SPECIAL ISSUE
Learning Assessments for Sustainability? Exploring the Interaction between Two Global Movements

education policy analysis archives

A peer-reviewed, independent,
open access, multilingual journal

epaa aape
Arizona State University

Volume 29 Number 125 September 27, 2021 ISSN 1068-2341

More is Not Always Better: A Study of Country-Level Factors Associated with Adolescents' Environmental Attitudes Using a Multilevel Analysis of PISA 2006

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Citation: Gong, B., & Zheng, Y. (2021). More is not always better: A study of country-level factors associated with adolescents' environmental attitudes using a multilevel analysis of PISA 2006. *Education Policy Analysis Archives, 29*(125). https://doi.org/10.14507/epaa.29.4846 This article is part of the special issue *Learning Assessments for Sustainability? Exploring the Interaction between Two Global Movements* guest edited by Oren Pizmony-Levy and Dafna Gan.

Abstract: In recent decades, environmental problems have rapidly worsened to become a planetary crisis, and mounting scientific evidence supports that this crisis is anthropogenic. With the growing concern over the anthropogenic ecological crisis, there has been more attention to the factors influencing people's pro-environmental attitudes. However, limited research on the adolescent population exists, and country-level factors were rarely explored with mixed findings. This study examines whether and how three country-level factors of national consumption, national average environmental knowledge, and national income level significantly impact students' environmental attitudes, using multilevel modeling methods. The analysis results show that adolescents'

Journal website: http://epaa.asu.edu/ojs/
Facebook: /EPAAA
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Manuscript received: 6/12/2019
Revisions received: 2/21/2021
Accepted: 6/6/2021

environmental attitudes are negatively related to the national consumption and environmental knowledge level after controlling for important individual-level factors while having no significant relationship with the national income level. This study concludes with a discussion on the future direction of environmental education and studies.
Keywords: PISA; ecological footprint; environmental attitude; environmental knowledge; multilevel modeling

Más no siempre es mejor: un estudio de los factores a nivel de país asociados con las actitudes ambientales de los adolescentes utilizando un análisis multinivel de PISA 2006
Resumen: Con la creciente preocupación por la actual crisis ecológica antropogénica, se ha prestado más atención a los factores que influyen en las actitudes proambientales de las personas. Sin embargo, existe una investigación limitada sobre la población adolescente, y los factores a nivel de país rara vez se exploraron con hallazgos mixtos. Este estudio examina si, y cómo, tres factores a nivel de país del consumo nacional, el conocimiento ambiental promedio nacional y el nivel de ingresos nacionales impactan significativamente en las actitudes ambientales de los estudiantes, utilizando métodos de modelado multinivel. Los resultados muestran que las actitudes ambientales de los adolescentes se relacionan negativamente con el consumo nacional y el nivel de conocimiento ambiental después de controlar por factores importantes a nivel individual, sin tener una relación significativa con el nivel de ingreso nacional. Se presenta una discusión de los hallazgos en relación con la dirección futura de la educación y los estudios ambientales.
Palabras clave: PISA; huella ecológica; actitud ambiental; conocimiento ambiental; modelado multinivel

Mais nem sempre é melhor: um estudo de fatores em nível de país associados às atitudes ambientais dos adolescentes usando uma análise multinível do PISA 2006
Resumo: Com a crescente preocupação com a atual crise ecológica antropogênica, tem havido mais atenção aos fatores que influenciam as atitudes pró-ambientais das pessoas. No entanto, existe uma pesquisa limitada sobre a população adolescente, e os fatores em nível de país raramente foram explorados com resultados mistos. Este estudo examina se e como três fatores em nível de país de consumo nacional, conhecimento ambiental médio nacional e nível de renda nacional impactam significativamente as atitudes ambientais dos alunos, usando métodos de modelagem multinível. Os resultados mostram que as atitudes ambientais dos adolescentes estão negativamente relacionadas ao consumo nacional e ao nível de conhecimento ambiental após o controle de importantes fatores de nível individual, embora não tenham relação significativa com o nível de renda nacional. É apresentada uma discussão das conclusões em relação aos rumos futuros da educação e dos estudos ambientais.
Palavras-chave: PISA; pegada ecológica; atitude ambiental; conhecimento ambiental; modelagem multinível

