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## Household Possessions and Parental Support in Mexican Students with High Scientific Competencies in PISA 2015

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**Abstract:** Traditionally secondary studies on achievement on Programme for International Students Assessment (PISA) tests point to the significant impact of socioeconomic status and cultural backgrounds of families as well as the role of parental involvement, which in some cases has had a negative impact on achievement. For this article, a model of structural regression was tested, with structural modelling software. This model included the following factors: domestic and educational assets, parental support for students, parents' perceptions about science, and science competencies among 214 high performing Mexican students on PISA tests in 2015. This resulted in a structural regression model with a goodness of fit, where science competencies were a positive significant variable, impacted by domestic and educational assets and parental involvement. An additional restricted model with four variables manifested as mediators, revealed that science competencies were predicted positively and significantly by domestic and educational assets, and by the manifest parental emotional support variable. Variables related to ownership of educational and cultural assets and resources, as well as parental support, particularly emotional parental support, have positive and significant impact on science competencies.

**Keywords:** Household assets, Mexican students, parents support, PISA 2015, scientific competencies.

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### Introduction

Some researchers who examine findings on learning outcomes, relate this to family variables linked to educational experiences of their children, especially academic learning. Parents' expectations about discipline and their children's learning, educational practices in the family and support at home, parent participation in school events, have been considered variables in parental or family involvement and these have correlated positively with academic achievement (Benner et al., 2016; Day & Dotterer, 2018; Hartas, 2015; Palomar et al., 2016).

Since the 2006 administration of the science focused Programme for International Students Assessment (PISA), a questionnaire for parents was distributed which included questions about different modalities of parental involvement. The same was true for the 2009 test emphasizing Reading. In the 2012 PISA emphasizing Mathematics, the questionnaire for parents was more specific regarding parent participation, with questions regarding parental support of learning at home (Bazán et al., 2016; Organization for Economic Cooperation and Development [OECD], 2013). Although the 2015 PISA, emphasizing Science included questions about parent participation in school such as, "Discussed my child's behaviour with a teacher on my own initiative" (OECD, 2017a), items related to this factor were not included in Derived variables in the optional PISA 2015 Parent Questionnaire OECD (2017b).

On the other hand, several studies have pointed to a correlation between parents' interest and parent participation in school-initiated activities and parental support of student learning, and academic outcomes among high performing students and students with outstanding achievement (Bazán et al., 2020; Castellanos-Simons et al., 2015; Chávez & Acle, 2018).

Castellanos-Simons et al. (2015) studied 79 high performing sixth-graders in three different educational settings: an urban public school, a private school, rural indigenous school in Mexico, and found that only the variable regarding parent teacher communication about their children's learning in Spanish classes was positively significant for academic achievement among children in the higher socio-educational context who attended private school. Additionally, a study of 28 high performing Mexican students, found that the mothers' level of schooling contributes to their ability to develop additional activities to

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enhance their children's capabilities (Chávez & Acle, 2018). Furthermore, Rodríguez et al. (2019) studied high performing students in Mexico, Argentina and Spain and found high levels of support for educational interventions with their high performing children.

Bazán et al. (2020) conducted a research with 362 sixth grade students in Mexico, about relationships between contextual variables, students' intellectual aptitudes, parents' educational level, and academic achievement in reading comprehension. That reading performance was explained "significantly, mostly by the student's intellectual aptitude, and to a lesser degree by the parents' support factor as reported by parents (mother or father) themselves" (Bazán et al., 2020, p. 390).

These studies also indicate that, the parents of academically high performing children, regardless of their socioeconomic status and education levels, engage in multiple additional activities with their sons and daughters to enhance their capabilities and to support academic learning at home. In addition, it was found that parents are interested in developing intervention activities programs to increase understanding, support for students with both high capabilities and high performance.

In studies that correlate family variables and academic achievement in general, family variables that include: parent expectations, parent involvement (participation) in their children's learning and family support of learning as part of educational practices within the family rather than by external prodding; these variables may be influenced by socioeconomic status and education levels of students' families and also by the level of involvement fostered by the school. Hence, several researchers have found that this correlation between family variables, family involvement and student performance in assessments, varies according to socioeconomic status and education levels of the families (Ataş & Karadağ, 2017; Bazán et al., 2016; Ho & Lam, 2016; Poon, 2020; Tan, 2019).

#### *Scientific competencies and Mexican students' performance on PISA 2015*

Every three years the OECD administers PISA in different countries and different languages, to assess students who are 15 or older, on essential knowledge and skills. This assessment occurs when students are nearing completion of compulsory education, in most participating countries whether or not they are members of OECD. In 2015, Mexico administered the computer version of the test to 7,568 students, 15 or older, from 275 educational institutions, encompassing all 32 federated states.

Although each assessment evaluates competencies in reading, mathematics, and science, the 2015 emphasis was on science although business competencies were included as well. The framework for PISA 2015 defined scientific literacy as the ability to engage with science related issues, and with the ideas of science, as a reflective citizen (OECD, 2017a). Thus, according to this conceptualization, a scientifically literate person should have developed the following three scientific competencies: 1. Explain phenomena scientifically. Recognise, offer and evaluate explanations for a range of natural and technological phenomena. 2. Evaluate and design scientific enquiry. Describe and appraise scientific investigations and propose ways of addressing questions scientifically. 3. Interpret data and evidence scientifically. Analyse and evaluate data, claims and arguments in a variety of representations and draw appropriate scientific conclusions (OECD, 2016).

Furthermore, the framework for science in 2015 included knowledge, understanding of methods and procedures, and epistemological knowledge (rationales for scientific affirmations). It also included areas with scientific content such as physics, chemistry, biology, earth and space sciences (OECD, 2016, 2017a).

The PISA database for 2015, presented cognitive results in science for 10 plausible values for each of the following aspects: general performance in Science, Scientific competencies, and areas with scientific content. Most research involving secondary analyses of these PISA data, utilize scores for general outcomes in science and to a lesser degree, indicators of other competencies or content areas. This study examined indicators for science competencies.

Similarly, PISA 2015 considered seven cognitive levels of achievement, by which students were ranked according to their scores on the test, where level 1b was the lowest performance level and 6 was the highest level (OECD, 2017b). Level 1b consisted of the recognition of simple scientific phenomena, and the use of everyday knowledge, while level 6 required problem solving through complex cognitive engagement, evaluation of complex experiments, and explanations (see Table 1).

