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Scientific Competence in Developing Countries: Determinants and Relationship to the Environment

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Abstract: In 2015, the United Nations General Assembly adopted Agenda 2030 to guarantee sustainable, peaceful, prosperous, and just life, establishing 17 Sustainable Development Goals (SDGs). According to this declaration, pursuing the path of sustainable development requires a profound transformation in how we think and act. People must have scientific competences—not only knowledge of science, but also skills, values, and attitudes toward science that enable them to contribute to the goals proposed. This overall approach, known as Education for Sustainable Development (EDS), is crucial to achieving the SDGs. Scientific competences not only depend on what students learn in their countries' formal education systems but also on other factors in the environment in which the students live. This study aims to identify the factors that determine scientific competence in students in developing countries, paying special attention to the social and cultural capital and the environmental conditions in the environment in which they live. To achieve this goal, we used data provided by PISA-D in the participating countries—Cambodia, Ecuador, Guatemala, Honduras, Paraguay, and Senegal—and multilevel linear modelling. The results enable us to conclude that achieving scientific competence also depends on the social and cultural capital of the student's family and on the cultural and social capital of the schools. The higher the score in these forms of capital, the greater the achievement in sciences.

Keywords: scientific competence; SDG; PISA-D; multilevel

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Citation: Chávez Charro, J.M.; Neira, I.; Lacalle-Calderon, M. Scientific Competence in Developing Countries: Determinants and Relationship to the Environment. *Sustainability* **2021**, *13*, 12439. https://doi.org/10.3390/su132212439

Academic Editor: Jordi Colomer Feliu

Received: 12 October 2021
Accepted: 1 November 2021
Published: 11 November 2021

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1. Introduction

In 2015, the United Nations General Assembly adopted Agenda 2030 to guarantee sustainable, peaceful, prosperous, and just life, establishing 17 Sustainable Development Goals (SDGs) [1]. According to this declaration, pursuing the path of sustainable development requires a profound transformation in how we think and act. People must have scientific competences—not only knowledge of science but also skills, values, and attitudes toward science that enable them to contribute to the goals proposed. This overall approach, known as Education for Sustainable Development (EDS), is crucial to achieving the SDGs.

Scientific competences not only depend on what students learn in their countries' formal education system but also on other factors in the environment in which the students live. These factors could thus ensure provision of the scientific competences necessary for preparing students to face the grave environmental problems that have especially strong negative effects on the poorest and developing countries.

This study aims to identify the factors that determine the scientific competence of students in developing countries according to the results of PISA-D, paying special attention to social and cultural capital and to the environmental conditions of the area in which the students live. The study also seeks to fill the gap in studies on education about the environment and sustainability in Africa, south and central America, and southeast Asia.

To achieve these goals, we analysed data from PISA-Development in the participating countries of Cambodia, Ecuador, Guatemala, Honduras, Paraguay, and Senegal [2]. To identify the factors that determine the scientific competence of students in these countries, we performed a multilevel analysis, considering three levels of information: from the student (level 1), from the school (level 2), and from the community (level 3).

The remainder of the paper is organised as follows: Section 2 offers a brief theoretical framework on education, scientific competences, and sustainable development, focusing on the determinants of scientific competences; Section 3 develops the empirical analysis, presenting the data, model, and method used; Section 4 presents the results; finally, Section 5 presents the conclusions.

2. Theoretical Framework

2.1. Education, Scientific Competence, and Sustainable Development

Not all kinds of education foster sustainable development. Therefore, we talk about Education for Sustainable Development (EDS), which is oriented to empowering learners with knowledge, skills, values, and attitudes to take informed decisions and make responsible actions for environmental integrity, economic viability, and a just society [3]. According to Tapio and Willamo [4], the factors that affect human action to face environmental problems can be divided into: (i) individual factors, (ii) social factors, and (iii) ecological factors. Individual factors include knowledge, or the rational logical part of human thinking and, more concretely, knowledge of specific information about the environment and environmental measures [5]. This knowledge is also known as scientific competence. The Programme for International Student Assessment (PISA) defines scientific competence as the ability to use scientific knowledge to understand and make decisions about the natural environment and the changes it undergoes in relation to human action [6]. Social factors include science, as the result of research and in turn as social organization [7]. Science is closely linked to education, which is an important means of protecting the environment [8]. Most environmental problems are due to a lack of environmental knowledge, a term used to mean knowledge and awareness of environmental problems and possible solutions to them [9]. Increasing knowledge of environmental problems can increase people's concern and awareness [10]. Some authors argue that a common premise for promoting sustainability is to increase people's awareness and education [11].

In line with the foregoing, the framework of action to achieve SDG 4 (ensure inclusive and equitable quality education and promote lifelong learning opportunities for all), establishes that all students should acquire the theoretical and practical knowledge essential for promoting sustainable development by 2030, establishing as goals: (i) "Percentage of students by age group (or education level) showing adequate understanding of issues relating to global citizenship and sustainability; (ii) Percentage of 15-year-old students showing proficiency in knowledge of environmental science and geoscience" [12] (p. 79).

