Psicothema

Psicothema 2022, Vol. 34, No. 2, 217-225
doi: 10.7334/psicothema2021.486

ISSN 0214 - 9915 CODEN PSOTEG

www.psicothema.com

Article

Academic Resilience in Mathematics and Science: Europe TIMSS-2019 Data

Francisco Javier García-Crespo[1], Javier Suárez-Álvarez[2], Rubén Fernández-Alonso[3], and José Muñiz[4]
[1] Universidad Complutense de Madrid, [2] University of Massachusetts Amherst, [3] Universidad de Oviedo, and [4] Universidad Nebrija

Abstract

Background: Academically resilient students are those who exhibit high performance starting from a disadvantaged socioeconomic situation. This study aims to identify the personal, school, and national factors that are associated with that resilience in the European Union (EU). **Method:** The sample comprised 96556 fourth grade students from 21 EU countries participating in TIMSS-2019. Two three-level logistic regression models were specified for the overall sample. **Results:** The EU has an average of 25.67% resilient students in mathematics and 24.16% in science. Student confidence and having done prior linguistic tasks at school were the variables with the most predictive power after accounting for gender and students' immigrant background. The European countries analyzed largely compensated for the doubly-disadvantaged situation of immigrant students. Those countries with higher proportions of low-performing students had fewer resilient students. **Conclusions:** The educational policies in the EU member states are able to largely compensate for unfavorable starting positions; fundamentally, policies of a social nature such as support for immigrant students, families, or schools.

Keywords: Resilience, academic performance, mathematics and science skills, ET2020, TIMSS.

Resumen

Resiliencia Académica en Matemáticas y Ciencias: Datos de Europa TIMSS-2019. **Antecedentes:** el alumnado académicamente resiliente es aquel que obtiene un alto rendimiento partiendo de una situación socioeconómica desaventajada. Esta investigación pretende identificar los factores personales, escolares y nacionales que están asociados a la resiliencia académica en la Unión Europea (UE). **Método:** la muestra fue de 96.556 estudiantes de 4º grado de 21 países de la UE participantes en TIMSS-2019. Para el conjunto de la muestra se ajustaron dos modelos de regresión logística multinivel de tres niveles. **Resultados:** la UE tiene un promedio de 25,67% de alumnado resiliente en matemáticas y 24,16% en ciencias. La confianza de los estudiantes y haber realizado tareas lingüísticas previas a la escuela son las variables con mayor poder predictivo después de tener en cuenta el género y los antecedentes inmigrantes de los estudiantes. Los países europeos analizados compensan en buena medida la situación doblemente desaventajada del alumnado inmigrante. Aquellos países que poseen un mayor porcentaje de alumnado con bajo rendimiento tienen menos estudiantes resilientes. **Conclusiones:** las políticas educativas de los estados miembros de la UE son capaces de compensar en gran medida las situaciones desfavorecidas de partida. Fundamentalmente aquellas de carácter social como el apoyo al alumnado inmigrante, a la familia o las instituciones educativas.

Palabras clave: resiliencia, rendimiento académico, competencia matemática y científica, ET2020, TIMSS.

Resilience, understood as the human capacity to overcome or adapt to adverse situations, has been widely studied in recent years (Agasisti & Longobardi, 2017; OECD, 2010; OECD, 2011b; OECD, 2018) and has become particularly important in the current COVID-19 pandemic. In educational research, a student is considered academically resilient if, despite coming from an unfavorable socioeconomic or cultural background, they perform much better than their initial circumstances might suggest (Agasisti et al., 2018; García-Crespo et al., 2019a; García-Crespo et al., 2019b; OECD, 2010; OECD, 2011a; OECD, 2011b; Servicio de Evaluación Educativa, 2017). Resilience has been linked to academic performance and other areas of life (Heckman & Rubinstein, 2001). Resilient students have more opportunities to develop their potential, greater likelihood of social growth, and lower risks of poverty (OECD, 2016). One way of increasing equity in education systems comes from supporting and strengthening academic resilience (Agasisti et al., 2016). However, resilience can be associated with academic failure and socioeconomic disadvantage, Coronado & Paneque (2016) proposed a revision to improve resilience in the face of failure and social disadvantage. Edwards & Ashkanasy (2018) adapted a five-level emotion model and explored the potential role of emotions in experiences of academic failure to build resilience.

Various studies have explored the personal and school variables that encourage students' academic or educational resilience. With regard to personal and family variables, Erberber, et al. (2015) using data from 28 countries participating in the *Trends*

Received: October 27, 2021 • Accepted: November 29, 2021
Corresponding author: Francisco Javier García-Crespo
Facultad de Ciencias Matemáticas
Universidad Complutense de Madrdid
28005 Madrid (Spain)
e-mail: javierg@ucm.es

in International Mathematics and Science Study (TIMSS) 2011, found that the variables most strongly associated with resilience were enjoying mathematics, absence of bullying at school, and academic expectations. Using an Asian sample from TIMSS 2011, Sandoval & Białowolski (2016) reported that the variables with the greatest possibilities for resilience were positive student attitudes towards mathematics and time spent on mathematics in the home. Recently, using data from 4th grade students from 18 European participants in TIMSS 2015 and the *Progress in International Reading Literacy Study* (PIRLS) 2016, Cordero & Mateos-Romero (2021) reported that the factors most associated with resilience were the skills learned by students before starting school and the socioeconomic levels of their peers. Using data from the *Programme for International Student Assessment* (PISA) 2015 and 2018 from Spain, Greece, and Italy, Gabrielli et al. (2021) reported that beliefs in self-efficacy, a positive family environment, and language attitudes at home was associated with resilience in students from immigrant backgrounds. Furthermore, for this group, the "double origin gap" (socioeconomic and migratory) makes them more dependent on the school environment than their native peers. Gender does not seem to be associated with resilience, except in the study by Clavel et al. (2021), using science data from PISA 2015 and samples from Southeast Asia. They found that boys were more likely to be resilient in Macao and Singapore. In any case, the literature review by López-Zambrano et al. (2021) concluded that the evaluation data and the data from student interactions with the learning environment were the most important variables for early predictions of academic success.