Table 1. Proficiency levels in scientific competency PISA 2015

Level	What students can typically do	Score points
6	At Level 6, students can draw on a range of interrelated scientific ideas and concepts from the physical, life and Earth and space sciences and use procedural and epistemic knowledge in order to offer explanatory hypotheses of novel scientific phenomena, events and processes that require multiple steps or to make predictions. In interpreting data and evidence, they are able to discriminate between relevant and irrelevant information and can draw on knowledge external to the normal school curriculum. They can distinguish between arguments that are based on scientific evidence and theory and those based on other considerations. Level 6 students can evaluate competing designs of complex experiments, field studies or simulations and justify their choices.	Higher than 707.93
5	At Level 5, students can use abstract scientific ideas or concepts to explain unfamiliar and more complex phenomena, events and processes. They are able to apply more sophisticated epistemic knowledge to evaluate alternative experimental designs and justify their choices and use theoretical knowledge to interpret information or make predictions. Level 5 students can evaluate ways of exploring a given question scientifically and identify limitations in interpretations of data sets including sources and the effects of uncertainty in scientific data.	Higher than 633.33 and less than or equal to 707.93
4	At Level 4, students can use more sophisticated content knowledge, which is either provided or recalled, to construct explanations of more complex or less familiar events and processes. They can conduct experiments involving two or more independent variables in a constrained context. They are able to justify an experimental design, drawing on elements of procedural and epistemic knowledge. Level 4 students can interpret data drawn from a moderately complex data set or less familiar contexts and draw appropriate conclusions that go beyond the data and provide justifications for their choices.	Higher than 558.73 and less than or equal to 633.33
3	At Level 3, students can draw upon moderately complex content knowledge to identify or construct explanations of familiar phenomena. In less familiar or more complex situations, they can construct explanations with relevant cueing or support. They can draw on elements of procedural or epistemic knowledge to carry out a simple experiment in a constrained context. Level 3 students are able to distinguish between scientific and non-scientific issues and identify the evidence supporting a scientific claim.	Higher than 484.14 and less than or equal to 558.73
2	At Level 2, students are able to draw on everyday content knowledge and basic procedural knowledge to identify an appropriate scientific explanation, interpret data, and identify the question being addressed in a simple experimental design. They can use every day scientific knowledge to identify a valid conclusion from a simple data set. Level 2 students demonstrate basic epistemic knowledge by being able to identify questions that could be investigated scientifically.	Higher than 409.54 and less than or equal to 484.14
1a	At Level 1a, students are able to use every day content and procedural knowledge to recognise or identify explanations of simple scientific phenomenon. With support, they can undertake structured scientific enquiries with no more than two variables. They are able to identify simple causal or correlational relationships and interpret graphical and visual data that require a low level of cognitive demand. Level 1a students can select the best scientific explanation for given data in familiar personal, local and global contexts.	Higher than 334.94 and less than or equal to 409.54
1b	At Level 1b, students can use every day content knowledge to recognise aspects of simple scientific phenomenon. They are able to identify simple patterns in data, recognise basic scientific terms and follow explicit instructions to carry out a scientific procedure.	260.54 to less than or equal to 334.94

Source: OECD (2017b).

According to the general results from the scores obtained on the 2015 PISA test for science (OECD, 2016), the general global average score obtained by Mexico in Science competencies was 416 points, while its OECD score was 493 points, and Japan obtained the highest score (538). The average score for Mexico in each of the scientific competencies was: Explaining phenomena scientifically = 414; Evaluating and designing scientific research = 415; and Interpreting scientific data and evidence = 415.

When we consider achievement levels on PISA 2015, only 0.1% of Mexico's students placed in levels 6 and 7 (levels 5 and 6) compared to 8% of students averaging OECD levels 5 and 6 (see Table 2).

Table 2. Percentage of students at each proficiency level in science (PISA 2015)

	Below Level 1b		Level 1b		Level 1a		Level 2		Level 3		Level 4		Level 5		Level 6	
	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.
México	1	-0	12	-1	35	-1	35	-1	15	-1	2	-0	0	-0	0	c
OECD average	1	0	4.9	-0	16	-0	25	-0	27	-0	19	-0	7	-0	1	0

Source: Output design based on OECD (2016), Table I.2.3 (p. 323).

*Note:* Below Level 1b (below 260.54 score points), Level 1a (from 260.54 to less than 334.94 score points), Level 2 (from 409.54 to less than 484.14 score points), Level 3 (from 484.14 to Less than 558.73 score points), Level 4 (from 558.73 to less than 633.33 score points), Level 5 (from 633.33 to less than 707.93 score points), Level 6 (above 707.93 score points).

Aside from the fact that only 1% of the OECD placed at level 7, it is shocking that no Mexican student obtained the maximum cognitive achievement level. Because of this, the report for Mexico by National Institute for the Evaluation of Education (2017), INEE for their acronym in Spanish, considered the attainments of 558.73 points or higher (levels 4, 5, and 6) which included 2.4% of Mexico's students.

Although we acknowledge that the attainment level of Mexican students on complex competencies in science is low, it is important to study the group of high performing students, in terms of family and socioeconomic variables and how these correlates to outcomes in the three scientific competency areas highlighted by PISA 2015. Knowledge of these correlations and their possible connections to socioeconomic and educational factors among the students' families may result in recommendations for family support in academic work on competencies in science and the school-family relations.

### Background

There have been several secondary studies on academic achievement reported on PISA 2015 and the connection to family variables. Significant correlations were found between socioeconomic status and educational levels of families and Reading outcomes for Turkish students assessed through PISA 2015 (Ataş & Karadağ, 2017). With these same data (PISA 2015), a relationship was found between household socioeconomic variables (household wealth and technological resources) and reading performance; a relationship always greater in Latin America than in Northern European countries that showed, at the same time, greater dispersion (Sayans-Jiménez et al., 2018).

In a secondary study on PISA 2015 in Perú, Muelle (2019) found that the socioeconomic status of the students and the socioeconomic composition of the school appear to be explained significantly to the poor performance in science, mathematics, and reading. Similarly, PISA 2015 data for Swedish students from obligatory schools reflected that the correlation between parental emotional support as perceived by students and the academic attainment reported by PISA 2015 (on its three domains: Science, Reading, and Mathematics) is impacted by student motivation (Yang, 2017). Likewise, index of economic, social and cultural status (ESCS) had the most direct impact on the attainment variable.