For years, the OECD's Programme for International Student Assessment (PISA) has been evaluating the degree to which 15-year-old students nearing the end of compulsory education have acquired key knowledge and skills essential for full participation in modern societies. The competences PISA usually evaluates are reading competence, mathematical competence, and scientific competence [6]. To include developing countries, the OECD also established PISA-D, so that these countries could determine their students' levels of competence (reading, mathematics, and scientific) and thus improve their public policy on educational issues. Thus, the PISA-D science framework considers scientific competence as key at both the local (intra-country) and international level to enable countries (individually and together) to face the tremendous challenges in water and food supply, disease control, energy production, and adaptation to climate change [6]. Facing all these challenges requires a significant contribution from science and technology. However, "this does not mean turning everyone into a scientific expert but enabling them to fulfil an enlightened role in making choices which affect their environment and to understand in broad terms the social implications of debates between experts" [6] (p. 28). Teaching and learning about science related directly to everyday life make knowledge useful for understanding how the natural world functions, while also teaching students to be informed citizens who are prepared to tackle social issues related to science intelligently [13]. Scientific competence, understood as "the ability to use knowledge and information interactively—that is 'an understanding of how it [a knowledge of science] changes the way one can interact with the world and how it can be used to accomplish broader goals'" [6] (p. 93), is perceived as a key competence all students must have [14,15]. With this competence, young people can respond to the current environmental and climate crisis by making informed critical decisions that influence their environment. This is the purpose of scientific literacy or competence [6].

2.2. Determinants of Scientific Competence

In scientific education, developing a student's interest in science probably results in higher levels in understanding of science and environmental awareness [16]. Determining how students can achieve good performance in such scientific competence is a challenge for all countries, especially the least developed. Recent studies argue that achieving scientific competence for 15-year-old youths in the PISA test depends on socioeconomic, family, environmental, and attitudinal factors [17–21] (see Figure A1 in Appendix A). Among these factors, we highlight the following:

The environment. The environment refers specifically to characteristics of the environment of both the school and the students' households that support success and education through disciplinary and academic climate in the school, as well as through cultural norms and values that motivate students to achieve higher goals [22]. The environment in which the children's families, schools, and community live their lives affects educational performance and thus students' behavior and development [23–28].

Family factors or cultural capital. Coleman [29] and Bourdieu [30] have studied the relationship between academic achievement and family. Bourdieu has stressed the crucial role of family resources (relational, material, and cultural) in shaping children's unequal education results. The family thus plays a fundamental role in students' learning and performance [31]; this influence has been called cultural capital. Citing Bourdieu, Cervini [32] (p. 454) stresses that "cultural capital, then, plays a role of intermediary factor between the student's social origin (family background) and their learning". In other words, children of higher social class will possess inherited cultural capital that is valued more highly by the school and will thus have greater success than students without such capital [32].

Social capital. Social capital is defined as a set of relational resources that groups and individuals can access based on their interests [30,33]. Social capital has come to be viewed as a flexible conceptual instrument that can be used to explain a wide range of social problems, including education [22]. Studies of the effect of social capital on academic performance have found a positive correlation between the two [34–36].

It is very important to know how these capitals influence students' achievement in countries with low and medium economic conditions and large cultural differences. It is also important to know how these capitals influence student achievement and how students' achievement is related to their scientific literacy and thus indirectly to their "climate or ecological consciousness", starting from the important natural wealth of developing countries.

3. Empirical Analysis

3.1. Data

To empirically analyze the factors determining scientific competence in developing countries, we used data reported by PISA-Development in the participating countries of Cambodia, Ecuador, Guatemala, Honduras, Paraguay, and Senegal [2]. The data come from two questionnaires. The first, completed by students, is the questionnaire on antecedents. It includes information on students' wellbeing, achievements, and attitudes towards school; learning in their households; and relationship with their parents, classmates, and/or professors; as well as parents' education and occupation. The second questionnaire, completed by the director of the school, includes information on the school: where it is located, how it is structured and organized, and what the learning environment is like. The PISA-D data represent around one million students 15 years old, 34,604 of whom from a total of 1299 schools completed the assessment (see Table 1). The sampling technique used for PISA-D for each participating country is a stratified sampling design in two stages. The sampling units at the first stage consisted of schools with eligible students (or with the possibility of having such students at the time of the evaluation). Schools were systematically sampled from a comprehensive national list with all PISA-D-eligible schools. The strata were defined for each of the countries according to their characteristics. The sampling units at the second stage consisted of students from the sampled schools. These students were chosen from a complete list of 15-year-old students from each of the sampled schools. A target cluster size (TCS) was set for each country; this value was usually 42 students.

Table 1. Countries participating in PISA-D and their achievement in sciences.

COUNTRY	Country Sample	Avg. in Sciences
Cambodia	5162	330
Ecuador	5664	399
Guatemala	5100	365
Honduras	4773	370
Paraguay	4510	358
Senegal	5182	309
Zambia	4213	309
OECD avg.		493
Total	34,604	

Source: [2].