The teaching and educational environment has also been shown to be a key element in increasing the likelihood of academic resilience (García-Crespo et al., 2021). Erberber et al. (2015) found that schools' interest in students' academic success, provision of educational resources, a safe, orderly school climate, and school discipline were the school-related variables that were most strongly associated with the condition of academic resilience. Sandoval & Białowolski (2016) reported that the chances of academic resilience were greater in schools with lower rates of bullying and higher levels of teacher expectations of student performance. Caprara et al. (2003), Klassen et al. (2013), and Tschannen-Moran & Hoy (2001) reported a positive effect between teachers' job satisfaction and student academic performance, which indicates that some characteristics of the teachers may increase the likelihood of resilience.

As the above indicates, there is relatively abundant evidence about the personal and school factors associated with academic resilience. Comparatively little is known, however, about the relationship between academic resilience and the characteristics of national education systems and their educational policies. Supra-national co-operative organizations have established Sustainable Development Goals (UNESCO, 2021) and Education and Training 2020 targets (European Comission, 2020), but there is hardly any evidence about whether indicators of educational policy increase the probability of academic resilience.

In this context, the present study has two main objectives. The first is to determine the prevalence of academically resilient students in mathematics and science in the European Union countries. The second is to analyze the individual, school, and national factors that are associated with the condition of resilience, either reinforcing it or weakening it. Understanding these two issues raised by our objectives is key in being able to improve the effectiveness of European education systems. To the best of our knowledge, this is the first study to examine the relationship between how well countries have met the Education and Training 2020 targets and the resilient students that there are in those countries. In summary, with this study we aim to shed light on the current situation of resilience in mathematics and science and its contextual predictors, as well as quantitatively estimating the efforts of countries to achieve the European Commission's objectives for 2020.

Method

Participants

The participating population was defined as students in the 4th grade of compulsory education in the 22 European Union countries participating in TIMSS 2019. The sample was made up of 96,556 students with a mean age of 10.24 years (s.d. 0.48) from 5,714 classes in 3,794 schools. The study also used responses from teachers (5,649 mathematics teachers and 5,487 science teachers) and 3,665 questionnaires completed by school principals (table 1).

Students were selected by two-stage stratified cluster sampling (Martin et al., 2020). Schools were selected in the first stage with a probability proportional to their size, and within the schools, the second stage was full class-groups which made up the clusters in TIMSS 2019. The data from the Netherlands was excluded as information from the family questionnaire was not provided, and so prevented the students' socioeconomic indicator from being determined, which was essential for the study to identify resilient students.

Instruments

Variables for Determining Academically Resilient Students

Mathematics and Science test. The test booklets for Mathematics and Science were produced following the framework established by Mullis & Martin (2017). The full bank of items is composed of 32 item blocks (16 for each subject) with approximately 10 items in each. The items, which were binary and partial credit, were distributed over 14 models of test booklet using a partially balanced incomplete matrix design (Fernández-Alonso & Muñiz, 2011). Each student completed a test booklet with approximately 40 items containing two blocks for each subject. Five plausible values per student were used for each Item Response Theory (IRT) scale with a mean of 500 and standard deviation of 100 (Martin et al., 2020).

Home Resources for Learning Normalized Index (HRLN). The HRLN index was constructed using IRT methodology from the responses to two items in the Student Questionnaire (Number of books in the home and Number of home study supports) and three items from the Home Questionnaire: Number of children's books in the home, Highest level of education of either parent; and Highest level of occupation of either parent (Martin et al., 2020; Mullis et al., 2020). The HRLN index is expressed in standardized points (Z) for the EU as a whole. Table 2 shows the mean and standard error for the index by country.

Predictors of Academic Resilience

Thirty-one variables were included in the prediction of academic resilience: 11 related to students, one related to families,

Table 1
Study Sample Data (by Country and EU Total)

Country	Schools	Classes	Students	Math teachers	Science teachers	Principals
Austria	193	302	4464	303	303	192
Belgium (Fl.)	147	256	4655	283	276	138
Bulgaria	151	211	4268	209	210	151
Croatia	153	263	3785	263	263	151
Cyprus	151	236	4062	229	168	147
Czech Republic	152	263	4692	264	257	151
Denmark	166	195	3227	190	190	145
Finland	158	316	4730	326	317	158
France	155	300	4186	300	300	151
Germany	203	211	3437	216	218	189
Hungary	149	252	4571	252	249	144
Ireland	150	231	4582	231	231	150
Italy	162	229	3741	229	229	159
Latvia	154	211	4481	203	189	152
Lithuania	207	250	3741	249	250	202
Malta	98	226	3630	210	209	98
Netherlands	112	182	3355	182	182	79
Poland	149	269	4882	225	189	149
Portugal	181	314	4300	314	314	181
Slovak Republic	157	269	4247	268	251	156
Spain	501	504	9555	509	514	487
Sweden	145	224	3965	194	178	135
Total UE	3794	5714	96556	5649	5487	3665

Table 2
Home Resources for Learning Normalized Index

	Mean	Standard error
Austria	0.04	0.03
Belgium (Fl.)	0.13	0.03
Bulgaria	-0.58	0.06
Croatia	-0.36	0.03
Cyprus	0.23	0.03
Czech Republic	0.16	0.02
Denmark	0.46	0.02
Finland	0.40	0.02
France	0.14	0.04
Germany	0.18	0.03
Hungary	0.04	0.04
Ireland	0.34	0.03
Italy	-0.45	0.04
Latvia	0.06	0.03
Lithuania	-0.10	0.03
Malta	0.17	0.02
Poland	0.05	0.03
Portugal	-0.18	0.03
Slovak Republic	-0.17	0.05
Spain	-0.07	0.03
Sweden	0.42	0.05

nine related to teachers, four related to school principals (Mullis et al., 2020), and six related to country (European Comission, 2020). These variables, classified at the student, classroom, and country level, are as follows:

Student variables (Level 1):

Gender: (0-Female and 1-male)

Immig: (0-Native and 1-immigrant)

Bullying: Student Bullying. TIMSS asked students about how often they experienced various bullying behaviors by their school peers. High values in this index indicate an absence of bullying.