The Turkish students from PISA 2015 also reflected that attainment in science competencies (science literacy) was explained by the high environmental awareness of the students as well as their environmental optimism. They also found significant differences in environmental awareness and in environmental optimism among students, based on socioeconomic status (Öztürk, 2018). A study with Indonesian students assessed through PISA 2015 found that science outcomes were directly, and positively influenced, for the most part by level of satisfaction with science learning and the socioeconomic and cultural status of the students. It was negatively influenced by students' environmental awareness (Susongko & Afrizal, 2018).

Ababneh and Abdel Samad (2018) reported with Jordan students, significant high correlation between Science Scores in PISA 2015 and environmental awareness and index of economic social and cultural status. Also, other family variables that significantly correlated with science scores in PISA 2015 were: ICT resources; home educational resources; Highest education of parents; and, science specific resources. The data from 53 countries assessed by PISA 2015 also reflected that students' environmental awareness was explained significantly by their satisfaction with science and secondly, by their Scientific Literacy or scientific competencies (List et al., 2020).

Another secondary study with data from Mexico on PISA 2015, tested a multilevel model to predict academic attainment using three indicators: scientific attainment, reading attainment, and mathematics attainment (Rodríguez & González, 2018). Researchers utilized as predictors, several compound variables gleaned from the student questionnaire regarding context, and one latent variable identified as family support as self-reported by parents), but the latter had no effect on educational attainment. One limitation was that in the compound variable family support, we encountered a validity issue regarding the construct and a drastic reduction from seven to three indicators.

*Parents self-reporting on PISA 2015 and its relation to attainment*

Tourón et al. (2018) analyzed the impact of several contextual variables on science performance for Spain on PISA 2015, using two contrasting Science attainment level groupings, one a 5 and 6 level and the other at level 1a and 1b. In regards to the family variables self-reported by parents, parents' views about science, parents' concerns for environmental issues, parents' actual support for learning, parents' emotional support, family well-being, family resources and socioeconomic and cultural status, have a positive impact on academic achievement.

Caponera et al. (2019) looked at PISA 2015 data for Italy, France, Malta, Portugal and Spain as well as the parent questionnaire. The authors reported that parent involvement had significant mediating impact between ESCS and science performance. Based on eight questions included for parents on PISA under Parents' Home-based Involvement (OECD, 2017a), the authors chose six indicators based on an analysis of main aspects shared by all students included in the sample. The results showed that socioeconomic index had a significant correlation with science achievement and also that parental support with science homework had a negative correlation with science achievement.

However, a study with data on Hong Kong students on PISA 2015 and of the parents questionnaire, its correlation with students of science performance, it showed no significant correlation between socioeconomic status and parent involvement, nor did these correlate significantly with levels of attainment in science (Tan, 2019). Looking at questionnaires on parent involvement for PISA (8 items about involvement at home and 10 items about involvement at school) a Confirmatory Factor Analysis was constructed for four dimensions: 1. Parent-child discussions; 2. Parental monitoring of learning (for home involvement); 3. Parent-teacher discussions; and 4. School organizational activities (for school involvement). Tan (2019) concluded that higher levels of parental involvement may not eventuate in higher levels of student achievement.

Similarly, in a study of Argentinean students tested by PISA 2015, researchers reported that parents' access to resources and their education levels, aligned with science resources available in their children's schools. The coalescing of these variables explains student achievement in science, to a great extent, as well as variations in students' average outcomes in schools (Quiroz, et al., 2020).

*Purposes and Hypotheses*

The literature reviewed points to a consistent need for including socioeconomic levels, family involvement variables, their correlations, and how these relate to indicators for attainment in science based on data from PISA 2015.

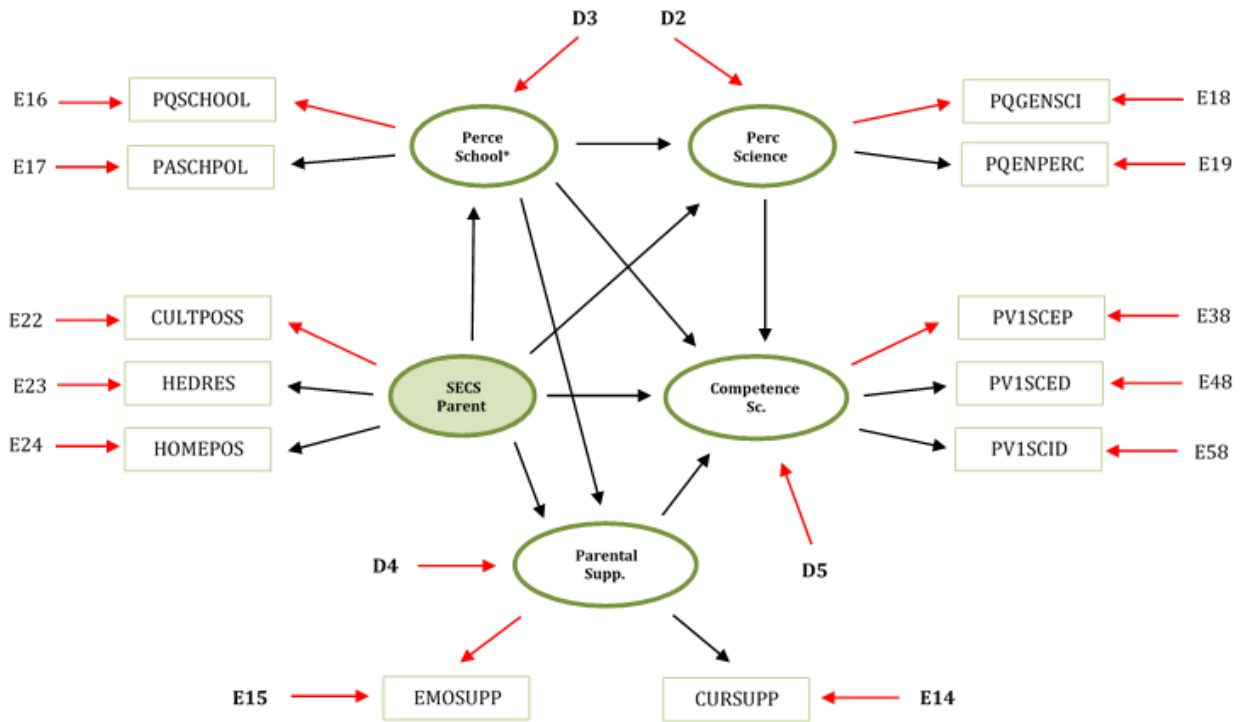
All of the studies cited herein included the socioeconomic, educational and cultural status (ESCS) of the family and were correlated with different family involvement indicators and performance outcomes on PISA. However, the student questionnaire includes at least three variables that are related to domestic and educational assets; these items inform the availability of assets based on socioeconomic status. These assets, in turn, have strong influence on cultural and educational aspects provided for students by their families. Therefore, this study, rather than focusing on ESCS levels, looks at 3 indicators of domestic assets: cultural possessions at home, and home educational resources.

