points for all students. These data differ from one another at the level of students (5333.47 / 43.66 = 122.15) and of schools (1180.77 / 62.20 = 18.98).

These parameters are significant. The likelihood ratio has a value of 353 699.55 for a null model with three parameters, which is compared with the definitive model.

The ICC has a value of .1812, meaning that 18% of the variance is variance between schools.

ICC = 1180.77 / (5333.47 + 1180.77) = .1812

Table 8 displays the results of the fixed part and the random part of the definitive model.

Table 8. Definitive mathematics performance model.

Fixed part	
Constant	527.36 (3.92)
Gender	-10.29 (.41)
Economic status of the students	11.78 (.84)
School climate	6.15 (.45)
School well-being	3.32 (.28)
Bullying	-8.86 (.67)
Ownership	9.75 (.32)
Random part	
Between students	4047.54 (37.26)
Between schools	557.86 (28.01)
-2 restricted likelihood log	193 037.51
Akaike information criterion (AIC)	193 041.51
Schwarz Bayesian criterion (BIC)	193 053.625
Number of parameters	9

According to the data in Table 8, the mean performance in mathematics for male students with an average economic status is 527.36 points.

Performance falls by 10.29 points for female students, which explains the gender gap in mathematics in favour of male students.

For each point increase in students' economic status, their performance increases by 11.78 points.

With regards to school climate, for each point increase in the quality of relations between students and teachers, performance in mathematics increases by 6.15 points.

For each point increase in students' school well-being, their performance increases by 3.32 points.

As for bullying, for each point increase in the frequency with which students suffer bullying, their performance in mathematics drops by -8.86 points.

With regards to the ownership of the school, being enrolled in a private school means that performance in mathematics increases by 9.75 points compared with a public school.

The results show a difference of chi-squared of 160 662.04 with six degrees of freedom, which is significant at .01, which confirms the better fit of the definitive model compared with the null model. The results show that both the AIC and the BIC of the definitive model also decrease with regards to the null model, so that the goodness of fit of the definitive model improves.

The predictors of the definitive model explain 24% of the differences in mathematics performance between the students (R^2 = .2411) and 53% of the variability between schools (R^2 = .5275).

4. Discussion and conclusions

The first objective of this work was to identify significant differences by gender in the variables relating to school environment. From this objective, three hypotheses were proposed.

The results mean the first hypothesis, which establishes significant differences in the perception of the school climate by gender, can be confirmed with female students scoring the quality of the relationships between students and teachers higher than male students do (Alshammari et al., 2022; González-Moreno & Molero, 2023).

The results mean the second hypothesis can be confirmed, which establishes significant differences in school well-being by gender, with male students displaying a more favourable opinion than female students of the conditions that foster a sense of belonging to the school. This differs from the results of other studies (Hernández et al., 2017; Jiang et al., 2024), which find significant differences in favour of female students.

The results confirm the third hypothesis, establishing significant differences in bullying by gender, with female students experiencing more bullying than male students (Riffle et al., 2021; Zhou et al., 2024).

The second objective was to analyse the influence of a set of predictors on school environment on the science, reading, and mathematics performance of the Spanish students who participated in PISA 2022. From this objective, six hypotheses are proposed.

The results mean that the fourth hypothesis can be confirmed, which states that gender is a significant predictor of performance in the three central areas of PISA; in this case, in favour of female students in reading. This is in accordance with the results of the works by Torppa et al. (2018) and Manu et al. (2023), who find a more positive attitude towards reading in female students than in male students. Similarly, male students score higher than female ones in science and mathematics, in accordance with the results of other studies (Bottazzi & Lusardi, 2021; Eriksson et al., 2020; Stoet & Geary, 2022), which show that male students' professional aspirations are directed more towards these two areas owing to the gender stereotypes associated with careers in the STEM field.