More is Not Always Better: A Study of Country-Level Factors Associated with Adolescents' Environmental Attitudes Using a Multilevel Analysis of PISA 2006

Climate change is real. The failure to immediately react to such a dire emergency will be costly (IPCC, 2018; Kharin et al., 2018). Thus, many scientists warn us that any conventional measures to alleviate climate change are far short of stopping the vicious cycle and even considered inaction. Given this urgency, international society gathered together and built a global consensus to mitigate carbon emissions aggressively. According to the United Nations Framework Convention on Climate Change (UNFCCC), attempting to achieve this target entails the leadership of significant emitters and polluters, most of which are the advanced countries (Baer et al., 2010). Unfortunately, most of the major emitters have not submitted their reduction targets yet. Even worse, the US decided to opt-out, making the future outlook of achieving the global target rather dim (Rajamani & Brunnee, 2017).

The reluctance of the major countries to commit to carbon reduction indicates a need for educational intervention to raise the general public's pro-environmental attitudes. The United Nations (UN) has continuously emphasized environmental education. In 1975, the United Nations Educational, Scientific and Cultural Organization (UNESCO) convened its member countries and announced the Belgrade Charter, setting the global framework for environmental education—although it was not about climate change but broader environmental issues (Kopnina, 2011). It explicitly claimed that the goal of environmental education is "To develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations, and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones" (UNESCO, 1976, p. 3). It also specified six objectives under the goal: awareness, knowledge, attitude, skills, evaluation ability, and participation. The more recent Paris Agreement emphasized the importance of environmental education as a way to enlighten citizens and influence their politics to enact global climate consensus (United Nations, 2015).

Environmental education seeks to internalize pro-environmental values, attitudes, and sense of responsibility, assuming that values determine action (Gifford & Sussman, 2012; Tilbury, 1995). Accordingly, environmental education studies were interested in finding educational and pedagogical methods to promote students' attitudinal changes (Bonnett & Williams, 1998; Eagles & Demare, 1999; Pooley & O'Connor, 2000). Similarly, broader environmental studies have attempted to find influential factors of environmental attitudes. The early studies focused on cross-national analysis to identify the country-level factors explaining environmental attitudes conducting correlation studies (see Deikmann & Franzen, 1999; Dunlap & Mertig, 1995; Franzen, 2003; Inglehart, 1995), and more recently multilevel analysis (Franzen & Meyer, 2010; Givens & Jorgenson, 2011; Marquart-Pyatt, 2012). Despite the constant interest in this topic, the studies produced mixed results showing variant relationships of national affluence and environmental degradation with environmental attitudes. Additionally, other factors are worth exploring the relationship with pro-environmental attitudes such as national consumption and environmental knowledge.

To fill this research gap, this study concentrates on three country-level factors: consumption, affluence, and environmental knowledge. Using multilevel modeling methods, this study examines whether these three country-level factors significantly impact students' environmental attitudes. The overarching research question is: To what extent can students' environmental attitudes be explained by the country-level characteristics such as consumption, affluence, and environmental knowledge after controlling for the individual-level factors?

Theory

As stated above, there is a well-established line of inquires exploring various explanatory variables that can relate to environmental attitudes. The existing literature has most extensively adopted three national wealth variables, environmental degradation, and environmental knowledge to explain the pro-environmental attitudes among many explanatory variables. Hence, in this study, we review the literature highlighting these variables and suggest our modified analysis model.