On the other hand, earlier studies show different ways in which parental involvement variables have been applied and this is probably why differences emerged regarding the effects of family involvement on academic attainment. In this study we selected three groups of family related variables: parental involvement in student learning; parents' perceptions regarding school quality; and parents' perceptions regarding science.

In a similar fashion, different indicators of attainment have been selected as the independent variable. In some cases, science scores have been selected, and in others, science scores were selected along with reading and mathematics scores. None of the aforementioned studies, selected indicators of scientific competencies as dependent variables.

This study analyzed causal relations between family variables reported by OECD such as derived variables in the optional PISA 2015 Parent Questionnaire (OECD, 2017b), and family socioeconomic and educational variables (domestic and educational assets) with outcomes in the three science competencies on PISA 2015 assessments. The sample included Mexican students age 15 and older with composite science scores equal to or above 558.73 and ranked at highest cognitive levels (4,5, and 6).

These variables were used to construct a hypothetical model for structural correlations among 5 factors (latent variables) and their indicators, tested through modeling of structural equations (see Figure 1) with the purpose of identifying factors that can be better predictors of science competencies among high performing students and to determine the effects of socioeconomic, educational and cultural status (domestic and cultural assets) as well as the student parental support factor.



**LATENT VARIABLES (Circles)**

**Competence Sc:** Science Competencies; **Perc Science:** Perceptions of parents about science; **Perce School:** Perception of parents about school; **Parental supp:** Parental Support; **SECS Parent:** Household and educational possessions.

**MANIFEST VARIABLES (Rectangles)**

**PV1SCEP:** Valor Plausible 1 of Scientifically explain phenomena; **PV1SCED:** Plausible valor 1 of Evaluate and design scientific enquiry, **PV1SCID:** Plausible valor 1 of Scientifically interpret data and evidence.

**EMOSUPP:** Parental Emotional Support, **CURSUPP:** Parental Support for Learning at home.

**PQSCHOOL:** Perception of parents regarding their children’s school; **PASCHPOL:** Perception of parents regarding school policies for parent involvement.

**PQGENSCI:** Parents’ views about science; **PQENPERC:** Parent concerns for environmental issues. **CULTPOSS:** Cultural possessions at home, **HEDRES:** Home educational resources, **HOMEPOS:** Home possessions.

Figure 1. Hypothetical model for predictors of science competencies

The hypothetical model assumes that the domestic and educational assets (family’s socioeconomic, educational and cultural status) factor directly predict the scientific competencies of high performing students on PISA 2015, as well as parental support for students, parents’ perceptions about the quality of their children’s schools, and parents’ perceptions about science. In addition, the model views that parent involvement and parents’ perceptions about science are the intervening variables most closely related to scientific competencies among high performing Mexican students on PISA 2015 assessments.

**Methodology**

*Participants*

This study had a database of 7,568 Mexican students age 15 and older assessed through PISA 2015 available on-line. Students are classified according to National Institute for the Evaluation of Education of México based on their cognitive level. The sample included students who scored 558.73 or more, yielding 214 students, 70 females and 144 males. These 214 students placed at levels 4 and 5, which correspond to cognitive levels 5 and 6 on PISA 2015.

*Measures*

We worked with the database provided by Mexico’s National Institute for the Evaluation of Education (2017) selecting variables that aligned with the purposes of the study. Below, the categories of variables are organized according to groups of factors: Science Competencies (of students); Parental support, Perceptions about school, and Perceptions about Science as self-reported by parents; and Socioeconomic, educational and cultural status of families.

### *Competencies in Science Achievement*

The first plausible values for each of the three competencies resulting from PISA 2015 for the Mexican sample: 1. Explain phenomena scientifically (PV1SCEP), 2. Evaluate and design scientific enquiry (PV1SCED), and 3. Interpret data and evidence scientifically (PV1SCID).

According to OECD (2017b), plausible values are multiple designated values for performance, based on test items and used to obtain more precise estimates of group competency to be obtained through aggregate exact estimations. As mentioned earlier, for each domain evaluated (science, reading, mathematics and finance) and for subscales in science PISA reported 10 values. Each plausible value was standardized by a general performance mean of 500 points with a standard deviation of 100 points.

### *Variables Derived from Parent Questionnaire*

PISA 2015 provided eight derived variables emerging from the responses of the parents on the Parents' Questionnaire selected by OECD using the IRT scaling model (OECD, 2017b). Six derived variables were chosen for this study, we did not include *Child's past science activities* nor the variable *Parents' view on future environmental topics*. The first was eliminated because we wanted to include recent or current activities carried out by parents. The second one was eliminated, because in an earlier study this variable correlated negatively with the variable *Parents concerns regarding environmental topics*.

Six variables were selected with pondered estimations already provided by the National Institute for the Evaluation of Education of México database (weighted likelihood estimates, WLE) for individual scores considering the OECD mean = 0 and standard deviation = 1.

*Family and emotional support for learning.* CURSUPP Parental current support for learning at home (WLE). Is a compound variable (derived) from eight questions to parents about parent support of children's learning at home (EMOSUPP). *Parental emotional support* (WLE) is a variable based on four questions about parent interest and support of their children's learning and difficulties at school.

*Perceptions regarding school quality and activities organized for parental involvement.* PASCHPOL. School policies for parental involvement (WLE). This variable is derived from six questions to parents regarding different activities organized by the school to increase parent involvement (PQSCHOOL). Parents perceived school quality (WLE). Variable derived from seven questions to parents regarding their perceptions of the quality of school learning.

*Parent expectations about science* (PQGENSCI). Parents' view on science (WLE). This variable emerged from five items through which parents evaluated the importance of science in life and society (PQENPERC). Parents concerns regarding environmental topics (WLE). This variable emerged from seven items regarding parents' perceptions about current environmental issues.

In regards to trustworthiness of the scales, the OECD (2017b) reported the following indexes (Chronbach's alpha coefficients) for Mexico: CURSUPP = 0.80, EMOSUPP = 0.87, PQSCHOOL = 0.88, PASCHPOL = 0.84, PQGENSCI = 0.86 y PQENPERC = 0.845.

