

CAN PARENTS CONTRIBUTE TO 15-YEAR-OLDS' SCIENCE ACHIEVEMENT?

¿PUEDEN LOS PADRES DE ESTUDIANTES DE 15 AÑOS INFLUIR EN SU RENDIMIENTO EN CIENCIAS?

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ABSTRACT

The main aim of this study was to evaluate the relationship between parental involvement and student science achievement using a structural equation modeling (SEM) approach.

Since it is not possible to eliminate the differences in students' economic, social and cultural status (ESCS), it is vital to understand which strategy could be most effective to promote equity in different school systems. Among the possible strategies, parental involvement has recently been conceived as a relevant factor. Data from a representative sample of 15-year-old Italian students who participated in the Organisation for Economic Co-operation and Development (OECD) Programme for International Student Assessment (PISA) 2015 were analyzed. The Italian data were compared with data from EU countries from the Mediterranean area that are culturally similar to Italy and that participated in the optional parent questionnaire, namely, France, Malta, Portugal, and Spain. Students completed the PISA test, and their parents completed the optional questionnaire that included questions regarding students' ESCS, attitudes and beliefs regarding science and their expectations regarding their children's educational careers.

The model was successful in explaining the PISA test scores in science: the predicted model showed a good fit to the data with 25% of the variance explained. The results showed that ESCS contributed to the prediction of science achievement; furthermore, the results evidenced the positive, significant effects of parental involvement factors mediating the relationship between ESCS and PISA test achievement, especially in France, Malta and Portugal. Although the mediation effects were not large, they were statistically significant for all countries considered and suggested that parental involvement plays a mediating role in the effects of ESCS on science achievement, as evidenced by the significant indirect effects observed in the SEM analysis. Increasing parental participation could be a useful intervention to reduce ESCS-related differences in achievement.

Key words: PISA, science achievement, parental involvement in schools, SEM, mediation effects

RESUMEN

El objetivo principal de este estudio ha sido evaluar la relación entre la participación parental y el rendimiento de los alumnos en ciencia utilizando un enfoque de la modelización de ecuaciones estructurales (SEM).

Puesto que no se puede eliminar las diferencias en la situación económica, social y cultural de los estudiantes (ESCS), es vital entender que estrategia puede ser más eficiente para promover la equidad en los sistemas escolares diferentes. Entre las estrategias posibles, la participación parental recientemente se ha concebido como un factor relevante. Se analiza los datos de una muestra representativa de la participación de los estudiantes italianos de 15 años en las evaluaciones de PISA 2015. Los datos de Italia se han sido comparados con los datos de otros países de la UE en la zona

del Mediterráneo que son culturalmente similares a Italia y han participado en las encuestas parentales opcionales, concretamente Francia, Malta, Portugal y España. Alumnos han completado las pruebas de PISA y sus padres – las encuestas opcionales que incluían las preguntas sobre la ESCS, las actitudes y creencias con respeto a ciencia y sus expectativas con respeto a las trayectorias educativas de sus hijos.

El modelo ha sido satisfactorio para explicar los resultados de pruebas de PISA en ciencia: el modelo predicado ha mostrado un buen ajuste a los datos con 25% de la variación explicada. Los resultados han mostrado que la ESCS contribuye en la predicción del rendimiento en ciencia; más aún los resultados manifiestan los efectos positivos y significantes de los factores como la participación parental en la intermediación de las relaciones entre la ESCS y el rendimiento de las pruebas de PISA, sobre todo en Francia, Malta y Portugal. Aunque los efectos de mediación no han sido grandes, pero han sido estadísticamente significados para todos los países que consideran y sugieren que la participación parental asume un papel de mediación en efectos de la ESCS en el rendimiento en ciencia, lo que se evidencia por los efectos indirectos significantes observados en el análisis de SEM. La participación parental incrementada se puede considerar como una intervención útil para reducir las diferencias relacionadas a la ESCS en el rendimiento escolar.

Palabras clave: PISA, rendimiento científico, implicación de padres en la escuela, SEM, mediación

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1. INTRODUCTION

In recent decades, the experiences of international surveys, such as the Organisation for Economic Co-operation and Development (OECD) Programme for International Student Assessment (PISA) and the International Association for the Evaluation of Educational Achievement (IEA) surveys, have allowed the participating countries to gain a more detailed picture of the characteristics and effectiveness of their education systems. Although in many countries the reduction of the disparity in achievement between students from different social groups or ethnic groups has been identified as an important task of the education system, this objective is far from being achieved. In fact, the results of the most important international surveys (e.g., the OECD PISA and the IEA Trends in International Mathematics and Science Study (TIMSS), Progress in International Reading Literacy Study (PIRLS) and International Civic and Citizenship Education Study (ICCS)) have repeatedly highlighted the persistence of a strong association between student performance and the socioeconomic status (SES) of students' families of origin in most countries across the world (Sirin, 2005; Chiu and Xihua, 2008; Martin, Mullis, Foy & Hooper, 2016; Mullis et al., 2016; OECD, 2016). A challenge for education systems is, therefore, to try to reduce the differences in performance between socioeconomically disadvantaged students and students from affluent homes. In the literature, several factors have been found to be related to student performance, including parental involvement; there is a wealth of evidence that parents who are actively involved in children's education can positively influence children's attainment and make a significant difference to their educational outcomes (Epstein & Dauber, 1991; Eccles & Harold, 1993; Desforges and Abouchaar 2003; Harris & Chrispeels, 2006). Indeed, actively engaging parents in education is a shared aspiration and goal of many countries and across different school systems.

