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"The role of Spanish schools in providing environmental knowledge in science"

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Abstract

Previous studies have shown that there is a positive relationship between environmental education and pro-environmental behaviors and attitudes. The aim of this study is to describe an empirical approach to measuring aspects of environmental science literacy through using data from OECD PISA 2006 in Spain. Four that purpose, we use multilevel model is to analyze in detail the impact of school activities and other additional sources on the environmental education of 15-years-old students. Our findings show that schools have a secondary role in the provision of environmental knowledge, since only few activities have a significant influence on students' environmental performance, while media seem to have a major role in providing that information.

1. Introduction

Formal education is recognized as a significant factor in explaining environmental behaviors and attitudes. General knowledge and even specific abilities related to environmental sciences are acquired through the educational system. Moreover, people can interact or/and use the media to get environmental knowledge. In general, promoting environmental education is considered as key issue to protect the environment. It has been shown that there is a positive relationship between environmental education and pro-environmental behaviors and attitudes.

In this context, a research about which is the main source from which people acquire environmental education can be really informative. In this respect, one of the main issues consists on identifying the impact of schools and alternative sources providing environmental knowledge. The aim of this study is to describe an empirical approach to measuring aspects of environmental science literacy through using data from OECD Programme for International Student Assessment (PISA) in 2006 which is focused in Sciences. Using specific information about environmental knowledge achieved by students, we implement a multilevel analysis that enables us to test the potential influence on multiple factors related to students´ attitudes and knowledge as well as activities carried out by schools to promote environmental awareness.

The structure of the paper is as follows. In the next section, we describe briefly the links between environmental education and pro-environmental attitudes and behaviors. The third section describes the data base and the variables included in the analysis. The forth section presents the empirical model employed and the main results obtained. Last section summarizes the main conclusion and provides some insights for future research.

2. Environmental education: definition, sources and impact on attitudes and behaviors

One of the main challenges of environmental discourses is to define environmental science and subsequently policies, programmes, and practices for environmental science education. People frequently use environmental education to describe what could also be designated as "environmental information". This includes information that can be acquired from the media, through advertisements, or even in simple story books. Science education, in some instances, can also provide environmental information without necessarily providing environmental education. Hines *et al.* (1986-87) define environmental education as more than just mere transfer of information. It involves four issues: a working knowledge of environmental issues, a specific knowledge of approaches to address those issues, the competency to make appropriate decisions, and the possession of certain affective qualities and attitudes that make people care about and pay more attention to environmental conditions.

It is claimed that the deeper the knowledge about environmental problems and the way to solve them, the higher is the probability that an individual is involved in actions to protect the environment (Kollumuss and Agyeman 2002). Additionally, well-informed citizens who know about environmental problems might have stronger pro-environmental attitudes and behaviours, because they are better aware of the possible damage (Danielson *et al.* 1995, Olli *et al.* 2001). Lubell *et al.* (2006) implemented an index of environmental knowledge using the proportion of correct answers to some questions related to air pollution in Texas, finding a positive relationship between that index and the support for air policies and pro-environmental attitudes.

Individuals with higher levels of education may be more socially aware. The costs of environmental activism might be lower for better-educated people because they have more civic skills (Lubell 2002). For example, Martinez and McMullin (2004) showed that around 90% of the members of a US environmental organization have a higher education level than high school. Further implications arise from the study by Govindasamy and Italia (1999), who found that people with knowledge about environment-friendly techniques in agriculture were more likely to pay a premium for organic food.

Additionally, several previous studies have stressed the relevance of informal education (Blomquist and Whitehead 1998, Lubell 2002, Hidano et al. 2005). Likewise, it is argued that people can extend their environmental education about the environmental issues through the media (by watching television or reading newspapers), internet or by means of social interaction. In this sense, educational campaigns to aware people about the benefits of pro-environmental behaviors and the negative consequences of irresponsible behaviors seen to be particularly effective in achieving better attitudes and behaviors (Serret and Ferrara, 2008). Thus, we can conclude that the literature has widely recognized the importance of non-formal education channels in generating environmental responsibility.