The previous studies focused on contextual factors of national wealth, represented by GDP per capita. Initially, the Postmaterialist theory proposed by Inglehart ignited a debate over the influence of wealth on pro-environmental attitudes (Inglehart, 1977, 1990). The Postmaterialist theory first appeared to explain the environmentalists' movement newly emerging as a social agenda in the Western countries. This theory assumed that only the affluent people or societies could have room to care about environmental problems. Conversely, this means that the developing countries struggling for day-to-day survival cannot place environmental protection among the top social priorities. Inglehart posited that the countries with Postmaterialist value are more willing to sacrifice their financial gains for taking environmental responsibility (Inglehart, 1995). Some studies supported this Postmateralist thesis, providing evidence of a positive correlation between national affluence and environmental concern through cross-national comparisons using international surveys and GDP per capita data (Diekmann & Franzen, 1999; Franzen, 2003; Franzen & Meyer, 2010; Franzen & Vogl, 2013; Gelisson, 2007; Kemmelmeier et al., 2002). However, the debate is still going on, as other studies have produced counter-evidence. Other researchers found that the national income level is not necessarily associated with the pro-environmental attitudes, and unlike the argument of Postmaterialist, the developing countries also have a higher environmental concern (Dunlap & Mertig, 1995; 1997; Dunlap & York, 2008; Givens & Jorgenson, 2011).

Along with national wealth, environmental degradation is another country-level variable adopted most extensively to explain environmental attitudes. The most representative theory that stresses the importance of environmental conditions is the "objective problems and subjective values" (OPSV) hypothesis (Brechin, 1999). The OPSV hypothesis is a revised thesis that Inglehart suggested in response to the counter-argument against the Postmaterialist thesis, attempting to explain the pro-environmental attitudes in the developing countries. The OPSV means that the high environmental concern observed in the developing countries does not reflect the change in their social value but instead reflect their objective deteriorating environmental condition (Brechin, 1999; Inglehart, 1995). Although Inglehart still stuck to the thesis that the primary driver of pro-environmental attitudes in the Western countries is mostly explained by the Postmaterialist value, not an environmental condition, the debate on the OPSV thesis made environmental degradation indicators widely adopted for the analysis. The studies have shown inconclusive results concerning the impact of environmental degradation on environmental attitudes. In particular, some studies using multilevel modeling found that the ecological footprint showed negative coefficients in predicting the environmental attitude measures, while CO2 emission indicator showed a positive coefficient (see Givens & Jorgenson, 2011; Haller & Hadler, 2008; Marquart-Pyatt, 2012). The mixed findings indicate that the best representation of environmental degradation is still debated.

Some previous studies attempted to explain the level of pro-environmental attitudes using measures of the knowledge or awareness of environmental problems. One example is the linear progression model, which assumes scientific knowledge as a foundation for pro-environmental attitudes and behavior. It is sometimes called a "knowledge-based argument" (Marquart-Pyatt, 2008, p. 1316), "informed citizenry model" (Dunlap, 1998, p. 490), or "knowledge-deficit model" (Kellstedt et al., 2008). Such models are commonly grounded in the belief that the scientific

knowledge and awareness of the environmental problems naturally trigger pro-environmental attitudes, behavior, and ultimately substantive reduction of waste and emission. Many studies contributed to mainstreaming this idea (see Bord et al., 2016; Franzen & Meyer, 2010; Gelissen, 2016; Haller & Hadler, 2008). However, the debate on the relationship between environmental knowledge and attitudes is still ongoing, with counter-arguments against the significance of environmental knowledge (Dunlap, 1998; Durrenberger et al., 1993; Kellstedt et al., 2008; Kollmuss & Agyeman, 2010; Komatsu et al., 2019). Therefore, it will be meaningful to test the knowledge-deficit model with the PISA data, including a wide spectrum of environmental knowledge.