Although previous research has revealed significant differences in the construct of parental involvement depending on students' age, students' school cycle and SES of their families, the construct generally includes three aspects: home-based involvement, school-based involvement, and academic socialization (Fan & Chen, 2001; Hill & Chao, 2009; Hill & Tyson, 2009). Home-based involvement entails parents' involvement activities at home, such as supervising homework, checking homework, and talking about school life; generally, parents' reactive behaviors (e.g., educational support practices) are negatively correlated with achievement, while proactive behaviors (e.g., discussion) are positively associated with academic achievement. This trend is probably the reason why research usually shows no association or a negative association between help given by parents in doing homework and students' achievement (Fan & Chen, 2001; Lee & Bowen, 2006; Sad, 2012). School-based involvement includes some activities implemented at school, such as communicating with teachers, attending class meetings, and participating in school activities; however, different studies have shown that such involvement does not directly predict changes in achievement (Altschul, 2011; Zhang, Hsu, Kwok, Benz, Bowman-Perrott, 2011; Robinson & Harris, 2014; Castro et al., 2015).

Academic socialization includes mainly parents' expectations and beliefs about their children's education. It also refers to the ability of parents to convey to their children the value and importance of studying and learning (Hill & Tyson, 2009; Benner, Boyle & Sadler, 2016). Hill and Tyson (2009), in their meta-analysis, found that academic socialization was the factor most strongly associated with academic performance in adolescence. Home-based involvement (with the exception of homework help) was also positively associated with performance, although to a lesser extent, while school-based involvement seemed to have a lesser effect. Parents' aspiration was the factor with the greatest impact on school performance, after socioeconomic and cultural differences were controlled, as evidenced in several studies (Fan, 2001; Fan & Chen, 2001; Jacobs & Harvey, 2005; Shute et al., 2011).

Moreover, studies have shown that the more parents are able to convey a sense of the importance of school and learning for their children's personal development, the more their children succeed in their schooling (Hong & Ho 2005; Hong et al. 2010; Powell 2012). For example, using data from the Education Longitudinal Study 2002-2013, Benner, Boyle and Sadler (2016) tested the relationship between parental involvement (i.e., home-based involvement, school-based involvement, and academic socialization) and academic achievement. They found that there was a strong relationship between parent expectations and achievement and that parental involvement exerted its influence on achievement even 10 years later.

Among middle and high school students, discussions among parents, teachers, and school administrators and discussions of schooling and future plans with adolescents had the strongest relations with academic outcomes (Epstein & Sanders, 2002; Yonezawa, 2000). Parent academic involvement reduced problematic behaviors at school and, in turn, improved school performance (McNeal, 1999).

Several studies (e.g., Sirin, 2005; Harris & Graves 2010; Shen, Washington, Bierlein Palmer, Xia, 2014; Martin, Mullis, Foy & Hooper, 2016; OECD, 2016) have also highlighted the importance of SES in predicting school success. As expected, previous research has also shown that there is a difference between parents from economically disadvantaged backgrounds and those from economically privileged backgrounds with respect to their concepts of educational responsibility. Parents from lower social classes more frequently support a clear division between school and family and do not consider themselves to be an inherent part of the education process, believing that the education of their children belongs exclusively or almost exclusively to school (Moles, 1993; Muller, 1993; Dodge & Feldman, 1990). Notwithstanding these differences, thanks to the latest sophisticated analysis techniques, it is possible to better understand the role that parental involvement can play in the student's performance, regardless of their SES. In fact, recent studies have shown that parental involvement acts as a mediator in the relationship between SES and academic achievement (e.g., Bicer, Capraro, & Capraro, 2013; González & Jackson, 2013): motivated families, independently of their socioeconomic index, can help students improve their academic performance through various forms of involvement.

1.1. THE CURRENT STUDY

The main purpose of the current study was to examine the relationship between parental involvement and student science achievement using the data from the PISA 2015 survey, following a series of studies that investigated the same topic (Borgonovi and Montt, 2012; Hampden-Thompson, Guzman and Lippman, 2013; OECD, 2017; Tan, 2018). All these studies investigated to what extent parental involvement is important for student outcomes and what forms of involvement are most associated with learning outcomes. Borgonovi and Montt (2012) studied parental involvement using the PISA 2009 data, analyzing the relationship between school-based parental involvement, home-based parental involvement, parents' early involvement in school life and children's reading literacy, among other outcomes. They distinguished three forms of home-based parental involvement: academically oriented involvement, nonacademically oriented involvement and parents' reading habits. The authors found that early involvement of parents; some forms of home-based involvement, both academic and nonacademic; and positive parents' reading habits and attitudes showed a positive relationship with reading performance for 15-year-old children, even after controlling for the SES of the family. School-based activities, on the other hand, showed a negative relation. Hampden-Thompson et al. (2013) found similar results using the student responses from the PISA 2000 data. They considered three types of parental involvement: social communication, cultural communication, and parental assistance with homework. In most countries, social and cultural communication were the best predictors of students' literacy. In contrast, helping children with their homework was negatively associated with children's literacy.