3. Data and variables

The OECD's PISA program provides information about skills of 15-year-old-students from an international point of view. PISA tests students in three domains (reading, mathematics and science) and takes place every three years, with special attention being paid to one of the domains each time. The main area in each wave takes up approximately 66 per cent of the study, with the two remaining areas accounting for 17 per cent each. This permits a broad and detailed view of students' education every nine years, with an approximation of their evolution every three years. Three PISA surveys have taken place so far, in 2000, 2003 and 2006, focusing on reading, mathematics and science, respectively.

In the last wave, PISA assessment offers the first comprehensive internationally comparative knowledge base on what students know about the environment and environment-related problems, from where their knowledge was gained, what attitudes they hold about the environment issues, and how students' environmental science performance interrelates with their attitudes to the environment. The results of the study highlighted the importance that schools have in the transmission of environmental science knowledge given that around 50 per cent of secondary school students recognized that they have acquired environmental knowledge during their formal education.

The development of the PISA 2006 science framework was guided by reference to what science knowledge and skills citizens require. Consistent with this guiding principle, the international group of science experts that was appointed by OECD governments decided to include aspects of environmental science and geosciences in the assessment framework. In the program, the knowledge and the skills of around 400,000 students in 56 countries are analyzed. Science knowledge and skills in PISA 2006 are broadly defined in terms of competencies, contexts, knowledge and attitudes. The survey gives a rich profile of how students relate to various environmental issues, from air pollution to water shortages. While this framework did not identify environmental science as a subfield in itself, the content and contexts of some of the PISA tasks are drawn from environmental issues.

PISA 2006 defines environmental science as the "scientific knowledge and the use of that knowledge to identify questions, to acquire new knowledge, to explain biological and geoscience phenomena related to the environment, and to draw evidence-based conclusions about the environment". Despite PISA 2006 was not exclusively designed for assessing environmental sciences, out of the 108 questions including into that wave, 24 were focused on environmental issues, and, of these, 14 in geosciences[1]. All those questions linked to the environment are related to several topics, such as disposal materials, biodiversity, pollution control, costal erosion or climate change. In addition, it is possible to find questions related to both positive and negative context. Thus, some items ask about potential solutions to specific issues or the existence of some environmental hazards. The questions cover the majority of the competences included in the PISA 2006 science framework[2].

Using those questions[3], PISA built two average scores representing students´ performance in environmental sciences and geosciences[4]. The methodology to obtain those scores is based on the techniques of item response modelling (Rasch, 1980). It is a basic Item Response Theory one-parameter logistic model where item difficulties and student abilities are estimated simultaneously[5]. Both environmental sciences and geosciences performance indexes are on a scale with an international mean of 500 score points and a standard deviation of 100 score points.

The aim of this study is to describe and identify the main sources of environmental knowledge with an especial focus on the role of schools in the provision of environmental education in the Spanish context. For that purpose, environmental scores are regressed on two different sets of variables: (i) individual factors related to students' characteristics and their sources of information and (ii) variables representing activities developed by schools. The dataset contains information referred to 19,604 students belonging to 686 schools.

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[1] Geoscience is a subject within environmental science, which is focused on earth systems.

[2] The questions considered to build the indexes are covering two of the three competences included in PISA 2006: explaining phenomena scientifically and using scientific evidence.

[3] Despite 24 (for environmental index) even 14 (for geoscience index) are not two much questions, there are other studies have used similarly number of items. For see some limitations of the indexes in detail, see OECD (2009).

[4] There is an alternative way to summarizing student performance. In this respect, four proficiency levels (A, B, C and D) can be derived, in a similar way the proficiency levels for science in PISA 2006. Beginning with the lower level, students at level D have an item difficulty score less than -0.7, being able to interpret a graph or figure, but showing only basic knowledge about the environment. Students at level C, obtain a score between -0.7 and 0, and they are able to understand environmental cycles, energy sources and sources of pollution, identifying the causes of the problems in some situations. Students at level B show a score ranging between 0 and 1, and are able to answer environment questions from little information provided, knowing about some important issues like ecosystem balance, climate change, natural sources of energy, etc. Finally, the highest level of proficiency is the A level, with scores higher than one, and the students set at this level are able to understand and explain complex environmental problems and processes such as acid rain or species evolution.