M_Like: Students Like Learning Mathematics and *S_Like*: Students Like Learning Science. The scales cover students' attitudes toward mathematics/science and studying mathematics/science. High values in this index indicate more positive attitudes towards mathematics and science and learning them.

M_Confident: Students Confident in Mathematics and *S_Confident:* Students Confident in Science. These scales measure how well students think they can do mathematics or science. Greater self-confidence is measured with higher values in this index.

M_Clarity: Instructional Clarity in Mathematics Lessons and *S_Clarity:* Instructional Clarity in Science Lessons. Students were asked about aspects such as whether they know what their teacher expects them to do, whether their teacher is easy to understand, or has clear answers to their questions. Students who perceive more clarity in their teachers' expectations have higher scores in this scale.

Task_Literary: Could Do Literacy Tasks When Beginning Primary School and *Task_Numeracy:* Could Do Numeracy Tasks When Beginning Primary School. Students were scored according to their parents' answers about how well they could do some Early Literacy and Numeracy Tasks such as read some words, write letters of the alphabet, or count by themselves when they began primary school. Students who were able to do more tasks before beginning primary school have higher scores in these scales.

Family variables (Level 1):

Perceptions: Parents Perceptions of Their Child's School. TIMSS 2019 asked students' parents about the extent to which they were satisfied that their child's school promoted academic standards and fostered a positive school climate. Higher scores in this scale indicate the students' families being more satisfied with the school.

Teacher variables (Level 2)

M_Emphasis and *S_Emphasis:* School Emphasis on Academic Success-Mathematics and Science Teachers. This index collects information about the school's expectations towards academic achievement. Higher expectations are reflected in higher scores in this index.

M_Safe_Orderly and *S_Safe_Orderly:* Safe and Orderly Schools-Mathematics and Science Teachers. Students' teachers were asked how much they agreed or disagreed with a set of statements on the Safe and Orderly School scale. High scores in this scale are associated with safer schools.

M_JobSatisfaction and *S_JobSatisfaction:* Mathematics and Science Teacher Job Satisfaction. The TIMSS 2019 Teachers' Job Satisfaction scale is based on teachers' responses to questions about how they feel about being a teacher. Greater teacher job satisfaction means higher scores in the scale.

M_Limited_St_Not_Ready and *S_Limited_St_Not_Ready:* Classroom Mathematics/Sciences Teaching Limited by Students Not Ready for Instruction. The scale presents teachers' answers about the extent to which their classroom teaching is limited by students not being ready to learn (i.e., lacking prerequisite knowledge or skills, lacking basic nutrition, being sleep deprived, or having learning impairments). Teachers who report their teaching not being affected by these limitations score more highly in this index.

S_Science_Investigation: Teachers Emphasis on Science Investigation. Those teachers whose students participate more frequently in activities related to scientific investigation and experiments have higher scores in this index.

Principal variables (Level 2)

M_Shortage and *S_Shortage:* Instruction Affected by Math/Science Resource Shortages. The scale presents principals' answers about the extent to which school teaching is limited by resource shortages. Principals who report resource shortages as not being a problem for teaching have high scores in this index.

Sc_Discipline: School Discipline-Principal. TIMSS 2019 asked school principals for their perceptions about the extent that discipline, disorder, and bullying behaviors were problems in their school. Higher values in the scale indicate principals who do not see these problems in their schools.

Enter_Lit_Num_Skills: Students Enter with Literacy and Numeracy Skills. This index measures the percentage of students who begin primary education with literacy and numeracy skills. Schools with higher percentages of students with those skill have higher scores in this scale.

Country variables (Level 3)

U_Mat19 and U_Sci19: Underachievement in mathematics/science in the digital age. The share of low-achieving students in reading, mathematics and science should be less than 15%.

EarlyLeavers: Early leavers from education and training. The indicator is defined as the percentage of the population aged 18-24 with at most lower secondary education and who were not in further education or training during the last four weeks preceding the survey. The share of early leavers from education and training should be less than 10%.

Employment2019: The employment rate of recent graduates, 2010-2019. The share of employed graduates (20-34 year-olds) having left education and training 1-3 years before the reference year should be at least 82%.

Adultlearning2016: Adult (aged 25-64) participation in learning, 4-week reference period, 2010 and 2019. An average of at least 15% of adults should participate in lifelong learning.

Tertiary: Tertiary educational attainment (30-34). The share of 30-34 year-olds with tertiary educational attainment should be at least 40%.

Using IRT partial credit scaling, the variables were transformed to a scale with a central point of 10, corresponding to the average from all the countries participating in the TIMSS 2019. The units of the scale were chosen so that two points on the scale would correspond to the logit standard deviation in all countries (Martin et al., 2020; Mullis et al., 2020). For the statistical analysis in this study, all of the variables in level 1, except Gender and Immig, and the variables in level 2 were standardized with a mean of 0 and standard deviation of 1 for all of the participating EU countries. The level 3 variables were left as percentages (European Comission, 2020).

Procedure

TIMSS 2019 was applied following the standards of the International Association for the Evaluation of Educational Achievement (IEA) (Martin et al., 2020). Each student completed a booklet of cognitive items in two 36-minute sessions split by a 30-minute break. They then completed the context questionnaire. In addition, the Home Questionnaire was given to families, the Teacher Questionnaire was given to math and science teachers, and the School Questionnaire was completed by the school principals (Martin et al., 2020).

Data Analysis

The first study objective required the identification of academically resilient students in mathematics or science. For this study, students were considered resilient if they met two conditions; being socioeconomically disadvantaged and having a score in mathematics or science above the third quartile of the EU as a whole, once the individual HRLN was discounted. Students were considered socioeconomically disadvantaged if their score in the HRLN index was below the first quartile for their country. Once academically resilient students were identified, the percentages of this group were calculated by country and for the EU as a whole.