We highlight that over half of the items were identical to those evaluated in PISA-2015, which enabled us to derive further information on the PISA results by connecting them to the scale. The other items were adapted to the PISA framework [6]. All this information considers the students' personal and socioeconomic characteristics, their social and cultural capital, and the characteristics of the environment that can influence the students' scientific competence or academic achievement in the sciences. All these characteristics condition these students' behavior in their relationship to the environment [6]. The data provided by PISA-D were used to evaluate these variables, while considering three levels of information: from the student (level 1), from the school (level 2), and from the community (level 3). Table A1 in Appendix A describes all variables used in this study. The data from the dependent variable were scaled using the Rasch model and expressed by assigning ten plausible values [37], presented on a continuous scale in which 500 points is equivalent to the average of the OECD countries, where the standard deviation is standardized at 100 points [38].

The independent variables associated with cultural capital were selected following Tramonte and Willms, who propose that there are two types of cultural capital, one static and the other relational [39]. The first is associated with possession of cultural goods and intellectual activities, and the second with discussions on cultural and political issues. Static cultural capital can only reflect the decisions and lifestyle of one's parents, whereas relationship cultural capital reflects how capital is used and transmitted [40].

The variables related to social capital were chosen according to the approaches in Coleman [29], for whom social capital can be presented in three forms: expectations and obligations, information channels, and social norms. In PISA-D [41], the variables that can be included in level (I) are communication within the family, attitude towards school, and relationships between students and teachers. Level (II) includes climate of discipline in the classroom, teacher's expectations, class size, and whether the school is in a high-crime area. For a more detailed description of each of the variables, see Table 2.

Table 2. Descriptive statistics of the variables.

Characteristics of the Environment						
Area	**Variable**	**Observations**	**Mean**	**Standard Deviation**	**Min**	**Max**
School environment (LEVEL 2)	Type of community in which the school is located	33,734	2.5948	1.288359	1	5
	Near highway or freeway	28,803	0.4222477	0.4939262	0	1
	Near busy roads or intersections	31,153	0.713286	0.452234	0	1
	Near dump or waste land	27,244	0.0934518	0.2910698	0	1
	Near geologically unstable area	27,148	0.0754015	0.264043	0	1
	Near industrial district	27,188	0.0798514	0.271068	0	1
	Number of days school is closed due to weather or illness	32,244	0.4918124	1.593598	0	20
	Time from home to school	32,898	1.916074	1.114331	1	5
School characteristics (LEVEL 2)	Public or private school	34,396	0.9540063	1.216799	0	9
	School resources	34,200	3.080643	1.399285	1	5
Characteristics of the Student and Their Socioeconomic Environment						
Area	**Variable**	**Observations**	**Mean**	**Standard Deviation**	**Min**	**Max**
Student's characteristics (LEVEL 1)	Grade compared	34,604	−0.2975668	1.039366	−3	3
	Repeater	33,692	0.305859	0.4607771	0	1
	Gender	34,604	0.4853774	0.4997934	0	1
Family's cultural capital (LEVEL 1)	Number of books at home	32,189	2.38218	0.9530487	1	4
	Mother's education level	30,481	2.527771	2.020261	0	6
	Household poverty index	33,501	3.253037	0.854383	1	4
	Household properties	32,501	−1.790417	1.4060211	−8.1792	3.9708
School's cultural capital (LEVEL 2)	Percentage of very poor students	33,418	4.428901	1.673123	1	6
	Level of instructional resources	32,664	3.00	1.414	1	5
Family's social capital (LEVEL 1)	Communication within the family	29,615	1.60e-07	1.004	−2.752	1.095
School's social capital (LEVEL 2)	Attitude towards school	32,413	7.536331	2.065439	0	10
	Discipline in the classroom	32,593	0.1640453	1.045713	−2.9394	2.2536
	Student–teacher relationships	32,475	6.541837	2.002628	0	10
	Teacher's expectations	32,664	7.130877	2.38518	0	10
	Class size	32,288	773.00	826.511	6	5111
Community's social capital (LEVEL 2)	Located in a high-crime neighborhood	27,403	0.1215195	0.326736	0	1

Source: Developed by authors.

3.2. Specification of Model and Estimation Procedure

To consider the hierarchical structure of the data from PISA-D 2017 and to study the conditioners of students' scientific competence in developing countries (Y_{ijk}), we applied multilevel linear models [42,43]. The econometric model for the estimation is given by Equation (1):

$$Y_{ijk} = \beta_0 + \beta_1 X_{1ijk} + \beta_2 X_{2ijk} + \gamma_1 Z_{1jk} + \gamma_2 Z_{2jk} + \gamma_3 Z_{3jk} + \beta_3 D_K + \mu_{0j} + \mu_{1j} X_{2ijk} + \varepsilon_{1ijk} \quad (1)$$

where, (i) indicates the student, who belongs to school (j) from country (k). The variable X_{1ijk} is a series of variables related to the student's personal and socioeconomic characteristics; X_{2ijk} is a set of variables associated with the family's cultural and social capital; Z_{1jk} is a group of variables that characterize and approximate the school's cultural and social capital; Z_{2jk} is the set of variables of the school's surroundings and natural environment; Z_{3jk} is the set of variables of the school's characteristics; and D_K represents the dichotomous variables that include the student's country of residence. Furthermore, μ_{0j} is the error of the random effects of the schools' level, μ_{1j} is the random slope for each school relative to the family's cultural or social capital cultural, and ε_{1ijk} is the error term in the students' level. We start from the assumption that μ_{0j}, μ_{1j}, and ε_{1ijk} follow a normal distribution with mean zero and variances $\sigma^2_{0\mu}$, $\sigma^2_{1\mu}$, and σ^2_{ε}.

