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Extracurricular Factors Influencing the Development of Mathematical Literacy in Greece and Portugal: A Comparative Analysis of PISA 2022 Findings

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Abstract

Mathematical literacy occupies a central place among the skills that individuals in modern societies seek to develop. Therefore, it is necessary to take into account the factors that influence its development. This study examined the relationships among staff adequacy, teacher support, socioeconomic background, and mathematics achievement in Greece using data from PISA 2022. Greece and Portugal were compared descriptively in order to contextualize the findings, while all regression analyses were conducted on the Greek sample. Analyses were performed using the IEA IDB Analyzer and incorporated all ten plausible values in mathematics achievement together with the 80 PISA replicate weights, in accordance with OECD methodological recommendations. Results indicated that both individual socioeconomic status and school-average socioeconomic composition were strong predictors of mathematics achievement. In contrast, staff adequacy and teacher support did not exert statistically significant independent effects after controlling for socioeconomic variables. The findings suggest that socioeconomic inequalities play a substantially greater role in shaping mathematical literacy than the resource-related indicators examined in the present study. Implications for educational policy and future research are discussed.

Keywords: Mathematical literacy, PISA, educational resilience, socioeconomic status, educational inequality

1. Introduction

Mathematical literacy is a fundamental skill for solving problems at the individual and social levels. It supports the development of creativity, innovation, and critical thinking, enabling individuals to actively participate in democratic societies and make informed economic decisions (Kappassova et al., 2025; Serin, 2023). As a complex concept, it includes the ability of individuals to formulate, use, and interpret mathematics in a variety of contexts, as well as to evaluate solutions in real-life situations (OECD, 2023; Pavong et al., 2025). Due to its importance, assessing the degree of its development in students is considered essential, a process that is carried out through the OECD's Programme for International Student Assessment (PISA). PISA findings allow countries to identify deficiencies, inequalities, and the effectiveness of their educational policies (Tan, 2024; OECD, 2024).

1.1 The Context of the Crisis and the Concept of Resilience

The PISA 2022 survey was conducted in the aftermath of the COVID-19 pandemic, revealing the impact of the health crisis on education. In this context, the importance of 'educational resilience' is highlighted, defined as the ability of students, especially those from socioeconomically disadvantaged backgrounds, to achieve high performance despite adversity, but also the ability of systems to recover after crises (Yang Hansen et al., 2025; OECD, 2023). This study compares Greece and Portugal, two countries with common characteristics but divergent educational trajectories, where Portugal appears to have maintained greater educational resilience, whereas Greece continues to face more pronounced systemic challenges. Portugal's educational resilience is not accidental but is largely attributed to targeted educational policies implemented over the past decades. A prominent example is the Educational Territories of Priority Intervention (TEIP) programme, alongside the National Programme to Promote School Success (PNPSE). These Portugal-specific policy frameworks focus on granting schools greater organizational and pedagogical autonomy, while strategically allocating additional funding and specialized staff to socioeconomically disadvantaged areas (Ferraz et al., 2019; Liebowitz et al., 2018). Such systemic initiatives are designed to foster inclusive school climates and actively decouple students' socioeconomic background from their academic achievement, providing a strong contextual contrast to the structural challenges faced by the Greek system.

1.2 Student performance in mathematical literacy in Greece and Portugal

The PISA 2022 results recorded an unprecedented decline in performance internationally, with the OECD average in mathematics falling by 15 points (OECD, 2023a). A substantial performance gap is evident between Greece and Portugal. Portugal showed remarkable stability with an average score of 472 points, matching the OECD average. In contrast, Greece scored an average of 430 points, lagging behind by 42 points, a difference equivalent to a learning gap of almost one school year (OECD, 2023d). This comparison ranks Greece among the lowest-performing developed countries. The divergence becomes more pronounced in the distribution of performance. In High Performance (Levels 5-6) in Portugal, the percentage reaches 7% (close to 9% in the OECD), while in Greece it is limited to just 2%, demonstrating a weakness in cultivating excellence. Similarly, in low performance (below level 2), almost half of Greek students (47%) fail to reach the basic level of proficiency, a percentage significantly higher than the 30% in Portugal and 31% in the OECD (OECD, 2023c; OECD, 2023d). Essentially, the average 15-year-old student in Greece in 2022 performed at the level of a 14-year-old in 2018, a clear indication of learning regression.