To pursue the second objective, analyzing the influence of the predictor variables on resilience in mathematics or science, multilevel logistic regression models were used (Cohen et al., 2013; Gelman & Hill, 2006; Snijders & Bosker, 2012), which appropriately model the variability of the data in the sampling designs of international large-scale assessments (De la Cruz, 2008; Iñiguez-Berrozpe & Marcaletti, 2018), while at the same time avoid the use of the replicated weightings in the TIMSS 2019 database (Fishbein et al., 2021). Two models were specified for the set of EU countries (one for each subject evaluated) with

three levels: student, school, and country. Analysis of the models considered the following parameters for each predictor: magnitude and regression coefficient; p-value of the coefficients or level of marginal significance of the variable; and odds ratio and its confidence interval (García-Crespo et al., 2019a). The models were specified with HLM6© and the cases were weighted with the original school and student weightings. These weightings, which reflect the probability of selecting the students and school in the study, allow proper reproduction of the population size and enhance the representativeness of the results (Rutkowski et al., 2010).

Missing contextual data was recovered using the linear trend process from the Missing Value Analysis module in SPSS, taking the class the student belonged to as segmentation (Fernández-Alonso et al., 2012).

Results

Resilient Students in Mathematics and Science in European Union Countries

Responding to the first study objective, Table 3 shows the percentage (and standard error) of academically resilient students in mathematics and science by country along with the EU average.

Table 3 shows that the percentages of academically resilient students in mathematics varied by country from 8.34% in France to 37.23% in Latvia. Only France (8.34%) and Spain (19.89%) had less than 20% resilient students in mathematics. In science, the percentages of resilient students varied between 39.13% (Finland) and 8.07% (France). If we take 20% as a limit, below which there is a low percentage of resilient students, six countries were below that: France (8.07%), Belgium (Fl.) (10.93%), Malta (13.95%), Austria (16.79%), Cyprus (19.58%) and Ireland (19.76%). The average proportion of resilient students in the EU countries that participated in TIMSS 2019 was 25.67% in mathematics and 23.16% in science.

Table 3
Percentage of Academically Resilient Students in Mathematics and Science in TIMSS 2019 by Country and for the EU Overall

	Mathematics		Science	
	Percentage	**pct_se**	**Percentage**	**pct_se**
Austria	30.14	1.60	16.79	1.53
Belgium (Fl.)	27.16	1.56	10.93	1.18
Bulgaria	28.35	4.65	24.97	3.68
Croatia	23.54	1.97	31.89	2.30
Cyprus	28.65	1.65	19.58	1.35
Czech Republic	29.71	1.98	29.69	1.81
Denmark	27.72	2.54	21.00	2.06
Finland	25.53	1.61	39.13	2.02
France	8.34	1.23	8.07	1.12
Germany	25.07	2.09	23.14	2.00
Hungary	20.54	1.68	26.25	2.00
Ireland	32.56	1.78	19.76	1.65
Italy	32.15	2.28	26.79	1.91
Latvia	37.23	2.50	37.43	2.19
Lithuania	27.41	1.83	25.99	1.76
Malta	21.03	1.57	13.95	1.35
Poland	22.52	1.56	31.07	1.89
Portugal	30.87	1.68	22.45	1.44
Slovak Republic	20.32	1.91	25.00	2.27
Spain	19.89	1.57	25.83	1.92
Sweden	20.28	2.02	27.74	1.98
Average EU	25.67	1.96	24.16	1.87

Factors Associated With Academic Resilience

Tables 4 and 5 show the regression coefficients for the predictors, together with the p-value and the odds ratio with the 95% confidence intervals for the regressions with criterion variables of mathematics and science resilience. They allow the identification of which factors, for each of the three levels examined, had greatest association with the criterion variables.

Table 6 gives a graphical indication of the effect of the variables on the probability of being resilient. It indicates whether the predictor variable has a positive effect (increases the probability) using ↑↑↑ if it is statistically significant at 99% ($0 \leq$ p-value $\leq .01$), ↑↑ if it is statistically significant at 95% ($.01 \leq$ p-value $\leq .05$) and ↑ if it is statistically significant at 90% ($.05 \leq$ p-value $\leq .10$). If the variable has a negative effect (reduces the probability), that is indicated by ↓↓↓ if it is significant at 99%, ↓↓ if it is significant at 95%, or ↓ if it is significant at 90%.

The resulting estimates show that, once immigration status and gender are discounted, the variable with the greatest predictive capacity is having carried out basic reading tasks at home before starting primary education, increasing the probability of resilience by 26.7 percentage points in mathematics and 10.4 in science; values similar to those provided by the parents' perception of the school (23.4% in mathematics and 18.7% in science). Looking at the results for the variables in Level Two of the analysis, we

Table 4
Summary of Results in Mathematics of Multilevel Binary Hierarchical Logistic Analysis for the European Union

Mathematics	**Coefficient**	**p-value**	**Odds Ratio**	**Confidence Interval**
Level 1				
Gender	0.34	0.01	1.405	(1.324,1.491)
Immig	0.87	0.01	2.377	(2.186,2.584)
Bullying	0.04	0.02	1.037	(1.006,1.069)
M_Like	0.07	0.01	1.069	(1.028,1.112)
M_Confident	0.24	0.01	1.267	(1.221,1.314)
M_Clarity	-0.08	0.01	0.919	(0.888,0.950)
Task_Literary	0.14	0.01	1.146	(1.106,1.188)
Task_Numeracy	0.03	0.06	1.033	(0.998,1.069)
Perceptions	0.21	0.01	1.234	(1.195,1.274)
Level 2				
M_Emphasis	-0.21	0.01	0.811	(0.777,0.847)
M_Safe_Orderly	0.09	0.01	1.096	(1.050,1.144)
M_JobSatisfaction	-0.01	0.73	0.993	(0.956,1.032)
M_Limited_St_Not_Ready	-0.04	0.03	0.960	(0.926,0.996)
M_Shortage	0.04	0.02	1.042	(1.006,1.079)
Sc_Discipline	-0.02	0.42	0.985	(0.948,1.023)
Enter_Lit_Num_Skills	-0.05	0.02	0.947	(0.906,0.989)
Level 3				
U_Mat19	-0.06	0.01	0.944	(0.935,0.953)
EarlyLeavers	0.01	0.93	1.001	(0.979,1.024)
Employment2019	-0.01	0.08	0.994	(0.987,1.001)
Adultlearning2016	-0.02	0.01	0.984	(0.978,0.990)
Tertiary	-0.01	0.03	0.989	(0.979,0.999)