The multilevel model used is explained by analyzing its fixed and random parts. The fixed component of the model, expressed by $(\beta_0 + \beta_1 X_{1ijk} + \beta_2 X_{2ijk} + \gamma_1 Z_{1jk} + \gamma_2 Z_{2jk} + \gamma_3 Z_{3jk} + \beta_3 D_K)$, defines the relationship between the student's academic performance and a set of co-variables of the student or the school, whose estimated slopes are assigned by the parameters β_1, β_2, γ_1, γ_2, γ_3, and another fixed effect defined by the slope of the country effect β_3. The random part of the model composed of $(\mu_{0j}, \mu_{1j} X_{2ijk}, \varepsilon_{1ijk})$ enables us to estimate the variances $\sigma^2_{0\mu}$, $\sigma^2_{1\mu}$, and σ^2_{ε}, and includes the remainder $\left[(\varepsilon]_{ijk}\right)$. This method gives each school the possibility of maintaining its own error component $[(\beta]_0 + \mu_{0j})$ and its own random slope $(\beta_2 + \mu_{1j})$ for any explanatory variable of the student's cultural or social capital. The model can thus indicate whether the effect of any variable of social or cultural capital on scientific competence changes among schools once we control for other characteristics of the educational institution itself considered in the fixed part of the model (γZ_{ijk}). Given the conditions explained, we can analyze possible heterogeneity among schools and these conditions, while at the same time measuring the "average" effect of each variable [40].

Given the hierarchical structure of the data, we specified four multilevel models. Model I considers only the variables of cultural and social capital belonging to the student. Model II incorporates the variables of the family's cultural and social capital. The goal of Model II is to show whether the cultural and social capital of the student's family has a different effect, independent of the school the student attends. For this effect, we then incorporate the random slopes of the variables that were statistically significant in Model I. Model III incorporates the variables of social and cultural capital concerning the school. Model IV adds the variables related to the natural environment of the area in which the school is located, as well as the characteristics of the school itself. Model V, like Model II, incorporates the variables that approach cultural and social capital as random slopes of the schools.

All the models include the gender, grade compared, and whether the student has repeated one or more grades in school as control variables. Since the PISA-D test included only seven countries, the multilevel characteristics of our data mean that the country effect is considered as a fixed effect, since capturing the variability between countries requires at least 30 countries [42,44,45].

4. Results

Table 3 shows the results of our estimations.

Of all the variables defining the school's environment, only "size of the community where the school is located", "number of days the school is closed", and whether "the school is near a geologically unstable area" are statistically significant. According to the results of Model IV (see column 5 in Table 3), the larger the community where the school is located, the higher the results for scientific competences. This means that students in large cities have a comparative advantage over students in schools located in less populated areas, which are usually rural. This result is similar to that obtained by Miller and Votruba-Drzal [46], who argue that the urbanization level influences academic achievement based on the differences they find between urban and rural population settlements. The second significant variable—with negative effects on scientific competences—is the number of days the school is closed due to weather or illness, a characteristic typical of developing countries. Finally, schools located in geologically unstable areas show higher student science competences than those in stable areas. This result must be related to the special awareness people develop when they live in such places.

Table 3. Multilevel estimations of PISA-D scientific competences.