*Domestic and educational assets.* Three indexes were added based on student responses to questions in five of the components of the variable Domestic assets (OECD, 2017b). These indexes implicate aspects of socioeconomic status and educational and cultural resources at home. Transformed variables with WLE were used as reported by National Institute for the Evaluation of Education according to the international metric included by OECD for 2015 with a mean of 0 and a standard deviation of one.

CULTPOSS. Cultural possessions at home (WLE). Is an index based on five items that explore ownership of cultural assets in the home, for example: classic literature, art books, etc. (HEDRES). Home educational resources (WLE). An index emerging from ownership of items and resources in the home such as having a quiet place to study or educational software (HOMEPOS). Home possessions (WLE). This indicator emerges from the items referring to assets and diverse items owned in the home, and it is one of the three components of the PISA index related to economic, social and cultural status (ESCS).

The INEE included variables derived from the IRT (item response theory) scaling. OECD (2017b) reported that these variables derived for Mexico obtained the following Cronbach's alpha coefficients: HOMEPOS = 0.87, CULTPOSS = 0.60, and HEDRES = 0.57.

### *Analysis of data*

When we examine PISA 2015 results for Mexican students, out of 214 students placed at levels 4 and 5 (cognitive levels 5 and 6), the first plausible value of each of the three scientific competencies were selected as indicators for the latent Science Competencies variable, which was the variable used as a predictor in the structural regression model (Raykov & Marcoulides, 2000) tested with the EQS 6.4 program. The three indicators for scientific competencies are: Explain phenomena

scientifically Science Competencies (PV1SCEP), Evaluate and design scientific enquiry (PV1SCED), and Interpret data and evidence scientifically (PV1SCID).

Four latent variables were included (constructs) as predictors for the factor *Science Competencies*: Parental Support, Perception of parents about school, Perceptions of parents about science y Household and educational possessions. Each of these four variables were posited as predictors for the factor Science Competencies and were also described by indicators.

Parental Support included two indicators: Parental Emotional Support (EMOSUPP) and Parental Support for Learning at home (CURSUPP). The Perception of parents about school factor (Perce School) contained two indicators: Perception of parents regarding their children's school and Perception of parents regarding school policies for parent involvement. The factor Perceptions of parents about science had two indicators: Parents' views about science and Parent concerns for environmental issues. For the factor Household and educational possessions (SECS Parent) which values the availability of educational and cultural resources, which included three indicators: Cultural possessions at home (CULTPOSS), Home educational resources (HEDRES), Home possessions (HOMEPOS).

Finally, the main structural regression model tested is narrowed down as follows:

$$\text{Science Competencies} = \text{Parental Support} + \text{Perception of parents about school} + \text{Perceptions of parents about science} + \text{Household and educational possessions} + D \text{ (errors o distortions related to measurement of Science Competencies).}$$

## Results

Table 3 presents the descriptive statistics for the variables included in this study. Because the high performing students were ranked at the level 4 and level 5 on the PISA scale, the average obtained by the students in the three competencies was higher than that reported by PISA for Mexico (Explaining phenomena scientifically = 414; Evaluating and designing scientific research = 415; Interpreting data and scientific evidence = 415). In this study, high performing Mexican students obtained the highest score in the competition for Evaluating and Designing Scientific Enquiry (575.60 points).

According to the parent questionnaire, in parental involvement, averages ranged between 0.13 and 0.16; in terms of the way parents perceived school quality (0.90) in contrast to their perceptions of school policies to increase parent involvement (0.38); and as for parents' perceptions about science the average was higher (0.93) compared to their concern for environmental topics (0.63).

Variables related to Domestic and educational possessions (CULTPOSS). The mean = 0.04, which is close to the mean reported by OECD (2017b) of 0.05 with a SD =0.99. In Home educational resources (HEDRES) and Home possessions (HOMEPOS) the Mexican high performing students sample scored below the averages reported by OECD (HEDRES = 1.13 with SD = 0.78 and HOMEPOS = 0.66 with SD= 0.53).

Table 3. Descriptive Statistics for competencies, parental variables, and possessions

	N	Mean	Std. Dev.	Jarque-Bera's Test		Normality Test	
				Asymmetry	Kurtosis	Statis.	Sign.
<i>Plausible Value 1 in Competency Subscale of Science:</i>							
Explain Phenomena Scientifically	214	558.8	43.15	0.24	-0.02	0.038	.20 *
Interpret Data and Evidence Scientifically	214	558.9	43.74	1.27	0.91	0.03	.20 *
+Evaluate and Design Scientific Enquiry	214	574.6	50.76	0.1	0.08	0.15	0
<i>Derived variables from Parent Questionnaire:</i>							
Parental current support for learning at home (WLE)	209	0.13	1.05	-0.23	-0.04	0.03	.20 *
Parental emotional support (WLE)	207	0.16	1.03	-1.62	1.99	0.33	0
Parents perceived school quality (WLE)	209	0.9	1.05	-0.21	-0.08	0.08	0.01
School policies for parental involvement (WLE)	208	0.37	1.1	0.19	0.26	0.07	0.01
Parents' view on science (WLE)	206	0.93	1	0.88	0.19	0.2	0
Parents concerns regarding environmental topics (WLE)	206	0.63	0.7	-3.16	10.91	0.48	0
<i>Domestic and educational possessions:</i>							
Cultural possessions at home (WLE)	209	0.04	0.95	0.58	0.65	0.11	0
Home educational resources (WLE)	211	-0.4	0.99	0.12	-0.74	0.16	0
Home possessions (WLE)	213	-0.61	1.19	0.29	0.34	0.03	.20 *

Note: \* In these cases the data present a normal distribution

### Structural Regression Outcomes

Figure 2 presents the model that emerged from structural regression where we see that the *Domestic and educational possessions (SECS Parent)* variable was the best predictor for scientific competence (with a coefficient for factorial regression