Table 5
Summary of Results in Science of Multilevel Binary Hierarchical Logistic Analysis for the European Union

Science	Coefficient	p-value	Odds Ratio	Confidence Interval
Level 1				
Gender	0.22	0.01	1.247	(1.177,1.320)
Immig	0.60	0.01	1.822	(1.667,1.992)
Bullying	0.08	0.01	1.089	(1.057,1.121)
S_Like	0.02	0.39	1.018	(0.978,1.059)
S_Confident	0.04	0.06	1.036	(0.998,1.076)
S_Clarity	0.02	0.20	1.023	(0.988,1.058)
Task_Literary	0.10	0.01	1.104	(1.066,1.144)
Task_Numeracy	-0.02	0.16	0.976	(0.944,1.009)
Perceptions	0.17	0.01	1.187	(1.151,1.224)
Level 2				
S_Emphasis	-0.20	0.01	0.818	(0.783,0.854)
S_Safe_Orderly	0.09	0.01	1.095	(1.048,1.145)
S_JobSatisfaction	0.02	0.43	1.015	(0.977,1.055)
S_Limited_St_Not_Ready	-0.08	0.01	0.922	(0.888,0.956)
S_Science_Investigation	0.07	0.01	1.067	(1.031,1.105)
S_Shortage	-0.01	0.41	0.985	(0.952,1.020)
Sc_Discipline	0.03	0.17	1.027	(0.989,1.066)
Enter_Lit_Num_Skills	-0.01	0.71	0.992	(0.949,1.036)
Level 3				
U_Sci19	-0.06	0.01	0.937	(0.927,0.947)
EarlyLeavers	0.01	0.78	1.003	(0.979,1.028)
Employment2019	0.01	0.93	1.000	(0.992,1.007)
Adultlearning2016	-0.02	0.01	0.984	(0.977,0.991)
Tertiary	-0.01	0.02	0.988	(0.978,0.998)

Table 6
Effect of the Variables on the Probability of Being Resilient

	Mathematics	Science
Level 1		
Gender	↑↑↑	↑↑↑
Immig	↑↑↑	↑↑↑
Bullying	↑↑	↑↑↑
Like	↑↑↑	
Confident	↑↑↑	↑
Clarity	↓↓↓	
Task_Literary	↑↑↑	↑↑↑
Task_Numeracy	↑	
Perceptions	↑↑↑	↑↑↑
Level 2		
Emphasis	↓↓↓	↓↓↓
Safe_Orderly	↓↓↓	↓↓↓
JobSatisfaction		
Limited_St_Not_Ready	↓↓	↓↓↓
Science_Investigation		↓↓↓
Shortage	↑↑	
Sc_Discipline		
Enter_Lit_Num_Skills	↓↓	
Level 3		
Underachievement	↓↓↓	↓↓↓
EarlyLeavers		
Employment2019	↓	
Adultlearning2016	↓↓↓	↓↓↓
Tertiary	↓↓	↓↓

Note: ↑↑↑= statistically significant at 99%, ↑↑ = statistically significant at 95%, ↑ = statistically significant at 90%. The up arrow means the effect is positive. The down arrow means the effect is negative. No value means the effect is not statistically significant

find that schools with a good educational environment increased the resilience possibilities of their students by approximately 10 percentage points in both mathematics and science. It is important to note the impact of variables that measure emphasis on academic success and whether there are limits for teaching when students do not have a favorable academic level. In these cases, those schools that have students with educational deficiencies, but that do not emphasize academic success as their main value, were capable of achieving a higher percentage of resilient students in both mathematics and science, with percentages between an additional 10% and 20 %. To conclude, and focusing on the three levels of analysis, those countries with the highest percentages of students at low performance levels had 5.6% fewer resilient students in mathematics and 6.3% less in science.

Discussion

This study had two objectives. Estimate the percentage of academically resilient students in the EU and identify the individual, school, and national factors most strongly associated with academic resilience.

In terms of the first objective, the average percentages of academically resilient students in mathematics and science in the participating EU countries were similar (25.67% mathematics and 24.16% science), in line with the average seen in reading competence in PIRLS 2016 (García-Crespo et al., 2019a). However, there was notable variation between countries, with a wider dispersion in the percentages between countries in science than in mathematics. Although in some countries, more than 30% of students were resilient (Latvia, Ireland, Italy, Portugal and Austria in mathematics, and Finland, Latvia, Croatia and Poland in science), in France, the percentage of academically resilient students was close to 8% in both subjects. In addition, the percentages of academically resilient students might be expected to be similar in the two subjects, and as Table 3 shows, while there are countries where that was the case, such as the Czech Republic (29.71% and 29.69%) and Latvia (37.23% and 37.43%), in other countries there were notable differences, such as Belgium (FL.) (27.16% and 10.93%) and Poland (22.52% and 31.07%). In this regard, one future line of research would be to analyze the variables that have greatest impact on being academically resilient in each subject by country and identify what led to these situations in these countries.