Contrasting results were found in some studies that analyzed PISA 2015 data (OECD, 2017; Tan, 2018). The OECD report on students' well-being confirmed the general results of the previous studies regarding the differential impacts of home-based and school-based parental activities. Focusing on the Hong Kong PISA 2015 data, Tan found three groups of different patterns of parental involvement, also characterized by different levels of ESCS¹. His results showed a complex relation between parental involvement and ESCS. However, he did not find significant differences in scientific literacy among the three groups. Perera (2014), using data from PISA 2006, found that parents' attitudes towards science had a positive, statistically significant effect on science achievement. Moreover, students from poor backgrounds appeared to benefit from positive parental science attitudes as much as students with high ESCS, such that the equality of student achievement was not affected.

Based on the literature referred to in this paper, three hypotheses are proposed to be tested based on the PISA 2015 data:

- H1) Parental expectations and the value that parents attribute to science influence both parental involvement behavior and students' science achievement.
- H2) High parental engagement during childhood and home-based parental involvement are associated with academic science achievement as measured through the PISA test.
- H3) Parental involvement mediates the relation between ESCS and achievement.

2. METHOD

2.1 SAMPLE

The PISA 2015 (OECD, 2016), promoted in 72 countries and economies by the OECD, was the data source for the analyses reported here.

However, in this research, we used data only from the four EU countries of the Mediterranean area that are culturally similar and that participated in the optional parent questionnaire, namely, France, Italy, Malta, Portugal, and Spain.² In these countries, the parents of participating students completed a questionnaire inquiring about their families and backgrounds, their children's school experiences, and their attitudes towards science and the environment (as this PISA wave focused on science).

In each country, the surveyed students constituted a representative sample of the population of 15-year-old students, derived from a two-stage stratified sampling approach.

In total, 29,369 student/parent clusters from the 5 countries were included in this study. Table 1 indicates the distribution of students and parents per country, both in our sample and in the population.

Table 1: Distribution of the samples and populations by country

COUNTRY	STUDENTS	
	N	POPULATION ESTIMATE
FRANCE	5,358	638,182
ITALY	9,174	405,000
MALTA	3,203	3,757

¹ The two indices, ESCS and SES, presented in this study are substantially similar. In PISA, instead of SES (socioeconomic status), the acronym ESCS (students' economic, social and cultural status) is used to explicitly acknowledge the cultural component that characterizes the index. The cultural aspect, such as the parents' educational level, is normally also included in the construction of the SES index referring to the studies previously presented.

² The countries selected for the current study are EU members that are in the southern rim of the EU and opted into the parent questionnaire. These countries are part of an informal alliance group, established in 2013 to build coordination on issues of common interest. This group is called EuroMed 7 and consists of 7 member states (Cyprus, France, Greece, Italy, Malta, Portugal, and Spain) (Myrianthis, 2019). Cyprus and Greece were not included in this study, as they did not collect parents' data in the PISA 2015.

PORTUGAL	6,881	91,566
SPAIN	4,753	280,262
OVERALL SAMPLE	29,369	1,418,767

Source: Original material

With respect to Table 1, the figures do not match with countries' sample size and the target population. The lower number of students analyzed in this study compared to those in the international database is related to the fact that a certain number of parents for each country did not fill in the home questionnaire. This reduction in response rates may introduce bias in the estimates if certain kinds of parents (e.g. those with higher ESCS) are more likely to fill in the questionnaire than others³.

2.2. MEASURES

In this study, we used the science achievement score as the outcome variable and several indexes/items as indicators of parental involvement, as well as the ESCS index. Some items were reverse coded to ensure that high scores on each item reflected agreement of the respondents. All the measures are described below.

Science Achievement. The PISA measured scientific literacy through the administration of specific questions designed according to a conceptual framework and statistical indications. The administration of the items was established by using a balanced incomplete block design via computer-based administration.

Item response theory (IRT) modeling was implemented, and the literacy score was computed by deriving ten plausible values for each student (OECD, 2017; R. J. Mislevy, A. E. Beaton, Kaplan, M. Sheehan, 1992). The plausible values scale scores were standardized on a scale, where the mean of 500 was set to correspond to the mean of overall achievement in 2006, with 100 points set to correspond to the standard deviation. Achievement data from subsequent PISA assessments have been reported on this scale.

Economic, Social and Cultural Status (ESCS). The economic, social and cultural status (ESCS) was derived by computing a composite score on different dimensions. The index was computed performing a principal component analysis on the following indicators: 1) parental education; 2) highest parental occupation; and 3) home possessions, including books at home (see OECD, 2017). The ESCS scale value was transformed, with zero being the mean of the OECD countries and one being the standard deviation. Each country contributed equally; that is, they received the same weight.

Parents' Views on Future Environmental Topics. This index was calculated based on parents' judgments on seven questions regarding environmental issues, such as "water shortages", in the next 20 years. The response options were on a three-point Likert-type scale: 1) *improve*, 2) *stay about the same*, and 3) *get worse*. IRT modeling was applied to parents' responses, and weighted likelihood estimate (WLE) scores were computed (OECD, 2017) with an international mean of zero and a standard deviation of one. All the items were reverse coded, so higher WLEs and higher difficulty meant higher level of environmental optimism (see the Appendix).