Variables	Model I	Model II	Model III	Model IV	Model V
School environment					
Community size where the school is located				5.172 ***	4.764 ***
				(0.768)	(0.717)
Near highway or freeway				2.890	2.284
				(1.745)	(1.630)
Near busy roads or intersections				0.423	1.646
				(1.923)	(1.785)
Near a dump or wasteland				−2.562	−3.923
				(3.244)	(2.958)
Near geologically unstable area				8.211 **	6.631 *
				(3.178)	(2.934)
Near industrial district				−1.744	−1.290
				(3.313)	(3.104)
No. of days school is closed due to the weather or illness				−1.714 ***	−1.632 ***
				(0.464)	(0.430)
Time from home to school				−0.504	−0.537
				(0.310)	(0.307)
School characteristics					
Public or private				−6.376 ***	−4.633 ***
				(1.314)	(1.237)
School resources				0.170	0.0601
				(0.816)	(0.750)
Student characteristics					
Grade compared	16.32 ***	15.83 ***	15.07 ***	15.05 ***	14.73 ***
	(0.352)	(0.348)	(0.409)	(0.436)	(0.433)
Repeater	−10.39 ***	−10.10 ***	−10.30 ***	−9.807 ***	−9.616 ***
	(0.651)	(0.645)	(0.762)	(0.820)	(0.814)
Gender/Male	10.31 ***	9.727 ***	10.44 ***	10.23 ***	9.641 ***
	(0.514)	(0.613)	(0.600)	(0.646)	(0.779)
Family's cultural capital					
Number of books at home	4.115 ***	3.906 ***	4.188 ***	4.306 ***	4.071 ***
	(0.308)	(0.305)	(0.360)	(0.390)	(0.386)
Mother's education	0.755 ***	0.387 *	0.776 ***	0.721 ***	0.477 *
	(0.145)	(0.173)	(0.169)	(0.182)	(0.216)
Household poverty index	0.874	3.207 ***	0.960	1.212	2.595 **
	(0.622)	(0.635)	(0.722)	(0.778)	(0.800)
Household properties	1.914 ***	0.894 *	1.444 **	1.062 *	0.477
	(0.386)	(0.421)	(0.447)	(0.488)	(0.533)
School's cultural capital					
Percentage of very poor students			−4.654 ***	−3.007 ***	−2.370 ***
			(0.527)	(0.563)	(0.530)
Level of instructional resources			9.166 ***	5.074 ***	4.461 ***
			(0.714)	(0.903)	(0.835)
Family's social capital					
Communication within the family	4.387 ***	4.258 ***	4.443 ***	4.578 ***	4.448 ***
	(0.312)	(0.329)	(0.371)	(0.400)	(0.421)
School's social capital					
Attitude towards school	−0.725 ***	−0.645 ***	−0.0333	−0.00760	0.0511
	(0.131)	(0.130)	(0.179)	(0.192)	(0.209)
Discipline in the classroom			1.496 ***	1.605 ***	1.576 ***
			(0.319)	(0.341)	(0.339)

Table 3. *Cont.*

Variables	Model I	Model II	Model III	Model IV	Model V
Student–teacher relationships			−2.758 ***	−2.940 ***	−2.818 ***
			(0.219)	(0.238)	(0.236)
Teacher's expectations			1.110 ***	1.122 ***	1.002 ***
			(0.186)	(0.201)	(0.200)
Class size			0.0985	0.0443	0.00854
			(0.0631)	(0.0654)	(0.0605)
Community's social capital					
Located in a high-crime neighborhood			2.165	−0.303	0.184
			(2.526)	(2.809)	(2.591)
Countries, reference Cambodia					
Ecuador	50.06 ***	34.61 ***	46.88 ***	42.66 ***	34.38 ***
	(2.984)	(2.615)	(3.179)	(3.238)	(3.011)
Guatemala	30.55 ***	20.63 ***	31.42 ***	26.65 ***	21.48 ***
	(2.923)	(2.515)	(3.114)	(3.310)	(3.044)
Honduras	45.05 ***	39.46 ***	53.40 ***	46.88 ***	43.79 ***
	(2.899)	(2.512)	(3.192)	(3.395)	(3.161)
Paraguay	30.01 ***	21.02 ***	32.44 ***	33.60 ***	27.88 ***
	(2.954)	(2.602)	(3.326)	(3.483)	(3.267)
Senegal	−27.55 ***	−29.86 ***	−13.80 ***	−23.54 ***	−25.28 ***
	(3.059)	(2.578)	(3.268)	(3.503)	(3.182)
Zambia	−5.307	−6.003 *	5.924	4.622	3.154
	(3.011)	(2.627)	(3.268)	(3.261)	(3.031)
Constant	313.3 ***	311.0 ***	297.8 ***	311.7 ***	307.0 ***
	(3.825)	(3.773)	(5.937)	(7.527)	(7.288)
Variance of random effects					
Student $\left(ch^2_{€}\right)$	654.4 ***	1607.53 ***	482.7 ***	407.6 ***	1030.99 ***
School $\left(ch^2_{u0)}\right)$	1519.3 ***	1426.85 ***	1508.0 ***	1505.3 ***	1415.47 ***
Slopes of X_{ij} $\left(ch^2_{u1)}\right)$					
No. of books at home		116.324 ***			125.858 ***
Mother's education		8.983 ***			8.259 ***
Household properties		18.514 ***			18.274 ***
Communication within the family		10.97 ***			11.27 ***
Attitude towards school		5.637 ***			4.546 ***
Number of students	25,604	25,604	25,604	25,604	25,604
Number of schools	1282	1282	1282	1282	1282
2LR	100,184.84	393.96	71,813.85	26939.99	179.3

Standard errors in parentheses: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

As to the schools' characteristics, it is very interesting that the school's infrastructure and resources have no significant effect on scientific competences but that the public or private character of the school does. The results show that public school students achieve a lower level of competence than those educated in private schools. According to the OECD [47], private school students score higher in science than public school students. If the socioeconomic profiles of students and schools are considered, however, public school students score higher than private school students on average in all OECD countries. Similarly, Castro Aristizabal et al. [48] find that 87.2% of school performance differences in science are explained by whether students attend public or private schools.