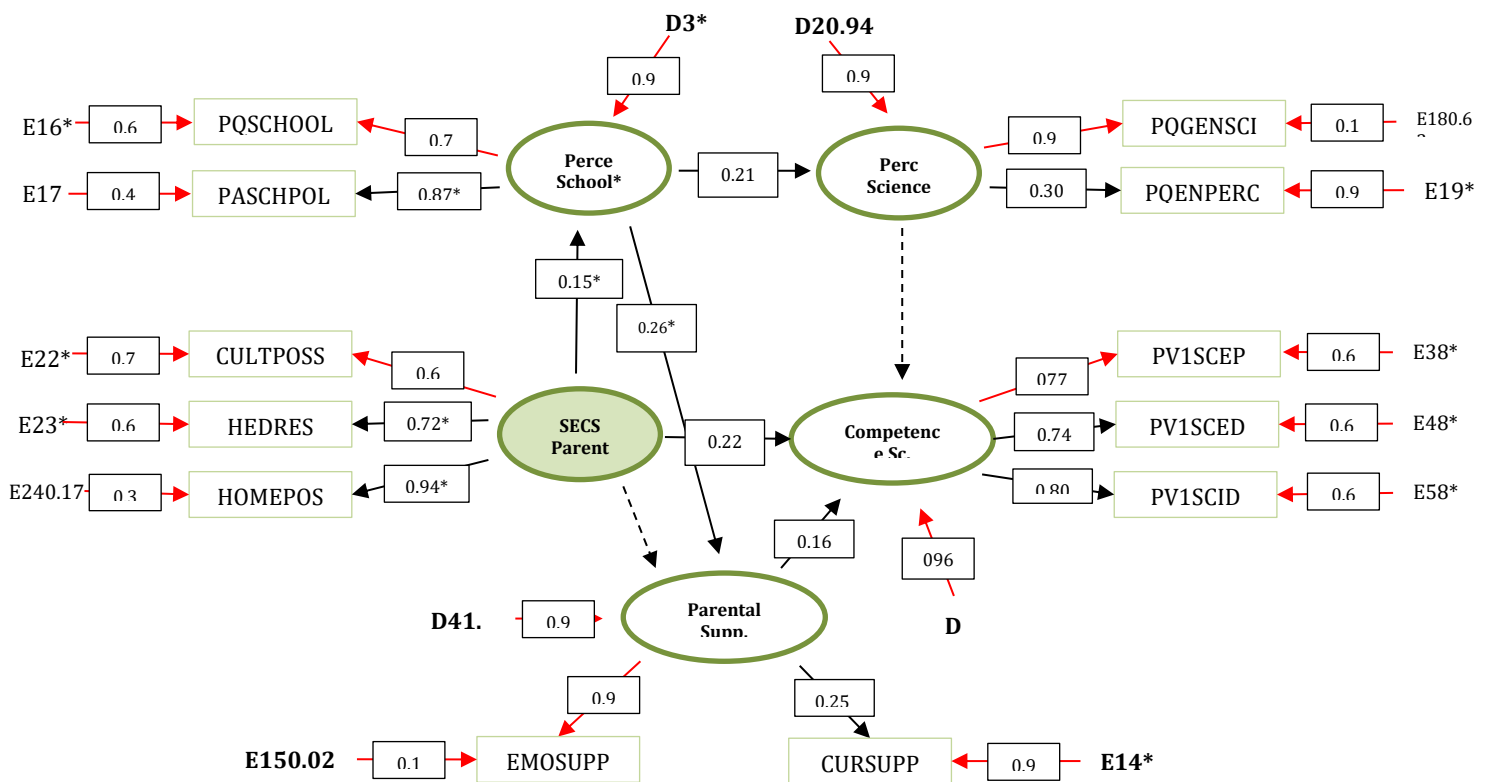


= 0.22). Similarly, the model demonstrates that the Parental support factor (PARSUPP) also positively predicted the scientific competencies factor (with a factorial regression coefficient = 0.16). Both regression coefficients were statistically significant.

On the other hand, the Parents' perception of school's factor (Perce School) had positive significant effects on Parental support (0.26) and on Parents' perceptions about science (Perc Science) with a coefficient = 0.21. The rest of the coefficients for factorial regression were not significant. The regression model had a goodness of fit (Chi squared = 60.92, P = 0.27, CFI = 1.00 and RMSEA = 0.02).

The model obtained is satisfactory and it confirms the effects of two latent variables related to Socioeconomic, educational and cultural conditions in the home and Parental support, on scientific competencies of high performing students on PISA 2015. But the model has some validity problems regarding the construct of two factors: 1. Parental support had a factor weight of 0.99 and another of 0.25, 2. Perceptions about science had a factor weight of 0.99 and another of 0.30.

Figure X: EQS 6 modelo re - path 1h.eds Chi Sq.=60.92 P=0.27 CFI=1.00 RM



**FACTOR (LATENT VARIABLES)**

**Competence Sc:** Science Competencies; **Perc Science:** Perceptions of parents about science; **Perce School:** Perception of parents about school; **Parental supp:** Parental Support; **SECS Parent:** Household and educational possessions.

**MANIFEST VARIABLES**

**PV1SCEP:** Plausible valor 1 of Scientifically explain phenomena; **PV1SCED:** Plausible valor 1 of Evaluate and design scientific enquiry, **PV1SCID:** Plausible valor 1 of Scientifically interpret data and evidence.

**EMOSUPP:** Parental Emotional Support, **CURSUPP:** Parental Support for Learning at home.

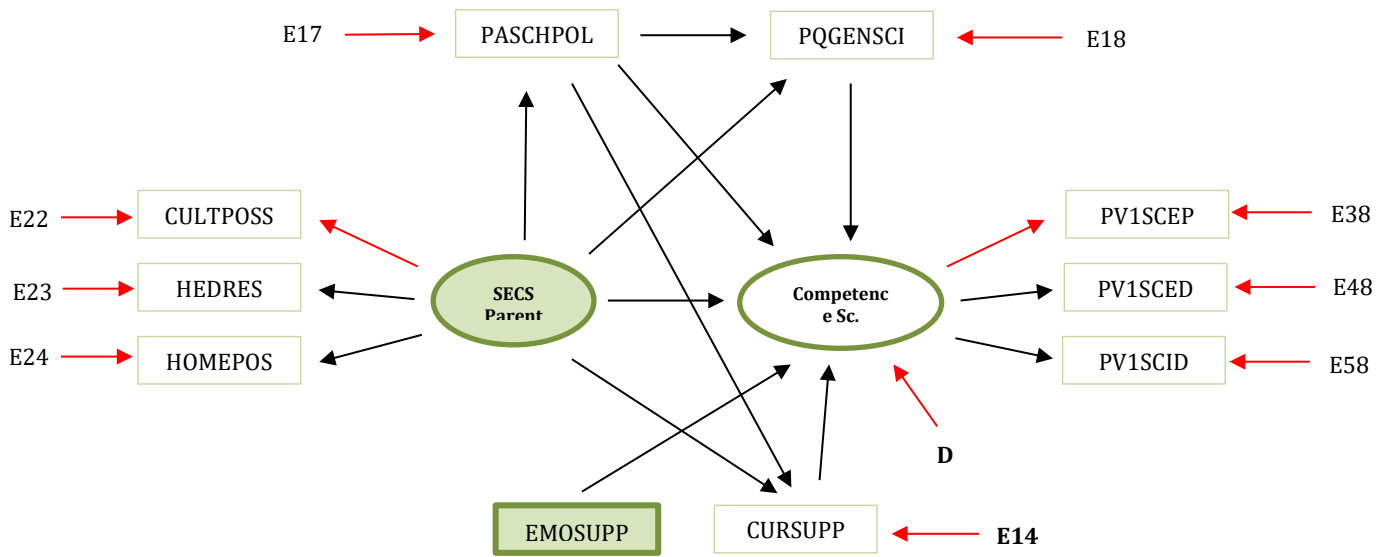
**PQSCHOOL:** Perception of parents regarding their children's school; **PASCHPOL:** Perception of parents regarding school policies for parent involvement.