Parents' Views on Science. This index describes how parents valued scientific approaches to daily life and in society (OECD, 2017). Respondents had to indicate their agreement or disagreement on a 4-point Likert-type scale, ranging from *strongly agree* to *strongly disagree*. Parents responded to five items, for instance, "Science is very relevant to me." IRT modeling was applied to parents' responses, and the WLE scores were computed with an international mean of zero and

³ Tables A.1 in Appendix shows the number and characteristics of students who answered the parental questionnaire as compared to those who answered the main PISA surveys.

a standard deviation of one. All the items were reverse coded, so higher WLEs and higher difficulty meant a point of view that highly valued science (see the Appendix).

Children's Past Science Activities. Parents had to indicate how often their children did different activities with scientific content when they were 10 years old (OECD, 2017). The response options were as follows: 1) *very often*, 2) *regularly*, 3) *sometimes*, and 4) *never*. All the ten items were reverse coded, IRT modeling was applied and the WLEs were computed, with the mean equal to zero and the standard deviation equal to one. Positive values indicated frequent behaviors (see Appendix).

Parents' Expectations of Students' Science Attainment. This item asked parents to indicate whether they expected their children to pursue scientific studies in the future. The responses were dummy coded, where one meant yes and zero meant no (see Appendix).

Parents' Home-based Involvement. This index summarized how often parents were engaged with their children in activities regarding science. The following items were included: 1) Discuss how well my child is doing at school, 2) Help my child with his/her science homework, 3) Ask how my child is performing in science class, 4) Obtain science-related materials (e.g., applications, software, study guides, etc.) for my child, 5) Discuss with my child how science is used in everyday life, and 6) Discuss science-related career options with my child. Parents had to respond on a five-point Likert-type scale ranging from *never or hardly ever* to *every day or almost every day*.

We computed this index by performing a principal component analysis on the overall student sample of the countries considered in the current study, giving equal weight to each country. The mean was zero, and the standard deviation was one.

2.3. DATA ANALYSIS

First, descriptive analyses were performed on the indicators used, and correlations between each of the indicators and the science achievement score were conducted using the IEA International Database (IDB) Analyzer software (IEA, 2017) and IBM SPSS Statistics 23.00 (IBM Corp., 2015). Then, a mediation analysis with structural equation modeling (SEM) assessed the direct and indirect effects of ESCS on science achievement through the mediation of the parental involvement factors described above by means of MPLUS 7.4 (Muthén and Muthén, 2017). The cases were weighted by senate weight: each country contributed the same to the comparison, regardless of the size of the population. In the model, according to the standard conventions, both the observed variables, represented in the graph with rectangles, and the latent variables, represented with ovals, were considered (see Figure 1). For the construction of the latent variables, the parceling method was used based on item-total correlations (Little, 2012).

3. RESULTS

3.1. DESCRIPTIVE AND CORRELATION ANALYSES

Table 2 and Table 3 show the mean score and the correlation between each index and the PISA science score for each selected country.

In all countries, parents showed positive values and expectations regarding science and the future careers that their child could pursue in the future. On the other indexes, there was some variation across countries. In particular, Parents' Views on Future Environmental Topics from Malta and Spain were more optimistic than parents' views from the other countries, where the values of the index were negative. Parents from France and Spain reported that their children were less involved in past scientific activities at 10 years than parents from the other countries. Finally, parents from France and Malta seemed less engaged with their children in home-based support activities for science than parents from the other countries. For France, Italy and Malta more than 30% of students have parents expecting their children will undertake a science career. This percentage increase up to 50% in Spain and Portugal.

Regarding the relation between science achievement and the indexes, the indexes in all countries showed positive relations, except for the level of environmental optimism, which showed a negative relation. Finally, in Italy, the relationship between parental home-based support and science literacy was found to be negative.

Table 2: Descriptive statistics of the indexes used by country

COUNTRY	INDICES OF PARENTAL INVOLVEMENT AND SCIENTIFIC LITERACY													
	SCIENTIFIC LITERACY		ECONOMIC, SOCIAL AND CULTURAL STATUS		PARENTS' VIEWS ON FUTURE ENVIRONMENTAL TOPICS		PARENTS' VIEWS ON SCIENCE		CHILDREN'S PAST SCIENCE ACTIVITIES		PARENTS' HOME-BASED INVOLVEMENT		PARENTS' EXPECTATIONS OF STUDENTS' SCIENCE ATTAINMENT	
	Mean score	e.s.	Mean score	e.s.	Mean score	e.s.	Mean score	e.s.	Mean score	e.s.	Mean score	e.s.	% of Yes	e.s.
FRANCE	495	(2.06)	-0.14	(0.02)	-0.11	(0.01)	0.22	(0.02)	-0.31	(0.02)	-0.24	(0.02)	35	(0.89)
ITALY	481	(2.52)	-0.07	(0.02)	-0.01	(0.01)	0.48	(0.02)	0.18	(0.02)	0.10	(0.02)	36	(1.44)
MALTA	465	(1.64)	-0.05	(0.01)	0.34	(0.02)	0.32	(0.02)	0.08	(0.02)	-0.10	(0.02)	39	(0.74)
PORTUGAL	501	(2.43)	-0.39	(0.03)	-0.03	(0.02)	0.49	(0.02)	0.22	(0.01)	0.18	(0.02)	51	(0.90)
SPAIN	493	(2.07)	-0.51	(0.04)	0.14	(0.02)	0.51	(0.02)	-0.04	(0.02)	0.07	(0.02)	49	(0.91)