Limitation of the Previous Research

There are limitations of the previous research published during the prolonged debate on the factors explaining pro-environmental attitudes. Most importantly, the previous research underestimated or did not correctly count in the psychological, structural, and cultural barriers to the advanced countries' pro-environmental attitudes. Primarily, there is mounting evidence that the current climate crisis is significantly associated with the consumerism of the advanced countries that can be measured by the per capita consumption level (Jorgenson, 2003; Toth & Szigeti, 2015). The advanced countries externalize environmental costs to the developing countries through off-shoring of pollution-heavy industries to maintain its high consumption level (Jorgenson & Clark, 2009; Marques et al., 2012; Rice, 2007; Rosales, 2008; Shue, 2014). Toth and Szigeti (2015) found that the last two decades' overshoot of the ecological footprint is mainly due to "the luxury consumption of the developed nations" (p.288). The real environmental impact of large consumption and consumption-based lifestyle embedded in the advanced countries can relate to their environmental attitudes and values. There are already studies insisting that the belief in capitalism grows along with the affluent and luxury lifestyle in the advanced countries, forming a psychological barrier to pro-environmental attitudes and actions (Gifford, 2011; Heath & Gifford, 2016). We have seen such psychological barriers in real cases. As Dunlap and York (2008) criticized, the advanced countries repeatedly sabotaged the global consensus-building process for sustainable development and carbon reduction.

Third, most previous studies are enlightenment models, commonly believing that the general public should be like scientists, gathering evidence to make a rational judgment. The Organization for Economic Cooperation and Development's (OECD) Programme for International Student Assessment (PISA) test on environment science literacy is contingent on this enlightenment model. The OECD PISA assumes that more cognitive knowledge is a foundation for better pro-environmental attitudes saying "Equally important are informed and motivated citizens that understand and can interpret sophisticated scientific theory and evidence and act upon this knowledge" (OECD, 2009b, p. 16). However, scholars already pointed out the limitation of this approach (Bell, 2005; Dunlap, 1998; Komatsu et al., 2019; Roczen et al., 2013). Komatsu et al. (2019) recently insisted that raising risk perception using science education is not enough to alleviate the climate crisis because the current natural science system is not designed to reconfigure the social relationship and cultural practice that is crucial to solving the environmental problems. Again, as Dunlap (1998) said, sophisticated knowledge related to environmental problems may be redundant and even possibly distract people from making their routine behavior decisions. As Roczen et al. (2013) revealed, many different types of knowledge exist, and not all types of knowledge are directly and meaningfully related to students' pro-environmental attitudes and behavior.

Lastly, most existing studies target adults' environmental attitudes and related factors, while only a few studies focused on adolescents (Boeve-de Pauw & Van Petegem, 2010; List et al., 2020).

There is no guarantee that the country-level predictors show the same impact on adolescents' pro-environmental attitudes because the worldview and attitudes are still under formation during the adolescent period. Adolescents may not be mature enough to consider broadly around their surrounding conditions as much as adults. Hence, we need to retest the adults' model in the adolescents' case.

Hypotheses

Based on the above critical analysis, we hypothesize that countries with more consumption, environmental knowledge, and national wealth may not be positively associated with a higher pro-environmental attitude level, as measured by the feeling of environmental responsibility. A higher level of consumption, environmental knowledge, and national wealth of a country may be associated with a lower pro-environmental attitude level. In contrast to the previous studies, we hypothesize that the advanced countries with more consumption, knowledge, and wealth can feel less responsible for environmental protection and less willing to sacrifice because of the structural, cultural, and psychological barriers to pro-environmental transition.

First, we hypothesize that the national consumption level would be negatively associated with pro-environmental attitudes. The advanced country people may feel less responsible for environmental protection because the real degradation is not visible to these people due to environmental harm's externalization. Suppose the students in the advanced countries were not properly educated about the real size of national ecological debt and the unequal exchange of produced goods globally. In that case, they may feel a lower necessity to enact pro-environmental policies that can limit their consumption level. This is the gap we focus on in this study but barely recognized by the previous studies. Second, we hypothesize that the environmental knowledge measured by PISA would be negatively associated with the students' pro-environmental attitudes. PISA narrowly defined environmental knowledge as scientific knowledge and skills. However, such a sophisticated scientific knowledge may not accompany any genuine understanding of the human-nature relation necessary for pro-environmental attitudes and behavior according to the studies (Bell, 2005; Komatsu et al., 2019). Our third hypothesis is that the national wealth level would be not positively associated with pro-environmental attitudes. As mentioned before, the debate on the relationship between national wealth and people's pro-environmental attitudes is still going on with mixed evidence. Thus, we are interested in exploring what the PISA data suggest regarding this relationship.