[5] For more details, see OECD (2007).

The dependent variable used in the analysis is the performance in environmental sciences[6]. The explanatory variables at student and school levels are described in Table 1. Regarding the former, first of all, we have included a dummy variable representative of GENDER, since we are interested in knowing whether there are differences between male and female students. Likewise, we also incorporate the variables INMIGRANT and RETENTION in order to test potential divergences in performance for students born in a different country or for those that have retaken at least one course. In addition, we include a representative variable of students' socioeconomic background, which is considered as the main factor to explain achievement in multiple studies (e.g. Coleman *et al.*, 1966; Hanushek, 1997 and 2003). This is an indicator of economic, social and cultural status (ESCS) of students created by PISA analysts from three variables related to family background from students´ questionnaire[7]. Finally, we consider variables specifically related to environmental issues such as the knowledge that students declare to have about the environment[8] (AWARENESS). Finally, we construct five variables (SOURCES) that contain information about the main sources from which they have obtained the environmental information according to their responses about five different environmental issues[9].

With regard to the school-level variables, we have constructed the variables PRIVATE and GOVDEP in order to test whether the private or subsidized nature of the school may affect the students´ results. However, this information could be biased since those schools usually have students with a better socioeconomic background, so that we have also include the mean of the variable ESCS (MEANESCS) for each school, the so-called peer-group effect, in order to take this into account[10]. Regarding the specific variables about environmental issues, we have constructed

[6] We also considered the use of performance in geoscience, but we decided not to use it because there was a high correlation between variables.

[7] The first variable is the higher educational level of any of the student's parents according to the *International Standard Classification of Education* (ISCED). The second variable is the higher labour occupation of any of the student's parents according to the International Socio-economic Index of Occupational Status (ISEI, Ganzeboom *et al*., 1992). The third variable is an index of educational possessions related to household economy.

[8] The specific question is the following: "How informed are you about the following environmental issues?" Five different topics are considered as environmental issues: greenhouse, genetic modified, acid rain, nuclear waste and forest clearing. The possible answers have a scale between 1 = "I have never heard of this" and 4 ="I am familiar with this and I would be able to explain this well". To obtain a global index of knowledge, we aggregate the values corresponding to each environmental issue, thus the range of values for the variables is 5-20.

[9] Specifically this information comes from students´ responses to this question: "*From which source/s did you mainly learn about each of these environmental issues?*" Six different topics are considered: air pollution, energy shortages, the extinction of plants and animals, the cleaning of forest for other land use, water shortages and nuclear waste.

[10] For a review on the effect of this variable on results see Betts (2000).

eleven variables using information provided by principals´ responses to different questions: CVSPC represents the existence of a specific environmental course in the curriculum of the school, SCIATIV incorporate information about five different activities related with sciences and ENVACTIV about five activities linked to specific environmental learning.

Table 1. Definition of variables

Block	Variable	Definition
Student level	GENDER	Dummy variable which takes value 1 if the student is a female and 0 otherwise
	ESCS	Index of socio-economic background
	IMMIGRANT	Dummy variable which takes value 1 if the student was born in another country and 0 otherwise
	RETENTION	Dummy variable which takes value 1 if the student belongs to the 9th grade or lower (retention) and 0 if he/she is in 10th grade (no retention)
	AWARENESS	Knowledge that students declare to have about several environmental topics (ST22Q01-05).
	SOURCES OF INFORMATION	Source from which the students declare to learn about several environmental topics (ST23QA1-F6). Six different sources, with a scale ranging from 0 to 6: SOURCE_SCHOOL: my school SOURCE_MEDIA: the media SOURCE_FRIENDS: my friends SOURCE_FAMILY: my family SOURCE_INTBOOK: internet or books
School level	PRIVATE	Dummy variable which takes value 1 if the school has private management and 0 otherwise
	GOVDEP	Dummy variable which takes value 1 if the school is government dependent and 0 otherwise
	MEANESCS	Average value of ESCS variable in the school
	CVSPC	Dummy variable which takes value 1 if there is an environmental specific course and 0 otherwise (SC21Q01)
	SCACTIV_	Different activities that schools organize to educate in science topics (SC20Q01-05). Five dummy variables are defined, with value 1 if the activity is organized by the school: SCACTIV_CLUBS: science clubs SCACTIV_FAIRS: science fairs SCACTIV_COMP: science competitions SCACTIV_PROJ: science projects SCACTIV_TRIPS: science trips
	ENVACTIV_	Extracurricular activities that schools organize to instruct about environmental topics (SC22Q01-05). Five dummy variables are defined, with value 1 if the activity is organized by the school: ENVACTIV_OUT: outdoor education ENVACTIV_MUS: trips to museums ENVACTIV_TECH: trips to science and/or technology centers ENVACTIV_PROJ: extracurricular environmental projects ENVACTIV_LEC: lectures and/or seminars