Table 1: Average performance in mathematics and proficiency distribution in PISA 2022

Country	Average Performance	Difference from OECD Average	% of High-Achieving Students (Level 5/6)	% of Low-Performing Students (Below Level 2)
Portugal	472	0	7	30
Greece	**430**	**-42**	**2**	**47**
OECD average	472	-	9	31

Source: OECD (2023c; 2023d)

1.3 Socioeconomic Background and Educational Equality

Analysis of the ESCS (economic, social, and cultural status) indicator reveals a complex picture. In Greece, the performance gap between privileged (top 25%) and non-privileged (bottom 25%) students is 76 points, which is less than the 101 points in Portugal and 93 points in the OECD. Furthermore, the ESCS explains only 12% of the variation in performance in

Greece, compared to 18% in Portugal (OECD, 2023c; OECD, 2023d). However, these seemingly positive figures mask the phenomenon of "equality in low performance." The smaller gap in Greece does not necessarily reflect improved outcomes among lower-achieving students, but rather the limited capacity of the system to support high-achieving students. Socioeconomically advantaged students in Greece achieve an average score of 470 points (below the OECD average), while their counterparts in Portugal score 522 points. The Greek system has a "low ceiling" that pushes performance down. Nevertheless, 12% of disadvantaged students in Greece are classified as academically resilient, exceeding expectations, which is a small but significant indication of potential.

Table 2: Key Indicators of Educational Equality in Mathematics (PISA 2022)

Indicator	Greece	Portugal	OECD Average
ESCS Performance Gap (Upper vs. Lower Quartile)	**76 points**	101 points	93 points
Percentage of Performance Variation Explained by ESCS	**12**	18	15
% Academically Resilient Students	**12**	9	10

Source: OECD (2023c; 2023d)

1.4 The Learning Environment and the Resource Crisis

The quality of the learning environment and the adequacy of resources are interlinked, determining the resilience of the education system. Portugal has built a strong safety net through a supportive climate, with 82% of students feeling that they "belong" at school, a percentage that remained stable during the pandemic. In contrast, in Greece the figure is 78%, with a recorded upward trend in feelings of loneliness and insecurity within school (OECD, 2023d). The pivotal distinction resides in the degree of pedagogical support afforded to students, which has been shown to engender a 15-point enhancement in academic performance. In Portugal, 75% of students report that their teachers demonstrate interest in their learning, and 79% indicate that they receive supplementary assistance. In Greece, the corresponding percentages were considerably lower (46% and 57% respectively), suggesting an inadequate provision of pedagogical support. Furthermore, while parental involvement has declined on an international level, in Portugal, 70% of teachers report systematic cooperation, in contrast to the mere 33% reported by their Greek counterparts. This disparity can be attributed, at least in part, to the structural crisis in resources experienced in Greece. Despite the shortage of teaching staff being experienced in both countries, the percentage of students affected differs. In Portugal, 62.1% of students are affected, whereas in Greece, the percentage is 54.3% (OECD, 2023b). Portugal has succeeded in maintaining higher performance and a more positive climate, thereby demonstrating its resilience. However, it is evident that digital readiness has been of crucial importance during the pandemic. Portugal, having previously invested in equipment, exhibited preparedness for distance learning. Conversely, Greece encountered inadequacies stemming from persistent shortages. Consequently, following the spring of 2022, The Greek government initiated a comprehensive digital transformation through the Recovery Fund, which included the installation of 36,000 interactive systems. The outcomes of this investment are anticipated to manifest in subsequent evaluations. Recent comparative education literature emphasizes that the relationship between school resources and student achievement is rarely direct. Contemporary studies highlight a more complex 'resource–climate–achievement' pathway, suggesting that material and human resources act primarily as foundational elements that enable the cultivation of a supportive school climate, which in turn fosters learning (Berkowitz et al., 2017). However, the effectiveness of this pathway is highly context-dependent. As current research indicates, structural inequalities and the overarching socioeconomic composition of a school can heavily constrain this mechanism, often acting as a dominant moderator that can either amplify or neutralize the benefits of available resources and teacher support (Tan, 2024).