In summary, we posit the following research hypotheses with respect to the association between the country-level factors and individuals' pro-environmental attitudes after controlling for the individual-level factors and the other country-level factors:

Hypothesis 1: Individuals in countries with higher national consumption levels exhibit lower levels of the feeling of environmental responsibility.

Hypothesis 2: Individuals in countries with higher average environmental knowledge exhibit lower levels of the feeling of environmental responsibility.

Hypothesis 3: Individuals in countries with higher national affluence exhibit lower levels of the feeling of environmental responsibility.

Methods

Data Source

For this study, we retrieved data from three different sources: PISA 2006, the Global Footprint Network (GFN), and the OECD database. We used PISA 2006 as a data source for the students' individual-level indicators that are potentially related to pro-environmental attitudes. PISA is a large-scale international standardized test targeting 15-year-old students from the member and non-member countries of OECD. PISA 2006 sampled about 400,000 students representing 20 million 15-years-olds in schools of 57 countries (OECD, 2009a). PISA has tested reading, mathematics, and science since its inception, and it added special topics in every wave. In 2006, PISA paid particular attention to the environmental topic and added environment-related items to the science test and the student survey to measure students' environmental knowledge and attitudes (OECD, 2009b). To represent country-level consumption and environmental degradation, we used ecological footprint per capita obtained from the GFN. The GFN provides information on the annual national ecological footprints and biocapacity of 189 countries and 26 regions. As an indicator of the national wealth, we retrieved GDP per capita data from the OECD database. We used single-year data of the year 2006 and this includes 265 countries.

The initial PISA data included 398,750 students nested within 14,365 schools and 57 countries. When we merged the PISA data with the GFN and OECD data, seven countries were dropped because they are not listed in either the GFN or the OECD data, and the number of students reduced to 367,149. We further addressed the remaining occasional missing data with listwise deletion, resulting in the final set of data of 347,298 students within 13,317 schools in 49 countries. The average number of students per country is 7,089. The country with the largest student sample is Mexico (29,961 students), while the country with the smallest number was Argentina (4,067 students). However, such a difference did not affect to the analysis as we applied student weight to properly represent the population.

Dependent Variable

Our dependent variable representing environmental attitudes is students' feeling of environmental responsibility, measured by a group of items from the PISA 2006 student survey. The reason why we chose PISA 2006 among any other wave of the tests is that PISA 2006 provided the most extensive measures related to the students' environmental attitudes compared with any other PISA test so far. For instance, an entire section in the PISA 2006 student survey (Section 4) was dedicated to the environmental topic and measured five constructs: environmental awareness, source of information, environmental concern, future outlook, and feeling of responsibility, with 30 items (Q22-Q26). In comparison, the PISA 2015 student survey included only two separate constructs (ST092-ST093) asking students about their level of environmental awareness and concern.

In this study, we chose to focus on the feeling of environmental responsibility scale in PISA 2006 amongst five choices available in the dataset. We deemed it the most valid indicator of pro-environmental attitudes because it explicitly asked students about their willingness to act upon specific regulative protective actions at the expense of the consumption-driven lifestyle (Table 1). Above all, Questions 'c' and 'g' in Table 1 asked whether the students recognize the possible opportunity cost of accepting pro-environmental enactment and are ready to sacrifice their consumption level. Also, Question 'b' intended to measure any sentiment against consumerism. These aspects seem different from the other environmental attitude measures used in the previous studies, which asked about environmental concern or anxiety. This measure is formed by the average

score of Q26(a) – Q26(g) on the PISA 2006 student survey, which is on a Likert scale of 1 (strongly agree) through 4 (strongly disagree). In our analysis, we reverse-coded these scores so that a higher score indicates a better pro-environmental attitude.