Table 3: Correlational analysis of the indexes used and the PISA science score per country

COUNTRY	CORRELATIONS BETWEEN THE PISA SCIENCE SCORE AND											
	ECONOMIC, SOCIAL AND CULTURAL STATUS		PARENTS' VIEWS ON FUTURE ENVIRONMENTAL TOPICS		PARENTS' VIEWS ON SCIENCE		CHILDREN'S PAST SCIENCE ACTIVITIES		PARENTS' EXPECTATIONS OF STUDENTS' SCIENCE ATTAINMENT		PARENTS' HOME-BASED INVOLVEMENT	
	Corr.	SE	Corr.	SE	Corr.	SE	Corr.	SE	Corr.	SE	Corr.	SE
FRANCE	0.45	0.01	-0.06	0.02	0.27	0.01	0.22	0.01	0.41	0.01	0.10	0.02
ITALY	0.31	0.02	-0.05	0.02	0.17	0.02	0.13	0.02	0.29	0.02	-0.08	0.02
MALTA	0.38	0.01	-0.17	0.02	0.26	0.02	0.28	0.02	0.34	0.02	0.14	0.02
PORTUGAL	0.39	0.02	-0.16	0.01	0.22	0.01	0.26	0.02	0.31	0.02	0.07	0.01
SPAIN	0.37	0.01	-0.03	0.02	0.22	0.02	0.17	0.02	0.34	0.02	0.06	0.02

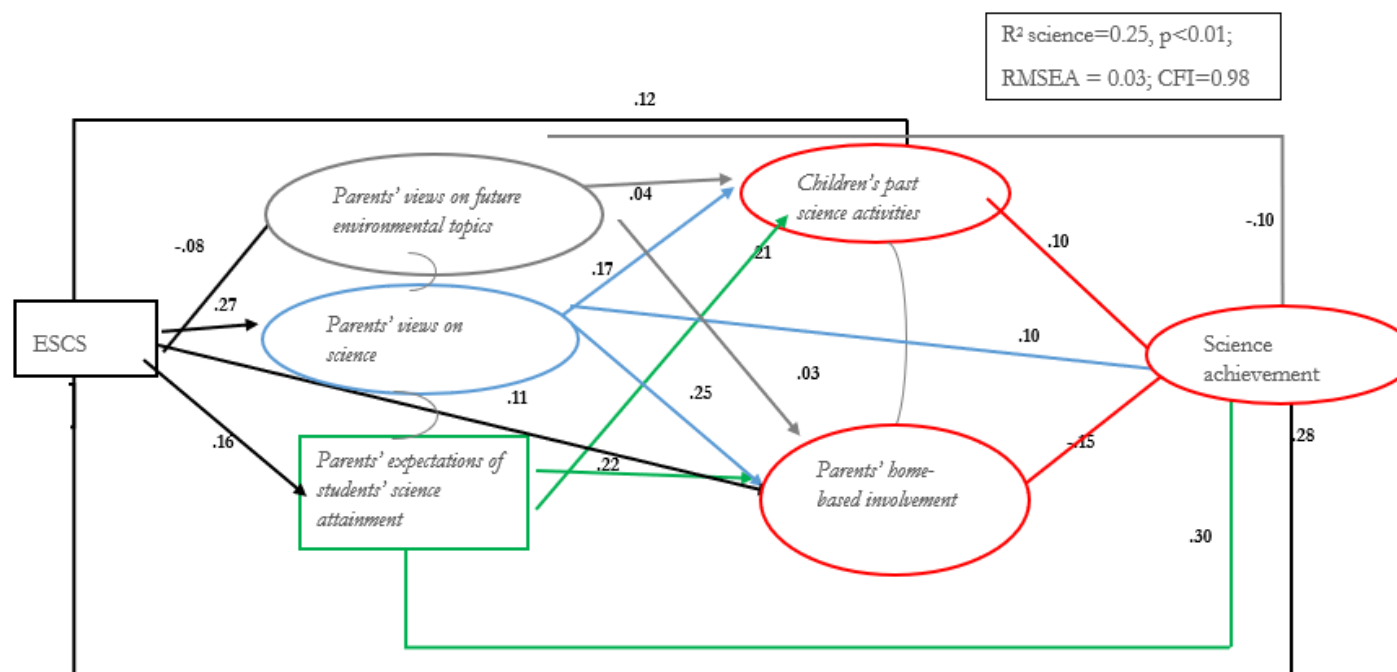
Source: Original material

3.2 PATH ANALYSIS

In performing the path analysis (Figure 1), the measures were used as follows:

- Family ESCS was used as an independent variable;
- Parents' expectations for their children's science attainment, parents' views on science and parents' views of future environmental topics were used as variables dependent on ESCS and independent of the two measures of parental involvement and science achievement;
- Parents' discussions with their children about school issues and early science activities at the end of primary school were considered mediating variables;
- The PISA science test score was considered a dependent variable.