2. Methodology

2.1 Purpose and Research Question

The purpose of this study was to examine the relationships among staff adequacy, teacher support, socioeconomic background, and mathematics achievement in Greece using PISA 2022 data. Although previous research has suggested that school resources and supportive learning environments may contribute to student achievement, the relative importance of these factors remains unclear once socioeconomic conditions are taken into account. Accordingly, the study addressed the following research question: To what extent are staff adequacy, teacher support, and socioeconomic background associated with mathematics achievement among Greek students?

2.2 Method

To investigate these relationships, a sequence of design-based regression models was estimated. Analyses were conducted using the IEA IDB Analyzer in conjunction with IBM SPSS Statistics. Following OECD PISA 2022 technical recommendations, all ten plausible values in mathematics achievement (PV1MATH–PV10MATH) and the 80 replicate weights were incorporated into the estimation procedure. Final estimates and standard errors were pooled across plausible values according to OECD guidelines. This research is:

- comparative (Pandey, 2025), as it performed a comparative analysis of quantitative data
- quantitative (Rauteda, 2025; Alford & Teater, 2025), as it analyzed numerical data using statistical techniques, and
- secondary (Dale, Arber, & Procter, 2025; Ratajczak et al., 2025), because it used exclusively published data and therefore non-primary data.

Multiple linear regression analysis was applied through a sequence of design-based regression models (Cohen et al., 2003; Field, 2024; Mandel & Lipovetsky, 2025; Tabachnick & Fidell, 2022). Because PISA uses a complex sampling design and plausible values for achievement estimation, all models were estimated using the IEA IDB Analyzer with the ten mathematics plausible values and the 80 replicate weights, following OECD technical recommendations (OECD, 2024).

2.3.Research Design

This study adopts a comparative design of two country cases (Greece–Portugal) with secondary analysis of quantitative data and interpretative synthesis. Mathematics achievement was estimated using all ten plausible values (PV1MATH–PV10MATH). Sampling variance was estimated through the Balanced Repeated Replication (BRR) procedure with Fay's adjustment using the 80 replicate weights supplied by PISA 2022. All analyses were weighted using the final trimmed nonresponse-adjusted student weight (W_FSTUWT). The analytical approach consists of extracting, classifying, and comparing the key indicators for the two countries in order to identify statistically significant differences, similarities, and distinct patterns. Descriptive comparisons were conducted for Greece and Portugal in order to contextualize the findings. However, all regression analyses were conducted exclusively on the Greek PISA 2022 subsample.

Table 3: Definition of variables used in the regression analyses

Variable	Role in the model	Description	Source/Measurement (PISA 2022)
Mathematics Performance	Dependent (Y)	Student score on the mathematics test.	Plausible Values PV1MATH–PV10MATH
Staff Adequacy Index	Predictor	Principal's perception of how much staff shortages hinder teaching (corrected index).	STAFFSHORT_corrected[1]
Teacher Support Index	Predictor	Average perception of students per school of how supportive teachers are.	TEACHSUP_corrected_school_mean
Socioeconomic Background	Control Variable	Index of economic, social, and cultural capital, at the individual and school levels.	ESCS (individual), ESCS_school_mean

Source: Authors' processing based on PISA 2022 dataset

Three models were used in this study, for which the following applies:

1. The first model examines the association between staff adequacy and mathematics achievement, controlling for individual ESCS and school-average ESCS (ESCS_school_mean).
2. The second model examines whether staff adequacy is associated with teacher support.
3. The third model examines the simultaneous contributions of staff adequacy, teacher support, and socioeconomic background to mathematics achievement.