In addition to the school's physical environment, its cultural and social capital are very important in explaining the student's scientific competences. These capitals are conditioned by the socioeconomic characteristics of the community in which the school is located. The results of Model III (column 4 in Table 3) show that the school's cultural capital, proxied by the "percentage of extremely poor students" and "school learning resource level", is statistically significant in explaining the level of science competences students achieve. A high percentage of very poor students in the school lowers the science competence levels. According to Alivernini and Manganelli [19], the factor that seems to be most closely associated with the difference between average school outcomes is the school's average socioeconomic level. Cohen-Vogel et al. [24] term the concentration of students with high poverty levels "ghettoization" of urban centers. Schools in these urban centers achieve poor academic results because most students—poor children and young people without access to adequate housing, health care, and nutrition—find it very difficult to concentrate and learn well. Many factors explain the interaction between social stratification and cultural production in schools and communities where racial, ethnic, and socioeconomic groups show persistent differences in academic performance [49,50].

Our results show that the "school learning resource level" variable is also very important in explaining the scientific competences students achieve. This result is similar to those of Murillo and Román [51], who suggest that schools' learning resources have significant effects on scientific competences in middle- and low-income countries, even when controlling for students' socioeconomic characteristics. Furthermore, our results contrast with those obtained for developed countries, such as Spain [6], where schools' technological resources showed no significant values [20]. These results probably reflect the fact that schools in developed countries have all the elements needed for learning, whereas educational institutions in developing countries do not.

If we now examine the effect of the school's social capital on the scientific competences students achieve, our estimations of Model III show positive results (column 4 in Table 3). Specifically, a good climate of classroom discipline and good teacher's expectations yield better student performance in science. These results are in line with Acar [22], who indicates that social capital, in the form of the school's disciplinary and academic climate, supports success and education. The results also show that cultural norms and values motivate students to achieve higher goals. This criterion reinforces Putnam's argument that the development of children and youth is strongly determined by the school's social capital [33]. These results contrast, however, with those of Glewwe and Kremer [52], who cannot draw any general conclusions about which teaching, and school variables increase learning in developing countries.

The values of the variable "student–teacher relationships" are noteworthy, as the relationship is significant but has a negative sign.

If we examine the results of the variance among the schools, we see a decrease when comparing Model II (value 1426.85) to the variance of Model I. This finding indicates that including the variables of families' social and cultural capital as random slopes (Model II) as well as the variables of the schools' social and cultural capital (Model V) reveals differences in the results between schools due to the influence of social and cultural capital associated with the student [34].

In addition to all previously discussed variables related to the school (e.g., its physical environment or cultural and social capital), other student-level variables are very important in explaining the results of students' scientific competence, and thus climate awareness. At this level, we considered not only the individual students' characteristics but also their cultural and social capital, variables again conditioned largely by the socio-economic environment of the student's family.

As we can see in Table 3, the results of our estimations show that the student's cultural capital, proxied by the "number of books at home", is not only statistically significant but is also the major factor explaining students' scientific competences. Other authors obtain similar results for mathematics in Latin-American countries [20,53], and for reading competence in OECD countries [39].

As to the student's social capital, we follow Coleman's definition as "relationships between children and parents" [29] and proxy this variable with "communication within the family".

The results in Table 3 indicate that this variable is statistically significant in all models and is positively related to competence in science. This result is in line with Caro [54] and Dufur and Parcel et al. [34], whose studies find a positive interaction of communication between parents and children and parent's education in the results of the PIRLS 2006 and PISA 2000 tests. The second variable used to proxy the student's social capital was "Attitude towards school". This variable is also significant, but only in models that do not include the school's variables.

Finally, concerning the individual factors, or the student´s individual characteristics, our results show that "gender", "grade", and "repeater" are statistically significant in explaining the scientific competences of students. First, we find that boys achieve better science skills than their female classmates, which agrees with the results obtained by Rodríguez-Mantilla et al. [20] in their study of predictors of science performance in PISA-2015 for Spain. For the case of Latin America and the Caribbean, the report from the Third Regional Comparative and Explanatory Study on Education Quality (TERCE) states that the results in science do not follow a definite pattern in terms of gender inequity in the achievement of learning. The gender gap in sciences is statistically significant in a small number of countries, and the advantage by gender is divided [55]. As to the other two characteristics, "grade" and "repeater", it is important to remember that the learning time is different in developing and poor countries. Children from poor families usually start school at an older age, miss many days of school during primary school, and are more likely to repeat a grade. Many of these children work part-time away from home at very young ages. Moreover, it seems that the time spent in class on the three main PISA subjects varies markedly and the school curriculum does not explore them in as much depth [6]. For these reasons, students who have repeated a year achieve lower results. These results are like those obtained in Gómez Vera's study of the countries of the southern cone of America based on PISA 2009 [56]. The fact that the students are in a higher grade than the average of other 15-year-olds means that they have achieved a higher level of science competence.

As to the results of country estimates, having Cambodia as a reference, we note that Latin American countries achieve higher performance in science competition, while Senegal and Zambia achieve lower levels.