Table 1

Survey Questions of the Feeling of Environmental Responsibility in PISA 2006

Q26. How much do you agree with the statements below?
a) It is important to carry out regular checks on the emissions from cars as a condition of their use. b) It disturbs me when energy is wasted through the unnecessary use of electrical appliances. c) I am in favour of having laws that regulate factory emissions even if this would increase the price of products. d) To reduce waste, the use of plastic packaging should be kept to a minimum. e) Industries should be required to prove that they safely dispose of dangerous waste materials. f) I am in favour of having laws that protect the habitats of endangered species. g) Electricity should be produced from renewable sources as much as possible, even if this increases the cost.

Individual-Level Independent Variables

We included six individual-level independent variables, which reflect each student's gender, family socioeconomic status, and science knowledge level. Although these variables are not of particular interest in our study, we included them in the models as the controlled covariates. These variables are proven by previous studies to influence our dependent variable, the level of pro-environmental attitudes. We obtained variables from the PISA 2006 student survey and cognitive test. The first one is gender (GENDER, 0=girl, 1=boy). Gender has been adopted as an independent variable in previous multilevel modeling studies of environmental problems, revealing that girls or females show a higher level of pro-environmental attitudes (Boeve-de Pauw & Van Petegem, 2010; Givens & Jorgenson, 2011). Socioeconomic status of individuals such as education and income level has been widely adopted in the previous studies (e.g., Boeve-de Pauw & Van Petegem, 2010; Marquart-Pyatt, 2012). To represent the socioeconomic status of the students' families, we used four variables. We selected educational resources at home to indicate the family's wealth and cultural resource closely related to the students' education (HEDRES). This is the composite index combining questions such as possession of study room, computer, dictionary, textbooks, and art pieces. We also used a variable representing parents' highest educational level by the years of schooling (PARED). As an indicator of the income level and economic status, we used the family wealth indicator (WEALTH). Additionally, we used a composite variable provided by PISA 2006 that reflects each student's family cultural capital, a composite score of a group of items in the student survey asking specific questions related to family activity and resources (CULTPOSS). Lastly, students' science knowledge has been explored extensively as a predictor of pro-environmental attitudes in previous studies (e.g., Boeve-de Pauw & Van Petegem, 2010; List et al., 2020). Thus, we adopted PV4SCIE, a composite science score in PISA 2006 that reflects the individual students' science test score, as a covariate that represents each student's science knowledge.

Country-Level Independent Variables

We included three country-level variables in this multilevel modeling. First, we adopted an ecological footprint per capita (EF) as an indicator of the national consumption level, reflecting the level of consumerism as a cultural norm of the given society. The ecological footprint data were retrieved from the database of the GFN. Simply put, the ecological footprint means "The demand that populations and activities place on the biosphere in a given year" (Ewing et al., 2010, p.1). The ecological footprint is a consumption-based measurement—it takes into account direct carbon emission through production activities on their land and indirect carbon emission by counting the countries' net import. For this study, we averaged the ecological footprint scores from 2001 to 2006 for each country to reflect the country's recent five years of ecological footprint levels. Second, we adopted GDP per capita to measure national wealth. This indicator has been widely used in previous studies to represent national wealth (e.g., Diekmann & Franzen, 1999; Franzen, 2003; Franzen & Meyer, 2010; Franzen & Vogl, 2013; Gelisson, 2007; Kemmelmeier et al., 2002). We averaged the most recent five years of GDP per capita for each country. Lastly, we used the PISA 2006 environmental science test's national average scores to indicate a country's students' overall environmental knowledge. PISA 2006 provides the most sophisticated environmental knowledge indicator, measured by the environmental science performance index (ESPI). The ESPI is derived from the PISA 2006 science test, by integrating students' competence related to environmental knowledge and logical problem-solving based on scientific evidence. Unfortunately, the student-level data of ESPI are not publicly available. So, we decided to use the country-level aggregated mean scores to see each nation's performance level of environmental education. Table 2 shows the descriptive statistics of all variables included in our analysis. Also, this table provides Cronbach Alpha score presenting reliability of the composite scores for the variables of environmental responsibility, home educational resource, wealth, and cultural possessions. We calculated this Alpha score with our data set and they show acceptable score range.