The unit of analysis in the regression models was the student, with school-level variables assigned to students according to their school membership. ESCS was measured at the student level, whereas ESCS_school_mean, STAFFSHORT_corrected, and TEACHSUP_corrected_school_mean were school-level indicators. The regression models were specified as follows:

Model 1: $\text{PV\_MATH} = \beta_0 + \beta_1\text{ESCS} + \beta_2\text{ESCS\_school\_mean} + \beta_3\text{STAFFSHORT\_corrected} + \varepsilon$

Model 2: $\text{TEACHSUP\_corrected\_school\_mean} = \beta_0 + \beta_1\text{ESCS\_school\_mean} + \beta_2\text{STAFFSHORT\_corrected} + \varepsilon$

Model 3: $\text{PV\_MATH} = \beta_0 + \beta_1\text{ESCS} + \beta_2\text{ESCS\_school\_mean} + \beta_3\text{STAFFSHORT\_corrected} + \beta_4\text{TEACHSUP\_corrected\_school\_mean} + \varepsilon$

3. Findings

3.1 Findings Using the First Model

Table 4: Regression Coefficients for Mathematics Performance

Predictor	B	Std. Error	Beta (β)	t	Sig. (p-value)
(Constant)	442.71	2.37	-	186.55	< .001
STAFFSHORT_corrected	2.13	1.68	.03	1.27	n.s.
ESCS_school_mean	56.07	3.93	.32	14.27	< .001
Index of economic, social and cultural status	16.12	1.21	.18	13.27	< .001

Note. Dependent variable: mathematics achievement estimated using all ten plausible values (PV1MATH–PV10MATH). Estimates were produced using the IEA IDB Analyzer with the final student

[1] *The staff shortage indicator is used in the form STAFFSHORT_corrected, which is an inverted transformation of the original PISA indicator (higher value = less shortage).*

weight (W_FSTUWT) and the 80 PISA replicate weights. Model summary: $R^2 = .20$, Adjusted $R^2 = .20$. n.s. = not statistically significant at $p < .05$.

3.2 Findings Using the Second Model

The second regression model examined whether perceived staff shortages were associated with teacher support after controlling for school socioeconomic composition. The model explained approximately 7% of the variance in teacher support ($R^2 = .07$, SE = .03), indicating a relatively limited explanatory capacity for the selected predictors. The results of this model are presented in Table 5. As shown in Table 5, school-average socioeconomic status (ESCS_SCHOOL_MEAN) was positively and statistically significantly associated with teacher support (B = 0.23, SE = 0.05, t = 4.29, β = .27, p < .001). This finding indicates that schools with more socioeconomically advantaged student populations tended to report higher levels of teacher support. By contrast, staff shortages (STAFFSHORT_CORRECTED) did not emerge as a statistically significant predictor of teacher support (B = -0.03, SE = 0.02, t = -1.48, β = -.10, p > .05). Although the coefficient was negative, suggesting that greater staff shortages may be associated with lower levels of teacher support, the magnitude of the relationship was small and failed to reach conventional levels of statistical significance. Overall, Table 5 indicates that teacher support is more strongly associated with school socioeconomic composition than with perceived staff shortages. This suggests that differences in teacher support may reflect broader socioeconomic conditions at the school level rather than staffing adequacy alone.

Table 5: Regression coefficients for teacher support

Predictor	B	Std. Error	Beta (β)	t	Sig. (p-value)
(Constant)	0.41	0.03	-	15.65	< .001
STAFFSHORT_corrected	-0.03	0.02	-.10	-1.48	n.s.
ESCS_school_mean	0.23	0.05	.27	4.29	< .001

Note. Dependent variable: TEACHSUP_CORRECTED_SCHOOL_MEAN. Estimates were produced using the IEA IDB Analyzer with the final student weight (W_FSTUWT) and the 80 PISA replicate weights. Model summary: $R^2 = .07$, Adjusted $R^2 = .07$. n.s. = not statistically significant at $p < .05$.