5. Conclusions

The results enable us to conclude that science competence in the countries participating in PISA-D are low, although the results are even lower in African countries. The achievement of scientific competence is greater in men than in women, and the differentiating results are generally related to the family's social and cultural capital, to which the students are subjected. The higher the scores in these capitals, the greater their achievement in science. The same occurs with the schools' cultural and social capital and its influence on the achievement of scientific competence. Schools with a higher number of poor students show lower results in achievement in the sciences, as do schools with fewer learning resources. The social capital of the schools also has a positive influence on science competence, measured as the presence of a good climate of discipline in the classroom and higher expectations from teachers. That the school belonged to a large urban area was also found to be a factor determining higher achievement in the sciences than schools in rural areas with settlements that have small populations.

We must stress the importance of cultural and social capital in achieving scientific competence and the way that such scientific literacy offers the competences students need to respond socially as needed to the environmental crisis. These results show the need to propose further studies to complement this one by considering additional factors that can affect academic performance, such as socio-emotional issues. Additionally, since PISA-D questionnaires do not always capture the most relevant contextual factors for these countries, future research needs to be carried out including more questions about real-life situations in those contexts and/or questions about the level of understanding the students have about their environment. In fact, this paper, as a first approximation in this line, has empirically demonstrated that being near a geological area makes students achieve better grades in science, surely worried about the environment in which they live. Finally, studies that tend to foster better development in the scientific competences are also so necessary in these times of environmental crisis.

To conclude, we argue that the current paradigm of education must change, as economic development alone is insufficient if one neglects the sustainability of the planet [57]. In response to the current environmental and climate crisis, there is an urgent need for young people to develop competences that enable them to make more informed, critical decisions that influence their environment. Scientific literacy prepares them for such decisions [6].

Author Contributions: Conceptualization, J.M.C.C. and I.N.; methodology, J.M.C.C. and I.N.; software, J.M.C.C.; validation, J.M.C.C. and I.N.; formal analysis, J.M.C.C., I.N. and M.L.-C.; investigation, J.M.C.C., I.N. and M.L.-C.; resources, J.M.C.C.; data curation, J.M.C.C.; writing—original draft preparation, J.M.C.C.; writing—review and editing, M.L.-C.; visualization, J.M.C.C., I.N. and M.L.-C.; supervision, J.M.C.C., I.N. and M.L.-C.; project administration, I.N. and M.L.-C.; funding acquisition, I.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National R&D Programme of the Spanish Ministry of Science, Innovation and Universities through the project 'Spanish Universities Involvement in Social Innovation Activities' (SUISIA) with grant number: RTI2018-101722-B-I00.

Data Availability Statement: Data supporting reported results can be found at: https://www.oecd.org/pisa/pisa-for-development/database/ (accessed on 10 December 2020).

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Description of variables.

Variable Name	Description	Questionnaire	Survey Item	Response Type	Minimum Value	Maximum Value
Dependent Variable						
Scientific Competence	"Ability to explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically " (OECD, 2015).					
Independent Variables						
Characteristics of environment						
School environment (LEVEL 2)	Size of community where school is located	To directors	SC001		1 = Village or rural settlement of under 3000 inhabs.	5 = Large city of over 1,000,000 inhabs.
	Near highway or freeway	To directors	SC010Q01NA	Dichotomous	0 = No	1 = Yes
	Near busy roads or intersections	To directors	SC010Q02NA	Dichotomous	0 = No	1 = Yes
	Near a dump or waste land	To directors	SC010Q04NA	Dichotomous	0 = No	1 = Yes
	Near geologically unstable area	To directors	SC010Q05NA	Dichotomous	0 = No	1 = Yes
	Near industrial district	To directors	SC010Q06NA	Dichotomous	0 = No	1 = Yes
	No. of days per year school is closed due to weather or illness	To directors	SC024Q05NA	Numerical	No. days	No. days
	Time from home to school	To students	ST061		1 = under 15 minutes	5 = over 90 minutes
School characteristics (LEVEL 2)	Type of school: public or private	To directors	SC006		1 = private	2 = public
	School resources	To directors	SCHRESOURSES		1 = very low resource level	5 = very high resource level
Characteristics of the student and their socioeconomic environment						
Student characteristics (LEVEL 1)	Grade compared. Student's current grade compared to standard grade-age of each country	Reported by PISA-D	ST001		-3	3
	Repeater. Has the student ever repeated a grade?	To students	ST009	Dichotomous	0 = No	1 = Yes
	Gender	To students	ST004		1 = female	2 = male