Figure 1: Relationships between parental involvement and science achievement – all countries



Source: Original material

To improve the readability of Figure 1, the measurement errors, parcels and correlation coefficients considered in this investigation are not depicted. Table 4 shows the results both for the model with all countries and for the models of each country.

Table 4: Direct effects: beta coefficients of the independent variables

		DETERMINANTS					
		ALL COUNTRIES (R ² = .25)	FRANCE (R ² = .33)	ITALY (R ² = .23)	MALTA (R ² = .27)	PORTUGAL (R ² = .29)	SPAIN (R ² = .26)
PARENTS' VIEWS ON SCIENCE	ESCS	.27 (.01)	.34 (.02)	.28 (.02)	.26 (.02)	.36 (.02)	.29 (.02)
PARENTS' EXPECTATIONS OF STUDENTS' SCIENCE ATTAINMENT	ESCS	.16 (.01)	.21 (.01)	.24 (.02)	.17 (.02)	.19 (.02)	.17 (.02)
PARENTS' VIEWS ON FUTURE ENVIRONMENTAL TOPICS	ESCS	-.08 (.01)	-.08 (.02)	-	-.15 (.02)	-.11 (.02)	-
HOME-BASED INVOLVEMENT	ESCS	.11 (.01)	.13 (.02)	.06 (.02)	.19 (.02)	.12 (.02)	.15 (.02)
	Parents' views on future environmental topics	.03 (.01)	-	.07 (.02)	-	.06 (.02)	-
	Parents' views on science	.25 (.01)	.24 (.02)	.25 (.02)	.24 (.02)	.23 (.02)	.21 (.02)
	Parents' expectations of students' science attainment	.22 (.01)	.19 (.02)	.19 (.02)	.23 (.02)	.20 (.02)	.18 (.02)
CHILDREN'S PAST SCIENCE ACTIVITIES	ESCS	.12 (.01)	.06 (.02)	.08 (.02)	.18 (.02)	.20 (.02)	.07 (.02)
	Parents' views on future environmental topics	.04 (.01)	-	.05 (.02)	-	-	-
	Parents' views on science	.17 (.01)	.10 (.02)	.18 (.02)	.19 (.02)	.18 (.02)	.14 (.02)
	Parents' expectations of students' science attainment	.21 (.01)	.26 (.02)	.22 (.02)	.20 (.02)	.17 (.02)	.20 (.02)
SCIENCE ACHIEVEMENT	SES	.28 (.01)	.36 (.01)	.24 (.02)	.27 (.02)	.30 (.01)	.31 (.02)
	Parents' views on future environmental topics	-.10 (.01)	-.05 (.01)	-	-.12 (.02)	-.14 (.02)	-.05 (.02)
	Parents' views on science	.10 (.01)	.11 (.02)	.09 (.02)	.14 (.02)	.07 (.02)	.08 (.02)
	Parents' expectations of students' science attainment	.30 (.01)	.35 (.01)	.25 (.02)	.28 (.02)	.25 (.01)	.31 (.02)
	Children's past science activities	.10 (.01)	.05 (.02)	.13 (.02)	.11 (.02)	.17 (.02)	.11 (.02)
	Home-based involvement	-.15 (.01)	-.13 (.01)	-.10 (.02)	-.10 (.02)	-.17 (.02)	-.14 (.02)

Statistically significant ($p < 0.01$) coefficients are indicated in **bold** font. Statistically significant ($p < 0.05$) coefficients are indicated in normal font. Standard errors appear in parentheses.

Source: Original material

The structural equation model with all countries had good indexes according to recommended cut-off values (Byrne, 2001) (RMSEA=0.03 and CFI=0.98) and explained 25% of the variance in science achievement.

Science achievement was predicted by all factors considered in the path model.

Science achievement was found to be strongly and positively associated with ESCS ($\beta=.28$, $p < 0.01$), parents' expectations of student education in science subjects ($\beta=.30$, $p<0.01$), and parent's view of science ($\beta=.10$, $p<0.01$). Parents' views on future environmental topics were negatively related to science achievement: the more pessimist parents' views on the future of the environment were, the more likely their children were to obtain better results on the PISA science test. Parents' discussions with their children about school and science issues were negatively related to achievement ($\beta= -.15$, $p<0.01$). The more time parents spent with their children doing activities related to science at the end of the primary school, the better students did in science ($\beta=.10$, $p<0.01$).

Parents' expectations about their children's science education and parents' views on science were associated with parents' behavior, both as children's past science activities and home-based involvement.

The relation between parents' behavior and parents' view on future environmental topics was statistically significant but negligible.

The model explained science achievement to a greater extent in France (33% of the variance in science achievement) and Portugal (29% of the variance explained) and to a lesser extent in Italy (23% of the variance explained).

More specifically, in France, in addition to ESCS ($\beta=.36$, $p<0.01$), parents' expectations of their children's education in science subjects contributed to explaining science achievement ($\beta=.35$, $p<0.01$).

With regard to mediation, the estimation of the indirect effects in the model enabled the clarification of how much ESCS influenced science achievement through its effect on the mediating variables considered, i.e., the levels of parental participation. The crucial parameters to consider were the estimates of the indirect effects. Indeed, the significance of the indirect effects is the unique requirement for mediation to be established (Zhao et al., 2010; Iacobucci et al., 2007). Table 5 illustrates the mediating effect of parental involvement between ESCS and TIMSS achievement.