In terms of the second objective, the data offer a consistent picture: academic resilience is a multidimensional phenomenon that seems to be associated with sociodemographic, family, personal, school, and educational policy factors (Erberber et al., 2015; Sandoval & Białowolski, 2016). The student demographic variables demonstrated the greatest effect. Boys were more likely to be resilient in both subjects (40 percentage points more in mathematics and 25 in science), something not observed by Sandoval & Białowolski (2016), but which was reported by Clavel et al. (2021). Nonetheless, García-Crespo et al. (2019a) found that girls were more likely to be resilient than boys in reading. These results may be due to the gender gap in STEM (Science, Technology, Engineering and Mathematics) subjects and language skills as seen in the results from boys (503 points in mathematics and 493 in science) and girls (499 points in mathematics and 489 in science) in TIMSS 2019 (Mullis et al., 2020) and in PIRLS 2016 (boys 501 points and girls 520) (Mullis et al., 2017). The data show that

immigrant students demonstrate higher proportions of resilience than native students (130 percentage points more in mathematics and 82 in science), which is consistent with the conclusions from Gabrielli et al. (2021) and validate the need for specific strategies in schools to encourage the inclusion of migrants and to reduce their vulnerability. Nevertheless, it is important to consider that it is reasonable to expect a higher proportion of students who are immigrants to be resilient according to the definition used here since it is more likely that immigrant students are overrepresented in the bottom quarter of socio-economic background. The same happens for boys, who are usually overrepresented in the top quarter of STEM high performers.

Another interesting interpretation of these findings is that the effect of some of the remaining variables in the model is statistically significant even after accounting for gender and immigrant background. For instance, being able to perform literacy tasks at the beginning of primary school and positive parental perceptions of children's schools was positively associated with academic resilience, both in mathematics (increases of 15% and 23% respectively) and science (10% and 19%) which underscores the fact that the family environment and early stimulation are key for increasing the chances of resilience (Cordeo & Mateos-Romero, 2021; Martín-Lagos, 2018; OECD, 2018). The statistically significant affective-emotional factors included self-confidence, which predicted increases of 27% in mathematics and 4% in science, and enjoying mathematics (increase of 7%), which is consistent with the evidence reported by Jacob (2002) and Waxman et al., (1997).

Amongst the school-related factors, it is notable that schools perceived as safe environments by the teachers increased the percentage of resilience by 10 percentage points in both subjects. This was confirmed by the students' perceptions, when students did not perceive bullying, the likelihood of resilience increased by 4% in mathematics and 8% in science. This is consistent with the results reported by Erberber et al. (2015) and García-Crespo et al. (2019b). At this second level of analysis, there was a higher percentage of resilient students in schools reporting that students do not enter with literacy and numeracy skills (5 %) and classroom teaching limited by students not ready for instruction (4 %) at the same time as instruction not affected by resource shortage (4 %). This seems to indicate that, despite the initial limitations with regard to the type of student, schools where the teaching processes are not affected by scarce resources are able to increase the percentage of resilient students. Yeung & Li (2021) concluded something similar, stating that when disadvantaged students' own resources or those of their families do not help them cope with adversity or increase their chances of success, school resources are very important for their academic success. In addition with regard to teachers, Waxman et al. (2003) stated affective relationships, high expectations, and opportunities to participate and contribute help to increase the probability of resilience. Delpit (1996) made contributions along similar lines, indicating that teachers' high expectations could structure and guide students' behaviors and challenge students beyond what they believe they are capable of. To finish off the school variables, it is important to note that, although Erberber et al. (2015) reported a positive relationship between resilience and a school's interest in students' academic success, the results from the present study are the opposite. One possible explanation, although it would be a future line of research, is that instead of schools with larger numbers of disadvantaged students focusing their interest on students' final achievement or excellence, they focus on the students achieving basic competencies, as once that is done, they will be more likely to be resilient. Another variable that suggests a new line of study is that measured by *Instructional Clarity in Mathematics Lessons* which seems to be negatively related to the condition of academic resilience in mathematics, and merits a more thorough analysis.

Finally, the country-level analysis (level 3 variables) allowed us to relate the level of achievement of the 2020 Objectives and the percentage of resilient students. The most important indicator was the percentage of low-achieving students, which was negatively related to academic resilience. The data indicate that in both subjects, the greater the percentage of underachieving students, the lower the proportion of resilient students, reaching 6 percentage points difference in both mathematics and science. The percentage of the population aged between 30 and 40 with higher education and the percentage of the adult population (aged 25-64) participating in educational or training activities exhibited significant negative effects, albeit with a very low impact (less than 2% of resilient students). This indicates that countries which have reached higher levels of achievement in these key indicators have a marginally lower percentage of resilient students.

In short, the results from this study indicate that investing in educational policies aimed at increasing student confidence in STEM subjects would likely increase the rates of resilience, as would investing in policies for reducing the gender gap in science-technology. It is also important to encourage family support, fundamentally by engaging in literacy tasks when beginning primary school. In the light of the results, policy makers could benefit students by acting directly on schools, aiming to achieve safer learning environments which have the necessary resources for the teaching-learning process and in which the students feel safe and secure, reducing bullying at school as far as possible. This would very likely lead to a reduction in the percentage of low-achieving students and increase the chances of socioeconomically disadvantaged students being resilient. In addition, intervening in these contexts has shown that educational systems can compensate for the initial disadvantages of immigrant students.

In line with previous research, these findings highlight the incremental effects of individual and affective variables on academic outcomes, even after accounting for family and background characteristics (Noftle & Robins, 2007; OECD, 2021a; OECD, 2021b; Suárez-Álvarez, Fernández-Alonso & Muñiz, 2014). Ultimately, fostering resilient students and educational systems relies heavily on combining policy, research, and practice. Bridging these gaps is essential to help policy makers make informed decisions, support teachers in daily practice, and enable children and adolescents to reach their potential (Suárez-Alvarez et al., 2020)

All of the results in this study are limited by the nature of the TIMSS study, which lacks student-variables such as cognitive ability and other, non-cognitive, skills which could be associated with resilience (Santos et al., 2018). It would also be useful to analyze whether these predictors of resilience remain significant over time or for other sets of countries with different sociocultural characteristics. In addition, the TIMSS study lacks a proper measure of teachers' self-efficacy according to student perceptions, according to the proposal from Lera et al. (2021). Finally, defining socioeconomically disadvantaged students using home-based resources may create problems of non-invariance across time

remain significant as certain traditional cultural possessions, such as books, may become less indicative of socioeconomic status (Avvisati, 2020). Together with the suggestions made previously in this study, these are potentially interesting directions for future research.

Acknowledgments

This research was funded by the Ministry of Economy, Industry and Competitiveness of Spain, Reference PSI2017-85724-P and Research Fund: FI-21-027.