Table A1. *Cont.*

Variable Name	Description	Questionnaire	Survey Item	Response Type	Minimum Value	Maximum Value
Family's cultural capital(LEVEL 1)	Number of books at home	To students	ST066Q01NA		1	4
	Mother's education level	Reported by PISA-D	MISCED_D		0 = No education *	6 = Highest level *
	Household poverty index	Reported by PISA-D	POVERTY		1 = very poor ***	4 = not poor ***
	Household properties **	Reported by PISA-D	HOMEPOS15		−8.1792	3.9708
School's cultural capital(LEVEL 2)	Percentage of very poor students in the school	To directors	SC022Q02NA		1 = under 1%	6 = over 30%
	Availability of instructional resources in the school and use teachers make of them	To directors	INSTRRESCAT		1 = has very basic instructional resources	5 = has more complex, expensive resources in the school
Family's social capital (LEVEL 1)	Communication within the family	To students	ST083		−2.752	1.095
School's social capital(LEVEL 2)	Student's attitude towards school. Measures the impact of school on the student, whether the student sees the importance of school for their future.	To students	ATSCH		0 = negative attitude	10 = full approval and value
	Climate of discipline in the classroom	To students	DISCI		0 = negative attitude	10 = full approval and value
	Student–teacher relationships	To students	STTCHREL		0 = lesser degree ****	10 = greater degree ****
	Teacher's expectations about students' success and ability to work	To students	TCEXPSUC		0 = lesser degree	10 = greater degree
	Class size	To directors	SC005		1 = less than 15 students	9 = more than 50 students
Community's social capital (LEVEL 2)	Is the neighborhood in which the school is located a high-crime neighborhood?	To directors	SC010Q03NA	Dichotomous	0 = No	1 = Yes

Notes: * The indexes of parents' education were obtained by recoding the education levels into the following categories: (0) None, (1) ISCED (International Standard Classification of Education) 1 (primary education), (2) ISCED 2 (lower secondary), (3) ISCED level 3B or 3C (upper secondary, professional/pre-professional), (4) ISCED 3A (general upper secondary) and in some cases ISCED 4 (post-secondary non-tertiary), (5) ISCED 5B (vocational tertiary), and (6) ISCED 5A and in some cases ISCED 6 (tertiary and graduate, leading to an advanced research qualification). ** Household properties refers to the availability of 16 household items, including three country-specific items viewed as measures of household wealth within the country context.*** Household poverty index: This is the index reported by PISA-D as "POVERTY", which includes four categories: "extremely poor", "severely poor", "poor", and "not poor", based on the results of another index that measures family resources, for example, whether family shares a hygienic bathroom with others who are not members of their household, whether they have a flush toilet, what material they have on the floor of their house, whether any family member has a bank account, and whether the student has gone hungry in the past month. **** Evaluated using a scale produced by students' degree of agreement with a series of questions about their interpersonal relationships with their teachers.

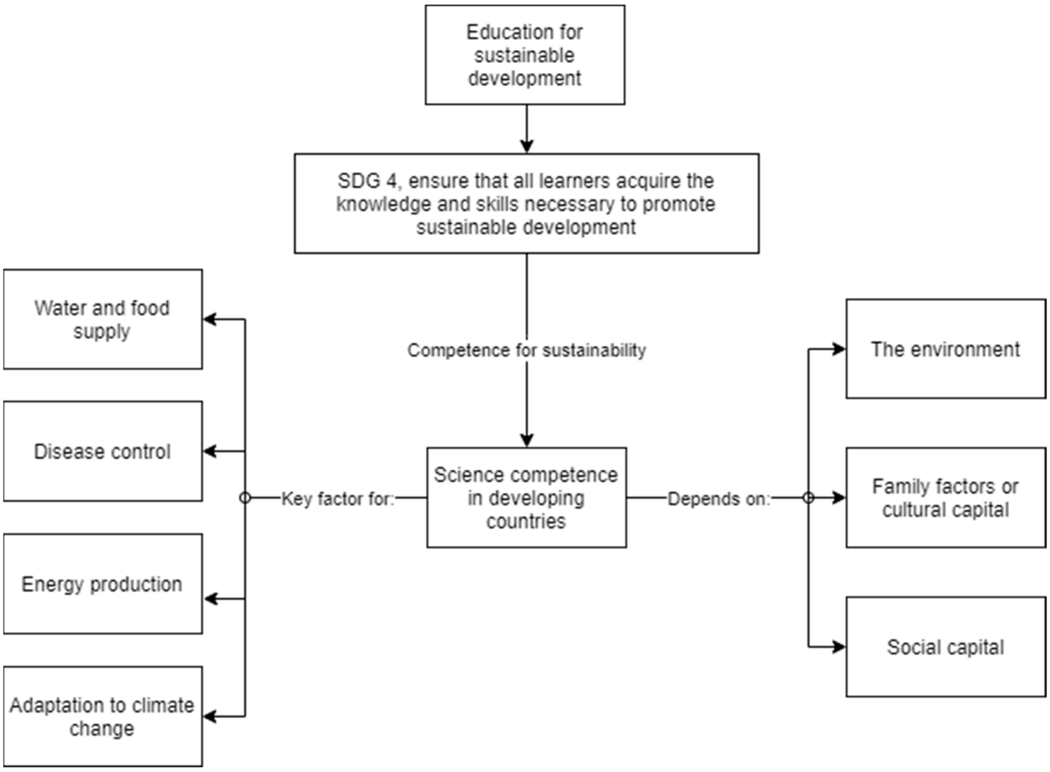

Figure A1. Determinants of scientific competence.

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