**PQGENSCI:** Parents' views about science; **PQENPERC:** Parent concerns for environmental issues.

**CULTPOSS:** Cultural possessions at home, **HEDRES:** Home educational resources, **HOMEPOS:** Home possessions.

Figure 2. Structural Regression Model for Science Competencies

Because of this detail, a restricted model was proposed where two factors remained intact (latent variables) with their respective indicators: science competencies (Competence Sc) as the dependent variable and Domestic and educational possessions (SECS parent) as the independent variable (see Figure 3). This restricted model included 4 mediating variables. Thus, we obtained a mixed analysis model which simultaneously tested interactions between latent variables, between manifest variables, and between latent and manifest variables (Raykov & Marcoulides, 2000).



**FACTOR (LATENT VARIABLES)**

**Competence Sc:** Science Competencies; **Perc Science:** Perceptions of parents about science; **Perce School:** Perception of parents about school; **Parental supp:** Parental Support; **SECS Parent:** Household and educational possessions.

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**EMOSUPP:** Parental Emotional Support, **CURSUPP:** Parental Support for Learning at home; **PQGENSCI:** Parents’ views about science; **PQSCHOOL:** Perception of parents regarding their children’s school;

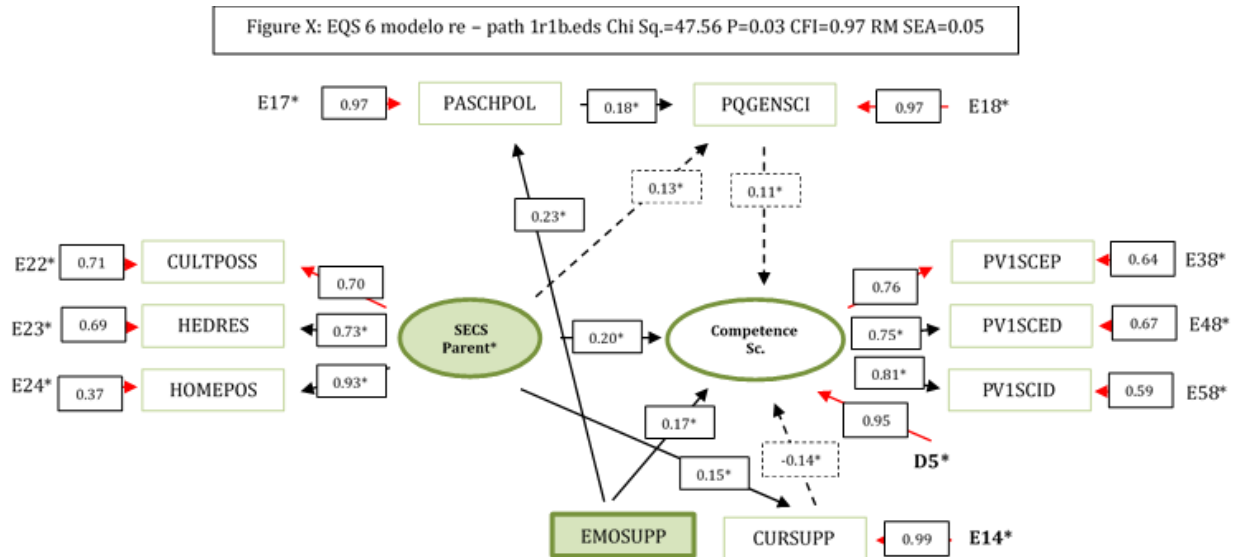
**CULTPOSS:** Cultural possessions at home, **HEDRES:** Home educational resources, **HOMEPOS:** Home possessions.

Figure 3. Hypothetical restricted model for predictors of science competencies

In this hypothetical restricted model, the two indicators of parental support factors were separated and included as manifest variables that predict science competencies: Parental emotional support (EMOSUPP) and Parental current support for learning at home (CURSUPP). We also included two variables that obtained more factorial weight in the model presented in Figure 3. Parents perceptions of school policies for parental involvement (PASCHPOL) and Parents’ views on science (PQGENSCI).

*Results from the restricted model*

Figure 4 presents the output from the restricted model which obtained an acceptable goodness of fit (Chi squared = 47.56, P = 0.03, CFI = 0.97 and RMSEA = 0.05). The factor (latent variable) science competencies, was predicted positively and significantly by both Domestic and educational possessions (0.20), and the manifest variable, Parental emotional support (0.17). The Domestic and educational possessions factor had a significant impact on the Parental current support for learning at home variable (0.15), however the latter had no significant impact on science competencies (ns -0.14).



#### FACTOR (LATENT VARIABLES)

**Competence Sc:** Science Competencies; **Perc Science:** Perceptions of parents about science; **Perce School:** Perception of parents about school; **Parental supp:** Parental Support; **SECS Parent:** Household and educational possessions.

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**PV1SCEP:** Plausible valor 1 of Scientifically explain phenomena; **PV1SCED:** Plausible valor 1 of Evaluate and design scientific enquiry, **PV1SCID:** Plausible valor 1 of Scientifically interpret data and evidence.

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**CULTPOSS:** Cultural possessions at home, **HEDRES:** Home educational resources, **HOMEPOS:** Home possessions.

Figure 4. Structural model obtained for predictors of science competencies

On the other hand, Parents' view on science was predicted significantly by Parents' perceptions on School policies for parental involvement (0.18), but has no significant effect on science competencies (0.11). Additionally, during the analysis, the model showed an impact correlation of the Parental emotional support factor on the Parents' perceptions of school policies for parental involvement, which was significant and positive (0.23).