Table 5: Direct, indirect and total effects with ESCS as the independent variable

CAUSAL EFFECTS	DETERMINANTS	SCIENCE ACHIEVEMENT AS THE DEPENDENT VARIABLE					
		ALL COUNTRIES	FRANCE	ITALY	MALTA	PORTUGAL	SPAIN
DIRECT		.28 (.01)	.36 (.01)	.24 (.01)	.27 (.01)	.30 (.01)	.31 (.01)
INDIRECT	Parents' views/expectations	.08 (.001)	.12 (.001)	.07 (.001)	.11 (.001)	.10 (.001)	.06 (.001)
	Parental behavior		-.02 (.001)	-	-	.01 (.001)	-
TOTAL		.36 (.01)	.45 (.02)	.31 (.02)	.38 (.02)	.01 (.02)	.37 (.02)

Source: Original material

Because of rounding, some totals may appear inconsistent.

The results evidenced the positive, significant effects of parental involvement factors mediating the relationship between ESCS and science achievement. More specifically, parents' expectations of their children's academic careers in science and their views on science mediated the effect of ESCS on science achievement, while parents' behaviors had a negligible or statistically nonsignificant effect. Regarding the single-country models, in France, Malta and Portugal, the mediation effects

of parents' expectations and views were more evident ($\beta = .12, .11$ and $.10$, respectively) than in Italy and Spain ($\beta = .07$ and $.06$, respectively).

4. DISCUSSION

This study investigated the role of parental involvement on 15-year-olds students' science achievement as measured through the PISA 2015 survey.

The model proved to be successful in explaining the PISA science scores: the predicted model showed a good fit to the data with 25% of the variance explained. Across the countries, the variance explained by the model varied from 33% in France to 23% in Italy.

Context factors, reflecting the availability or unavailability of economic and cultural resources within the family, play a relevant role in predicting the performance of students (e.g., Sirin, 2005; Chiu & Xihua, 2008; Levpušek et al., 2013). This aspect is confirmed by the present study, in which the socioeconomic index was found to be linked to science achievement (Chiu & Xihua, 2008; Martin, & Mullis, 2013; Mullis et al., 2016; OECD, 2016).

Parents' high expectations that their children will pursue scientific studies seems to be positively associated with achievement, and in this study, it was one of the constructs most related to performance on the PISA test in each country, in accordance with previous studies (Fan & Chen, 2001; Shute et al., 2011; Singh et al., 1995).

According to the previous literature, early activities related to science seem to have a positive impact on future science achievement (Borgonovi & Montt, 2012).

On the other hand, support for students on their science homework was found to be negatively correlated with science achievement, in line with previous research (Cooper, 1989; Fan & Chen, 2001; Driessen et al., 2005; Lee & Bowen in 2006; Cooper, 2007; Sad, 2012; Guzman and Lippman, 2013; Hampden-Thompson et al. 2013).

As found in prior studies (González & Jackson, 2013; Cooper, et al., 2009), although the mediating effects were not large, they were statistically significant and suggested that parental involvement plays a mediating role on the effects of ESCS on science achievement, as evidenced by the significant indirect effects observed in the SEM analysis.

We are aware of the limitations of this study. A first limitation is the cross-sectional research design and hence the correlational nature of the study, which prevents the evaluation of the causal links underlying the observed associations. Data from international surveys, such as those presented here, provide a snapshot of education systems but fail to capture the underlying processes. Longitudinal studies would instead allow us to monitor the same group of subjects over the years and would be valuable in clarifying the role that parental involvement plays in student performance. For example, this study highlighted the negative impact of helping children with their homework. Correlational analyses allow us to state that students with poorer science achievement receive more help at home in their homework, but no conclusions can be drawn about the possible causal relationship. A longitudinal study, on the other hand, would allow us to see whether, among students who struggle more at school at a given time, students who received help from their parents were able to partially overcome this disadvantage compared to students who did not receive this kind of help. Moreover, to better understand the relationship between teachers and parents, qualitative case studies involving only a few schools that would allow the phenomenon to be investigated in greater depth would be helpful.

In addition, since the students of parents who did not answer the questionnaire had a lower ESCS on average than the overall sample and got lower scores in science (except in Portugal, where these differences are not statistically significant), the generalization of results to the population of 15-year-old students in each country requires particular caution.

Notwithstanding these limitations, this study seems to suggest that parental involvement not only directly influences students' achievement but also mediates the effects of socioeconomic

background as a possible means of offsetting the inequity of school systems. Thus, parental involvement should be considered one aspect to investigate in depth for a deeper understanding of how school communities can operate to mitigate the strong effect of socioeconomic and cultural differences on students' achievement, which has been amply and repeatedly demonstrated with every OECD PISA and IEA TIMSS, PIRLS, and ICCS survey. This theme is linked to the extensive literature on equity in education systems. A fair education system guarantees equal learning opportunities for students, regardless of their family backgrounds. Studying and understanding which factors could reduce the influence of students' socioeconomic backgrounds on their academic success is crucial, from both a theoretical and a strictly applicative point of view. To reduce inequalities and offer everyone the greatest opportunities for cultural and economic growth, socioeconomic differences in a democratic society should influence student outcomes as little as possible.