3.3 Findings using the Third Model

Table 6 presents the findings of the third regression model, in which teacher support was introduced together with staff adequacy and the two socioeconomic indicators in order to predict students' mathematics performance. The model explained approximately 20% of the variance in mathematics achievement ($R^2 = .20$, SE = .02), indicating a moderate explanatory capacity for the selected predictors. The results show that socioeconomic background remained the strongest factor associated with mathematics performance. More specifically, individual socioeconomic status (ESCS) was positively and statistically significantly related to mathematics achievement (B = 16.12, SE = 1.21, t = 13.28, β = .18). This indicates that students from more advantaged socioeconomic backgrounds tended to achieve higher scores in mathematics. At the school level, the average socioeconomic composition of the school (ESCS_SCHOOL_MEAN) had an even stronger effect (B = 53.54, SE = 4.10, t = 13.07, β = .30). This finding suggests that students attending schools with a more advantaged socioeconomic profile achieved substantially higher mathematics scores. Therefore, the school socioeconomic environment appears to be the strongest predictor in the model. By contrast, staff adequacy, measured through the corrected staff shortage variable (STAFFSHORT_CORRECTED), did not reach statistical significance (B = 2.49, SE = 1.62, t = 1.54, β = .04). Although the coefficient was positive, its magnitude was small and the effect was not statistically significant. Similarly, teacher support at the school level (TEACHSUP_CORRECTED_SCHOOL_MEAN) was positively associated with mathematics achievement, but the effect also did not reach conventional levels of statistical significance (B = 11.01, SE = 6.05, t = 1.82, β = .05). These findings indicate that, after applying the full PISA estimation procedure with all ten plausible values and replicate weights, the strongest predictors of mathematics achievement are the individual and school-level socioeconomic indicators. Staff adequacy and teacher support show positive but statistically non-significant associations with performance. Overall, the findings indicate that socioeconomic background, particularly at the school level, is the strongest factor associated with mathematics achievement. Staff adequacy and teacher support show positive but statistically non-significant associations with performance once socioeconomic variables are taken into account.

Table 6: Regression Coefficients for Mathematics Performance (Final Model)

Predictor	B	Std. Error	Beta (β)	t	Sig. (p-value)
(Constant)	438.16	3.88	-	112.80	< .001
STAFFSHORT_corrected	2.49	1.62	.04	1.54	n.s.
ESCS_school_mean	53.54	4.10	.30	13.07	< .001
Index of economic, social and cultural status	16.12	1.21	.18	13.28	< .001
TEACHSUP_CORRECTED_SCHOOL_MEAN	11.01	6.05	.05	1.82	n.s.

Note. Dependent variable: mathematics achievement estimated using all ten plausible values (PV1MATH–PV10MATH). Estimates were produced using the IEA IDB Analyzer with the final student weight (W_FSTUWT) and the 80 PISA replicate weights. Model summary: $R^2 = .20$, Adjusted $R^2 = .20$. n.s. = not statistically significant at $p < .05$.

Overall, the findings highlight the dominant role of socioeconomic background in mathematics achievement. School-average socioeconomic composition was consistently the strongest predictor across the models, while individual ESCS also remained a strong and statistically significant factor. Staff adequacy and teacher support showed weaker and statistically non-significant associations with mathematics performance once socioeconomic variables were taken into account. These results suggest that differences in mathematical literacy among Greek students are explained primarily by socioeconomic conditions at both the student and school levels, rather than by the resource-related indicators examined in the present analysis. The interpretation of these findings requires attention to three main methodological and substantive considerations:

• The explanatory power of the model predicting teacher support remained limited, indicating that the variance in the TEACHSUP_corrected_school_mean index is only partly explained by the variables included in the analysis. School socioeconomic composition was positively associated with teacher support (B = 0.23, SE = 0.05, t = 4.29, β = .27), whereas staff adequacy was not a statistically significant predictor (B = -0.03, SE = 0.02, t = -1.48, β = -.10). This suggests that teacher support is more closely related to the socioeconomic composition of schools than to perceived staff shortages. Other unmeasured school-level factors, such as leadership, instructional practices, school climate, student engagement, or sense of belonging, may contribute significantly to shaping teacher support.