References

Agasisti, T., & Longobardi, S. (2017). Equality of educational opportunities, schools'. *Social Indicators Research, 134*(3), 917-953. https://doi.org/10.1007/s11205-016-1464-5

Agasisti, T., Avvisati, F., Borgonovi, F., & Longobardi, S. (2018). *Academic resilience. What schools and countries do to help disadvantaged students succeed in PISA*. Education Working Papers, nº 167, OECD Publishing, Paris. www.oecd-ilibrary.org/docserver/e22490ac-en.pdf

Agasisti, T., Soncin, M., & Valenti, R. (2016). School factors helping disadvantaged students to succeed: Empirical evidence from four Italian cities. *Policy Studies, 37*(2), 147-177. https://doi.org/10.1080/01442872.2015.1127341

Avvisati, F (2020). Measuring socio-economic status in PISA: A review and suggested improvements. *Large-scale Assessments in Education, 8*. https://doi.org/10.1186/s40536-020-00086-x

Caprara, G. V., Barbaranelli, C., Borgogni L, L., & Steca, P. (2003). Efficacy beliefs as determinants of teachers' job satisfaction. *Journal of Educational Psychology, 95*(4), 821-832.

Clavel, J. G., García-Crespo, F. J., & Sanz San Miguel, L. (2021). Rising above their circumstances: What makes some disadvantaged East and South-East Asian students perform far better in science than their background predicts? *Asia Pacific Journal of Education*. https://doi.org/10.1080/02188791.2021.1886905

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2013). *Applied multiple regression/correlation analysis for the behavioral sciences*. Routledge. https://doi.org/10.4324/9780203774441

Cordero, J. M., & Mateos-Romero, L. (2021). Exploring factors related with resilience in primary education: Evidence from European countries. *Studies In Educational Evaluation, 70*(1), 101045. https://doi.org/10.1016/j.stueduc.2021.101045

Coronado Hijón, A., & Paneque Folch, M. (2016). Resiliencia al fracaso escolar y desventaja sociocultural: un reto para la orientación y la tutoría [Resilience to school failure and socio-cultural disadvantage: A challence for guidance and tutoring]. *Trauma, contexto y exclusión. Promocionando la resiliencia*. Grupo Editorial Universitario GEU.

De la Cruz, F. (2008). Modelos multinivel [Multi-level models]. *Epidemiol, 12*(3), 1-8. http://sisbib.unmsm.edu.pe/bvrevistas/epidemiologia/v12_n3/pdf/a02v12n3.pdf

Delpit, L. (1996). *The politics of teaching literate discourse*. New Press.

Edwards, M. S., & Ashkanasy, N. M. (2018). Emotions and failure in academic life: Normalising the experience and building resilience. *Journal of Management & Organization, 24*(2), 167-188. https://doi.org/10.1017/jmo.2018.20

Erberber, E., Stephens, M., Mamedova, S., Ferguson, S., & Kroeger, T. (2015). Socioeconomically disadvantaged students who are academically successful: Examining academic resilience crossnationally. *IEA'S Policy Brief Series, 5*. http://www.iea.nl/policy_briefs.html

European Comission (2020). *Education and Training Monitor 2020*. https://op.europa.eu/webpub/eac/education-and-training-monitor-2020/en/chapters/foreword.html#targets

Fernández-Alonso, R., & Muñiz, J. (2011). Diseños de cuadernillos para la evaluación de las competencias básicas [Booklet designs for the evaluation of basic skills]. *Aula Abierta, 39*(2), 3-34.

Fernández-Alonso, R., Suárez-Álvarez, J., & Muñiz, J. (2012). Imputación de datos perdidos en las evaluaciones diagnósticas educativas [Imputation methods for missing data in educational diagnostic evaluation]. *Psicothema, 24*(1), 167-175. http://www.psicothema.com/psicothema.asp?id=3995

Fishbein, B., Foy, P., & Yin, L. (2021). *TIMSS 2019 User Guide for the International Database*. Boston College, TIMSS & PIRLS International Study Center. https://timssandpirls.bc.edu/timss2019/international-database/

Gabrielli, G., Longobardi, S., & Strozza, S. (2021). The academic resilience of native and immigrant-origin students in selected European countries. *Journal of Ethnic and Migration Studies*, 1-22. https://doi.org/10.1080/1369183X.2021.1935657

García-Crespo, F. J., Fernández-Alonso, R., & Muñiz, J. (2019). Resilient and low performer students: Personal and family determinants in European countries. *Psicothema, 31*(4), 363-375. https://doi.org/10.7334/psicothema2019.245

García-Crespo, F. J., Fernández-Alonso, R., & Muñiz, J. (2021). Academic resilience in European countries: The role of teachers, families, and student profiles. *PLoS ONE, 16*(7).

García-Crespo, F. J., Galián, B., Fernández-Alonso, R., & Muñiz, J. (2019). Educational resilience in reading comprehension: Deteminant factors in PIRLS-Europe. *Revista de Educación, 384*, 65-89. https://doi.org/10.4438/1988-592X-RE-2019-384-413

Gelman, A., & Hill, J. (2006). *Data analysis using regression and multilevel/hierarchical models*. Cambridge University Press.

Heckman, J. J., & Rubinstein, Y. (2001). The importance of noncognitive skills: Lessons from the GED testing program. *The American Economic Review, 91*(2), 145-149.

Iñiguez-Berrozpe, T., & Marcaletti, F. (2018). Modelos lineales multinivel en SPSS y su aplicación en investigación educativa [Linear multilevel models in SPSS and its application in educational research]. *REIRE Revista d'Innovació i Recerca en Educació, 11*(1), 26-40. https://doi.org/10.1344/reire2018.11.118984

Jacob, B. A. (2002). Where the boys aren't: Non-cognitive skills, returns to school and the gender gap in higher education. *Economics of Education Review, 21*, 589-598.