How can these differences be reduced? The data that emerged from this work seem to indicate that the participation of parents, through its different components, has a role in mediating the effects of ESCS on achievement. In fact, the influence of parental involvement on achievement is also indirect because several variables of the construct can mediate and strengthen the relationship between ESCS and achievement. Thus, it follows that increasing participation can be a useful, though not resolving, intervention to reduce the differences in achievement related to ESCS.

To achieve this goal, it is necessary that the involvement of parents is seen by all the actors involved as a tool that allows us to better address any school difficulties of children from disadvantaged backgrounds. Unfortunately, however, there is still a gap between the rhetoric of parental involvement, on the one hand, and the concrete involvement of parents in school, on the other hand (Hornby, 2011; Christenson & Sheridan, 2001). Often, in fact, the role of parents at school is to support teachers and respond to their requests, participating as volunteers in initiatives such as raising funds or helping the teacher with the class, for example by retrieving materials; however, it is less common to see teachers and parents working together as equals through mutual respect, for example through productive parent-teacher meetings (Grant and Ray, 2010), to improve the quality of the education offered, taking into account the differences between families from different socioeconomic backgrounds.

Importantly, the best practices of parental involvement, regardless of families' socioeconomic backgrounds, are relevant in determining whether a student will continue and succeed at school: even parents with low educational levels can work productively with schools to pursue quality education for their children (Epstein, 1986; 1995; Gianzero, 2001).

The necessary skills to be parents who support their children's learning can be taught through seminars, support programs and specific courses (Epstein & Connors, 1993; Henderson & Mapp, 2002). Flaxman and Inger (1992), for instance, identified three ways in which parents can be involved with schools: direct involvement in school management, participation in decision making at school and participation in parent education programs or specific projects developed using family resources and support programs.

Much work can and must be done in this regard, as parent involvement is one of the few areas that can be shaped to address the problem of the inequity of education systems.

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APPENDIX

Table A.1 Comparison of students answering the parental questionnaire and the overall PISA students by country

	Whole PISA sample					Sample of students with home questionnaire filled in				
	N. of students	Science achievement		ESCS		N. of students	Science achievement		ESCS	
		Mean	(e.s.)	Mean	(e.s.)		Mean	(e.s.)	Mean	(e.s.)
FRANCE	6,108	494.98	(2.06)	-0.14	(0.02)	5,358	506.53	(2.06)	-0.08	(0.02)
ITALY	11,583	480.55	(2.52)	-0.07	(0.02)	9,174	488.06	(2.64)	-0.03	(0.02)
MALTA	3,634	464.78	(1.64)	-0.05	(0.01)	3,203	475.22	(1.81)	-0.02	(0.01)
PORTUGAL	7,325	501.10	(2.43)	-0.39	(0.03)	6,881	502.30	(2.35)	-0.39	(0.03)
SPAIN	6,736	492.79	(2.07)	-0.51	(0.04)	4,753	502.28	(2.41)	-0.44	(0.04)

Statistically significant ($p < 0.01$) differences are indicated in **bold** font.

Table A.2 Description of the items related to Parent Questionnaire indices⁴

Parents' view on future environmental topics	
Do you think problems associated with the environmental issues below will improve or get worse over the next 20 years?	
Item	1 Improve, 2 Stay about the same, 3 Get worse
PA036Q01TA Air pollution	
PA036Q03TA Extinction of plants and animals	
PA036Q04TA Clearing of forests for other land use	
PA036Q05TA Water shortages	
PA036Q06TA Nuclear waste	
PA036Q07NA Extreme weather conditions	
PA036Q08NA Human contact with animal diseases	
Parents' view on science	
How much do you agree with the following statements?	
Item	1 Strongly agree 2 Agree 3 Disagree 4 Strongly disagree
PA033Q02TA <Broad science> is important to help us to understand the natural world.	
PA033Q06TA <Broad science> is valuable to society.	
PA033Q07TA <Broad science> is very relevant to me.	
PA033Q08TA I find that <broad science> helps me to understand the things around me.	
PA033Q09TA Advances in <broad science> usually bring social benefits.	

⁴ At this page https://www.oecd.org/pisa/data/CY6_QST_MS_PaQ_Final.pdf it is possible to download the Parent questionnaire used in PISA 2015.

Child's past science activities

Thinking back to when your child was about 10 years old, how often would your child have done these things?

Item	<i>1 Very often 2 Regularly 3 Sometimes 4 Never</i>
PA002Q01TA	Watched TV programmes about science
PA002Q02TA	Read books on scientific discoveries
PA002Q03TA	Watched, read or listened to science fiction
PA002Q04TA	Visited web sites about science topics
PA002Q05TA	Attended a science club
PA002Q06NA	Construction play, e.g.<lego bricks>
PA002Q07NA	Took apart technical devices
PA002Q08NA	Fixed broken objects or items, e.g. broken electronic toys
PA002Q09NA	Experimented with a science kit, electronics kit, or chemistry set, used a microscope or telescope
PA002Q10NA	Played computer games with a science content

Item	Do you expect your child will go into a < science related career>?
PA032Q03TA	<i>1 Yes 2 No</i>

Source: Original material