• Staff adequacy was not a statistically significant predictor of teacher support in the second model, and teacher support did not reach conventional levels of statistical significance in the final achievement model. Similarly, the association between staff adequacy and mathematics achievement was positive but not statistically significant. These findings suggest that socioeconomic background, particularly school-average ESCS, is the dominant factor associated with mathematics performance.

• PISA data are cross-sectional in nature, which limits the ability to draw causal conclusions. Moreover, the present analyses combine student-level and school-level variables within a single regression framework. Although the use of all ten plausible values and replicate weights appropriately addresses the complex PISA sampling design, future research should employ multilevel modelling or multilevel structural equation modelling in order to better account for the hierarchical structure of students nested within schools and to examine school-level relationships more rigorously.

Despite the above limitations, the findings underscore the dominant role of socioeconomic composition in shaping mathematics achievement. Resource-related indicators and teacher support remain relevant for understanding the broader school environment, but their independent associations with achievement were weaker and not statistically significant after socioeconomic background was taken into account.

3.4 Limitations and Implications for Future Research

The following inherent limitations were identified in this study:

- Correlation, not causation: The analysis identifies associations among the examined variables, such as school resources, teacher support, socioeconomic background, and mathematics achievement. However, the design of the PISA survey (cross-sectional survey) and the secondary nature of this analysis do not allow for reliable causal conclusions to be drawn. Any causal interpretation should therefore be treated with caution and supported by future longitudinal or experimental research.
- Validity of self-report data: Indicators relating to school climate, support, and resource shortages are based on questionnaires completed by students and principals. Therefore, they are perception and self-report data, which may be influenced by subjective interpretations or biases.
- Risk of ecological fallacy: The analysis is conducted at the national level (macro level). Drawing conclusions about individual students or schools (micro-level) based on national averages should be done with extreme caution, as there may be significant intra-national variations that are not reflected in the comparison.

Future research should examine additional school- and student-level factors that may shape mathematical literacy, including instructional quality, school leadership, student engagement, and broader indicators of school climate.

4. Discussion

This study examined the relationships among staff adequacy, teacher support, socioeconomic background, and mathematics achievement in Greece using PISA 2022 data. The descriptive comparison between Greece and Portugal highlighted substantial differences in mathematics performance and educational outcomes, with Portugal continuing to outperform Greece despite certain structural similarities. The regression analyses revealed that socioeconomic composition is substantially more important than resource-related indicators in explaining variation in mathematics achievement. Both individual socioeconomic status and school-average socioeconomic status were strongly associated with performance, whereas staff adequacy and teacher support did not exert statistically significant independent effects once socioeconomic variables were taken into account. These findings are consistent with a large body of international research demonstrating that socioeconomic inequalities remain among the strongest determinants of educational achievement. Students attending socioeconomically advantaged schools benefit from more favourable learning conditions and tend to achieve higher academic outcomes, regardless of the specific resource indicators examined. The results also suggest that the relationship between school resources and achievement is complex and may depend on broader school-level processes not fully captured in the present analysis, such as school leadership, instructional quality, student engagement, or broader aspects of school climate. Consequently, efforts to improve mathematical literacy in Greece should focus not only on resource allocation but also on addressing persistent socioeconomic inequalities that shape educational opportunities and outcomes.

5. Conclusion

This study examined the relationships among staff adequacy, teacher support, socioeconomic composition, and mathematics achievement in Greece using PISA 2022 data. After applying the full OECD-recommended estimation procedure based on ten plausible values and replicate weights, the results showed that socioeconomic composition emerged as the dominant predictor of mathematics achievement at both the individual and school levels. Students attending socioeconomically advantaged schools consistently achieved higher mathematics scores, while staff adequacy and teacher support did not demonstrate statistically significant independent effects once socioeconomic conditions were taken into account. These findings suggest that policies aiming to improve educational outcomes in Greece should not focus exclusively on resource indicators but should also address the broader socioeconomic inequalities that continue to shape students' learning opportunities and academic achievement.

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