Source: own elaboration

4. Results

In order to complete our analysis, we use a multilevel analysis since data provided by PISA 2006 are nested at two different levels, school and student. With this type of data, classic methods, such as OLS regression, would not produce correct standard errors (Bryk and Raudenbush, 1992; Snijders, 1999; Hox, 2002). Therefore, multilevel models need to be used as they take the issue of correlated errors into consideration and provides more realistic and conservative statistical testing.

Statistical methods that explicitly take into account hierarchically structured data have increased their popularity in recent years. As a result, many general purpose software packages such as SPSS, Stata and SAS has incorporated their own procedures for handling nested data. However, in this study we have employed HLM 6 (Raudenbausch *et al*., 2004), a statistical program designed specifically for estimating multilevel models.

We followed a consolidated tradition in the applied statistics literature about student-level/school-level data, using an "additive" approach in which we have a baseline specification and subsequently covariates are added step by step (Dronkers and Robert, 2008). More specifically, we estimated three different models:

a. The first model (baseline model) aims at decomposing the variance between the two levels: students (i = level 1) and schools (j = level 2), without adding any explanatory variable:

$$Y_{ij} = \beta_{0j} + r_{ij} \qquad (1)$$

$$\beta_{0j} = \gamma_{00} + u_{0j} \qquad (2)$$

where Y_{ij} represents the performance in environmental sciences of student *i* in school j, which is explained according to the deviation of the school *j* (u_j) from the average performance of schools (γ_0) and the deviation of the student *i* from the average results obtained by students belonging the same school *j*. In the first column of the Table 2, we can notice that this model is significant as a whole, meaning that the intercept is significantly different from 0, and therefore the hierarchical analysis is convenient. Likewise, the variance decomposition of this model (Table 3) allows us to identify that only 8,2 % of the total variance in the performance of students is explained by differences *between schools*. Although the results of this previous analysis must be interpreted cautiously because they only provide information about whether available data require the implementation of a multilevel analysis, they show an initial clue about the limited role of schools in explaining students´ environmental knowledge.

b. The second model includes a group of explanatory variables at student level. The inclusion of these level 1 variables transform the equation (1) in the following terms:

$$Y_{ij} = \beta_{0j} + \beta_{1j}X + r_{ij} \qquad (3)$$

Moreover, if we assume that the effect of the explanatory variable (X_{ij}) can be different among schools (changes in the slope of the regression coefficients), the equation (2) would also add a new component:

$$\alpha_{ij} = \gamma_0 + u_j$$
$$\beta_j = \gamma_1 + \pi_j \qquad (4)$$

In our case, we have included a set of dummy variables (gender or grade) for which coefficients must be interpreted as differences between means. In addition, we have other variables such as the socioeconomic status or variables related to environmental issues (awareness and sources of information). In those cases, the coefficients represent the slope. Table 2 reports the estimates for this model under the Model 2 column. These results indicate that female students present significant lower results as well as students born in another country. However, as it could be expected, the main negative factor that affects the environmental performance is to retake some course, since those students have an average score 55 points lower than the others. In contrast, the socioeconomic background (ESCS) has a positive and significant relationship with environmental scores. Likewise, students´ awareness about environmental issues can be considered as a significant factor to explain the results. Finally, among the variables representing the sources of information for students it is worth noting that school does not seem to have a significant impact on results, while students that use media as their main source of information obtain significant higher results.