The results mean that the fifth hypothesis can be accepted, which states that students' economic status predicts their performance (Coleman et al., 1966; Xie & Ma, 2019), particularly in science and mathematics and to a lesser extent in reading. This agrees with the results of the work of Eriksson et al. (2022), which show that, in the 2018 edition, in the societies with the biggest performance gap, the environment had a stronger connection to variance in performance in mathematics and science than in reading. Similarly, the results are in line with other works (Gamazo & Martínez-Abad, 2020; Yeung et al., 2022) which show that the economic and cultural status, which includes the educational level of the parents, has an impact on children's expectations.

The results mean that the sixth hypothesis can be confirmed, which states that school climate has a significant effect on performance (Izaguirre et al., 2023; Ramazan et al., 2023). This underlines the importance of the relationship between teachers and students to promote learning (Zysberg & Schwabsky, 2021), as well as teaching quality (Rohatgi & Scherer, 2020). Similarly, school climate has more of an effect on mathematics and science than on reading, that is, on the areas where male students score higher than female students.

The results also mean that the seventh hypothesis can be conformed, which states that school well-being has a significant effect on performance. This agrees with the results of other research (Burns et al., 2020; Haw & King, 2023; Kiuru et al., 2020; Tan et al., 2022), with a larger effect in mathematics and science than in reading, that is, the areas where male students score higher than female students. In this sense, the work of Sortkaer and Reimer (2018) points to a correlation between school well-being and performance, which is stronger in male students than in female ones.

The results mean that the eighth hypothesis can be confirmed, which states that bullying has a significant effect on performance, in line with the results of other studies (Karakus et al., 2022; Molina-Muñoz et al., 2023; Ozyldirim & Karadağ, 2024). This explains the results of the work by Giménez et al. (2024), which shows that bullying has a negative influence on performance in science and mathematics in the 2018 edition of PISA. It should be observed that female students experience more bullying that male students, with a large effect in the areas where male students outperform female ones (science and mathematics) and in the area where female students outperform male ones (reading).

The results mean that the ninth hypothesis can be confirmed, which states that school ownership predicts student performance, with students from private schools scoring higher than those from public schools, primarily in science and reading (Aparicio et al., 2017), owing to the impact on performance of the economic status of the students who attend a particular school (Le Donné, 2014). However, other studies (Larsen et al., 2023; Pivovarova & Powers, 2019) note that after adjusting for the economic status variable, students being educated in public or private schools does not explain the differences in their performance.

This work draws a series of conclusions that relate to improving performance in science, reading, and mathematics in educational practice.

Firstly, female students have a more favourable opinion than male students of the school climate, which has a large effect on performance in mathematics and science. In this sense, the impact of school climate on performance suggests a need to create an environment that promotes students' learning, so that they feel emotionally secure in schools, something that requires improving the relationship between teachers and students.

Secondly, the large effect of school well-being on performance, in mathematics and science as well, suggests a need to reinforce students' sense of belonging to the school by implementing activities that foster interaction between peers. As in the previous, case, this conclusion invites us to consider in more depth the relationship between school well-being and performance in the STEM areas by gender.

In third place, given the large effect of bullying on performance in the three core areas of PISA, measures must be implemented in schools against intimidation, bullying at school, and cyberbullying.

Fourthly, as private-school students perform better than public-school ones, it is necessary to provide more resources to schools that are publicly funded and located in disadvantaged settings in order to eliminate the performance gap.

The limitations of this work derive from the missing data that affect large-scale international assessments such as PISA, which can be overcome by analysing the cases that have complete information from all variables. Similarly, as this is an *ex post facto* study, it is necessary to take into account the OECD self-reports about the PISA results. They show basic information about the validation of variables which must be complemented with reliability and validity analyses.

In conclusion, this research has identified significant differences by gender in variables relating to the school environment, as well as the influence of predictors that relate to the school environment (school climate, school well-being, and bullying) on the performance of Spanish students in science, reading, and mathematics in PISA 2022.

Author's contributions

Pablo Javier Ortega-Rodríguez: Conceptualisation; Data Curation; Formal Analysis; Investigation; Methodology; Software; Visualisation; Writing (original draft); Writing (review and editing).

Artificial Intelligence (AI) Policy

The authors do not claim to have made use of Artificial Intelligence (AI) in the preparation of their articles.

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