Klassen, R., Wilson, E., Siu, A. F. Y., Hannok, W., Wong, M. W., Wongsri, N., Sonthisap, P., Pibulchol, C., Buranachaitavee, Y., & Jansem, A. (2013). Preservice teachers' work stress, self-efficacy, and occupational commitment in four countries. *European Journal of Psychology, 28*(4), 1289-1309. https://doi.org/10.1007/s10212-012-0166-x

Lera, M. J., León-Peréz, J. M., & Ruiz-Zorrilla, P. (2021). Adaptation of the Teacher Effi cacy Scale to Measure Effective Teachers' Educational Practices Through Students' Ratings: A Multilevel Approach. *Psicothema, 33*(3), 509-517. https://doi.org/10.7334/psicothema2020.262

López-Zambrano, J., Lara Torralbo, J. A., & Romero, C. (2021). Early prediction of student learning performance through data mining: A systematic review. *Psicothema, 33*(3), 456-465. https://doi.org/10.7334/psicothema2021.62

Martin, M. O., von Davier, M., & Mullis, I. V. (2020). *Methods and Procedures: TIMSS 2019 Technical Report*. Boston College, TIMSS & PIRLS International Study Center. https://timssandpirls.bc.edu/timss2019/methods

Martín-Lagos, M. D. (2018). Education and inequality: A meta-synthesis after the 50th anniversary of Coleman's report. *Revista de Educación, 380*, 186-209. https://doi.org/10.4438/1988-592X-RE-2017-380-377

Mullis, I. V., & Martin, M. O. (2017). *TIMSS 2019 Assessment Frameworks*. Boston College, TIMSS & PIRLS International Study Center. https://timssandpirls.bc.edu/timss2019/frameworks/

Mullis, I. V., Martin, M. O., Foy, P., Kelly, D., & Fishbein, B. (2020). *TIMSS 2019 International Results in Mathematics and Science*. Boston College, TIMSS & PIRLS International Study. https://timssandpirls.bc.edu/timss2019/international-results/

Mullis, I., Martin, M., Foy, P., & Hooper, M. (2017). *PIRLS 2016 International Results in Reading*. Boston College, TIMSS & PIRLS International Study Center. http://timssandpirls.bc.edu/pirls2016/international-results/

Noftle, E., & R. Robins (2007). Personality predictors of academic outcomes: Big five correlates of GPA and SAT scores. *Journal of Personality and Social Psychology, 93*(1,) 116-130. https://doi.org/10.1037/0022-3514.93.1.116

OECD (2010). *PISA 2009 results: Overcoming social background - equity in learning opportunities*. OECD Publishing, Paris. https://doi.org/10.1787/9789264091504-en

OECD (2011a). *Does participant in pre-primary education translate into better learning outcomes at school? PISA in Focus nº 1*. OECD-ilibrary. http://cort.as/-M3Ms

OECD (2011b). *How do some students overcome their socio-economic background? PISA in Focus, nº 5*. https://www.oecd-ilibrary.org/education/how-do-some-students-overcome-their-socio-economic-background_5k9h362p77tf-en

OECD (2016). *PISA 2015 results: Policies and practices for successful schools* (Vol. 2). OECD Publishing, Paris. https://doi.org/10.1787/9789264267510-en

OECD (2018). *The resilience of students with an immigrant background: Factors that shape well-being, OECD Reviews of migrant education*. OECD Publishing, Paris. https://doi.org/10.1787/9789264292093-en

OECD (2021a). *21st-Century Readers: Developing Literacy Skills in a Digital World*. OECD Publishing, Paris. https://doi.org/10.1787/a83d84cb-en

OECD (2021b). *Beyond Academic Learning: First Results from the Survey of Social and Emotional Skills*. OECD Publishing, Paris. https://doi.org/10.1787/92a11084-en

Rutkowski, L., González, E., Joncas, M., & von Davier, M. (2010). International largescale assessment data: Issues in secondary analysis and reporting. *Educational Researcher, 39*(2), 142-151.

Sandoval-Hernández, A., & Białowolski, P. (2016). Factors and conditions promoting academic resilience: A TIMSS based analysis of five Asian education systems. *Asia Pacific Education Review, 17*, 511-520. https://doi.org/10.1007/s12564-016-9447-4

Santos, M. A., Ferraces, M. J., Godas, A., & Lorenzo, M. M. (2018). Do cooperative learning and family involvement improve variables linked to academic performance? *Psicothema, 30*(2), 212-217. https://doi.org/10.7334/psicothema2017.311

Servicio de Evaluación Educativa (2017). Éxito contra todo pronóstico: el alumnado académicamente resiliente [Success against all odds: Academically resilient students]. *Informe Evaluación, 12*, 1-8.

Snijders, T. A., & Bosker, R. J. (2012). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. Sage.

Suárez-Alvarez, J., Fernández-Alonso, R., Kyllonen, P. C., De Fruyt, F., Fonseca-Pedrero, E., & Muñiz, J. (2020). Editorial: Bridging the gap between research and policy in fostering social and emotional skills. *Frontiers in Psychology, 11*, 426. https://doi.org/10.3389/fpsyg.2020.00426

Suárez-Álvarez, J. R., Fernández-Alonso, J. Muñiz (2014). Self-concept, motivation, expectations, and socioeconomic level as predictors of academic performance in mathematics. *Learning and Individual Differences*, *30*, 118-123. https://doi.org/10.1016/j.lindif.2013.10.019

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 17*(7), 783-805. https://doi.org/10.1016/S0742-051X(01)00036-1

UNESCO (2021). *UNESCO and Sustainable Development Goals*. https://en.unesco.org/sustainabledevelopmentgoals

Waxman, H. C., Gray, J. P., & Padrón, Y. N. (2003). *Review of research on educational resilience*. Center for Research on Education, Diversity & Excellence, University of California.

Waxman, H. C., Huang, S. L., & Padron, Y. N. (1997). Motivation and learning environment differences between resilient and nonresilient latino middle school students. *Hispanic Journal of Behavioral Sciences, 19*(2), 137-155. https://doi.org/10.1177/07399863970192003

Yeung, W. J., & Li, H. (2021). Educational resilience among asian children in challenging family environment. *Social Indicators Research, 153*, 675-685. https://doi.org/10.1007/s11205-019-02143-7