c. Finally we estimate a model where school variables (Z_{lj}) are also included. Thus, not only variations in the intercept and slopes are possible but also interactions among level 1 and level 2 variables:

$$Y_{ij}= \beta_{0j} + \beta_{1j}X + r_{ij}$$
$$\beta_{0j} =\gamma_{00} + \gamma_{01}Z_{lj} + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11} Z_{lj} + u1$$

In our analysis, we have constructed two different models. In the first attempt (Model 3) we test if there are significant divergences in the performance between students in government-dependent or private schools and those attending to public schools, although we also include the variable MEANESCS in order to take into account the *peer-group* effect as we explained in the previous section. Afterwards, we estimate the complete model in which a further set of variables referred to schools' activities for promoting environmental knowledge and attitudes are incorporated (Model 4).

The first significant conclusion that can be drawn from the estimation of these models is that, after taking into account the average value of the variable ESCS, students from public schools outperform those from private and government-dependent schools, although differences with the former are not significant. Calero and Escardíbul (2007) obtained similar results using information from PISA 2003, although in that case students were assessed in math achievement. With regard to variables related to school activities for promoting environmental learning, the general conclusion is that they have a scarce influence on results, since most of the estimated parameters are low and non-significant. However, there are some activities that can be linked with higher levels of environmental performance such as science trips or lectures given by guest speakers.

5. Conclusion

In this study we have used information provided by PISA 2006 dataset in order to test the potential relationships between multiple student and school factors on the environmental performance of Spanish students through a multilevel analysis. The results obtained lead us to conclude that students with higher levels of awareness about environmental issues obtain better results in terms of performance. However, their main source of information is the media instead of schools. This result is linked to the fact that most of activities carried out by schools do not seem to have a significant impact of the environmental learning of students.

Theses disappointing results about the limited role of schools in providing environmental education lead us to consider the extension of the analysis to the international context in a future research, thus we can test whether the results obtained for the Spanish case can be considered as a general trend or derive from Spanish schools´ inadequate performance.

Table 2. Estimation of Fixed Coefficients in different multilevel models

Variable	Modelo 1		Model 2		Model 3		Model 4	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Intercept	508.09**	1.23	416.14**	3.81	421.97**	3.98	415.48**	6.09
Level-1 variables								
Gender			-12.65**	1.21	-12. 70**	1.21	-12.73**	1.21
ESCS			8.86**	0.68	7.56**	0.74	7.56**	0.74
Immigrant			-10.71**	2.49	-10.74**	2.48	-10.62**	2.48
Retention			-55.39**	1.41	-55.28**	1.41	-55.33**	1.40
Awareness			7.57**	0.23	7.56**	0.23	7.55**	0.23
Source_school			-0.44	0.36	-0.40	0.35	-0.43	0.36
Source_media			5.93**	0.31	5.96**	0.31	5.94**	0.31
Source_friends			-1.97*	0.82	-2.04*	0.82	-2.04*	0.82
Source_family			-0.97*	0.45	-0.97*	0.45	-0.97*	0.45
Source_intbook			-0.26	0.34	-0.26	0.33	-0.26	0.34
Level-2 variables								
Private					-5.05	3.59	-5.34	3.71
Gov-dependent					-9.91**	2.20	-10.06**	2.24
Mean ESCS					14.11**	2.04	14.03**	2.04
CV_specific							-0.91	2.38
Scactiv_clubs							-1.54	1.89
Scactiv_fairs							-0.23	1.83
Scactiv_comp							1.33	1.90
Scactiv_proj							1.73	2.18
Scactiv_trips							8.58*	4.22
Envactiv_out							-0.48	2.07
Envactiv_mus							1.16	3.03
Envactiv_tech							-3.46	2.72
Envactiv_proj							-0.85	2.18
Envactiv_lect							3.28*	1.62

**Significant at 99% level.
 * Significant at 95 % level.

Table 3: Variance decomposition in different multilevel models

	Model 1	Model 2	Model 3	Model 4
Students (r_{ij})	8312.83	6529.91	6529.71	6527.80
Schools (u_{oj})	740.53	285.53	280.34	251.66
Total (u_{0j} + r_{ij})	9053.36	6815,44	6810,05	6779,46
% Var. Schools	8.2			

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