### Discussion

The purpose of this study was to identify the factors that best predict scientific competencies among high performing Mexican students on PISA 2015. In addition, factors such as socioeconomic, educational, and cultural backgrounds (Domestic and educational possessions or assets) as well as parental support for students were examined in terms of their possible effect on science competencies. Initially, a hypothetical structural regression model was tested utilizing four factors as possible direct or indirect predictors for science competencies, these consisted of parents' perceptions of school quality, perceptions about science, and their self-reported academic and emotional support, as well as ownership of resources at home.

The output from this first model pointed to strong and positive correlations regarding Mexican high performing students' science competencies is explained, first, by domestic and educational assets or possessions; and second, by Parental support for students. These data are associated in part to findings from secondary analysis of data reported by PISA 2015 and they offer new perspectives for the debate regarding parental involvement and academic achievement. These findings support those of Ataş and Karadağ (2017) and Yang (2017), who reported that parents' socioeconomic status as well as their education levels (ESCS) positively impact academic performance on PISA. Similarly, the findings of Caponera, et al. (2019), Muelle (2019) and Tourón et al. (2018), also demonstrate that the socioeconomic and cultural status of the family have a significant impact on science achievement on PISA 2015.

In other words, previous studies have confirmed that socioeconomic status (ESCS) has a positive and significant effect on academic achievement, however the present study demonstrates that other variables related to socioeconomic, educational and cultural conditions of the families have a significant effect on students' academic outcomes in science. In this study, the variable identified as Domestic and educational possessions, also included three indicators related to the families' socioeconomic status: Cultural possessions at home, home educational resources, and Home possessions.

Based on these findings we can identify Domestic and educational possessions as a latent variable to be included as a predictor of academic achievement particularly for science competencies among high performing students. Likewise, the results obtained in this study confirm the findings of Sayans-Jimenez et al. (2018) and also on the basis of PISA 2015; but in a different domain such as reading performance.

This study found that Parental support is the second-best predictor for science competencies, although the previous studies statistically different relationships between the Parent involvement and performance on PISA variables.

Earlier research examined did not find positive or significant predictors for the family involvement constructs regarding performance on PISA 2015 (Rodríguez & González, 2018; Tan, 2019). One possible explanation for this difference between the effects of the factor we identified and parent involvement factors in the studies mentioned, might be related to issues of validity for parent involvement constructs utilized with the PISA questionnaires. For example, it is hard to consider parents sitting at the dinner table having a conversation with their son or daughter, as an indicator for parent support for learning at home. The issue of validity has already been discussed in a study on mathematics achievement 2012 (Bazán, et al., 2016) where the same parent questionnaire 2015 was used but the focus was mathematics.

On the other hand, when studies looking at secondary analyses of PISA data included aspects of parent involvement as predictors or mediating manifest variables (indicators), differences were reported regarding the relationship established with indicators of achievement or scientific competency.

According to the restricted model emerging from this study, the manifest variable Parental emotional support had a positive and significant impact on the latent variable Scientific competencies among high achieving Mexican students. On the contrary, although the manifest variable Parental current support for learning at home did not register a significant effect on the factor that describes science competencies, it did yield a negative coefficient (-0.14).

In the first case the findings of this study confirm both the findings of Yang (2017) as well as those of Tourón et al. (2018), regarding the positive and significant effect of parents' emotional support on students' performance on PISA 2015. In the first study, parents' emotional support as perceived by the students had a significant effect on the performance variable that included three domains: Science, Reading and Mathematics (Yang, 2017), while in the second study parents' self-reported emotional support, also impacted academic achievement (Tourón et al., 2018). Consequently, both the data collected in this study and studies We have referenced, seem to confirm that the emotional support offered by parents to their children in their learning and with academic challenges, is what has significant impact on their academic performance, particularly in science competencies.

In the second case, the findings from this study coincide with findings in Caponera et al. (2019), where parent support with science homework had a negative correlation with achievement in science. Although the parental support with science learning at home and achievement in science was not statistically significant, this may be pointing to a trend to a negative correlation between supporting learning at home and performance on science competency assessments for high performing Mexican students.

This negative correlation between variables helping with homework at home and family involvement, and the attainment on PISA assessments has been reported in other studies using secondary analyses in mathematics PISA 2000 (Klieme & Stanat, 2009; Kotte et al., 2005) and mathematics PISA 2012 (Bazán, et al., 2016). The latter studies outlined possible explanations for negative correlations. For one, it is likely that parents who report higher levels of support for their children with homework and school activities are those whose children are already having problems in the domains assessed by PISA.

Another possible reason is that parents may be referring to support they provide for their children relates to the science curriculum though not necessarily to the scientific competencies assessed through PISA. In this study, the sample included students at the 4 and 5 levels according to the OECD scale. For this reason, the parental support with science homework as self-reported by parents may have more to do with the learning for the science curriculum rather than more general scientific competencies.

### Conclusions

The variables related to possession of assets and educational and cultural resources in the home, have significant impact on science competencies based on three indicators (Explain Phenomena Scientifically, Interpret Data and Evidence Scientifically Evaluate and Design Scientific Enquiry) for high performing Mexican students on PISA 2015. Therefore, the construct Domestic and educational possessions may be used for secondary analyses of learning, either as a complementary analysis for including ESCS, or as a predictor variable to complement ESCS.

The variable related to parental support for studying and learning at home, predicted achievement in science competencies PISA2015 assessments both significantly and positively. In addition, when we split this factor into two manifest variables, parents' emotional support for their children correlates significantly and positively to the science competencies factor.

### Recommendations

Although in this study and in the study by Tourón et al. (2018), parents of high performing students on PISA 2015 had relatively high scores regarding their parents' views on science and on how parents perceived school quality, the structural models obtained did not demonstrate that these variables directly influenced academic performance (scientific competency). Therefore, more research is needed on the possible impact of these variables on scientific competencies.

Variables regarding Parents' perceptions on the quality of children's school and policies for parent involvement in their children's school, as well as Parents' views on science, appeared to have no effect on high performing Mexican students' science competencies assessment.

### Limitations

One important limitation we may point out in this study relates to the sample size for high achieving students. This is a structural limitation that has to do with the low academic achievement and low cognitive levels of Mexican students on a number of iterations of the PISA exams. As we see in Table 1, no Mexican students scored at level 6 in achievement, and only 214 students scored at level 4 in cognitive achievement. Hence, causality relation analysis models were more modest, so we must also be cautious not to make generalizations based on this study.

### Authorship Contribution Statement

Bazán-Ramírez: Concept and design, data acquisition, data analysis / interpretation, drafting manuscript. Montes-Iturrizaga: Critical revision of manuscript, statistical analysis. Castro-Paniagua: Editing/reviewing, supervision.

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