Table 2

Descriptive Statistics of the Variables Included in This Study

Variable	*M*	SD	Min	Max	*n*	Alpha
Dependent variable						
Environmental responsibility	3.21	.48	1.00	4.00	347,298	.76
Individual-level independent variables						
Boy	.49	.50	.00	1.00	347,298	-
Science knowledge	477.57	104.13	21.39	883.18	347,298	-
Home educational resource	-.22	1.10	-4.84	1.65	347,298	.61
Parents' education in year	12.71	3.46	3.00	18.00	347,298	-
Wealth	-0.48	1.19	-5.00	3.32	347,298	.77
Cultural possessions	-0.03	0.97	-1.93	1.46	347,298	.58
Country-level independent variables						
Ecological footprint per capita	5.43	2.73	1.15	16.11	49	-
ESPI[1]	481.81	36.90	396.00	543.00	49	-
GDP per capita	25,568.33	19,364.83	543.11	89,739.71	49	-

[1] ESPI: Environmental science performance index

Analysis

We used multilevel modeling to analyze the data. This statistical method is designed to analyze data with a multilevel structure, such as individuals nested within schools, schools nested within countries (Gelman & Hill, 2019; Raudenbush & Bryk, 2012). The nested data structure violates the basic assumption of the ordinary least square regression that individual observations are independent of each other because, for instance, students in the same school are influenced by the common school characteristics (Finch et al., 2014). In such cases, the same school students tend to be more similar to each other than students in the other schools. For such multilevel data, the ordinary least square regression would misestimate the model coefficients' standard errors, while multilevel modeling offers a more valid estimation by allowing each group or cluster to have distinctively varying intercepts and regression coefficients. To analyze our multilevel data, we used the *nlme* package in the R program designed for multilevel modeling (Pinheiro et al., 2020).

In most applications, multilevel analysis uses grand mean standardization to interpret the outcome variables more convenient and make the computation smoother and faster (Hox et al., 2018). We applied this technique and standardized all explanatory variables using their grand means calculated for all individuals in the dataset. We assumed three-level models composed of the student, school, and country levels and included six student-level explanatory variables and three country-level variables. Following Hox et al. (2018), we used a three-step successive modeling approach to unveil results that can help us answer our research questions. First, we fit a null (i.e., no predictor) random intercept model to provide the baseline statistics of the nested data (Model 0). We allowed the intercept to vary across schools and countries. Second, we added the student-level independent variables. In addition to the random intercepts as in Model 0, we allowed each student-level independent variable slopes to vary across the countries (Model 1). We did not allow the slopes to vary at the school level because it would over-complicate the model estimation and lead to convergence issues, plus this study does not focus on the school-level differences. In our third model (Model 2), we added on top of Model 1 the country-level independent variables as fixed effect terms. Because the focus of this study is on the country-level factors, by comparing Model 2 against Model 1, we can characterize the effects of those country-level factors after controlling for the student-level factors. Our modeling formulas are given bellow, where i is the index of individual students, j is the index of schools, k is the index of countries, and e, U, V denote the random deviation terms at the first, second, and third level, respectively.

Model 0 (Baseline model)

Level 1 (Student level): $(\text{Environmental responsibility})_{ijk} = \beta_{0jk} + e_{ijk}$

Level 2 (School level): $\beta_{0jk} = \gamma_{00k} + U_{0jk}$

Level 3 (Country level): $\gamma_{00k} = \gamma_{000} + V_{00k}$

Model 1 (Random intercept model with student-level covariates)

Level 1 (Student level): $(\text{Environmental responsibility})_{ijk} = \beta_{0jk} + \beta_{1k}(\text{Gender})_{ijk} + \beta_{2k}(\text{Parents' education})_{ijk} + \beta_{3k}(\text{Family wealth})_{ijk} + \beta_{4k}(\text{Cultural possessions})_{ijk} + \beta_{5k}(\text{Home educational resource})_{ijk} + \beta_{6k}(\text{Science knowledge})_{ijk} + e_{ijk}$

Level 2 (School level): $\beta_{0jk} = \gamma_{00k} + U_{0jk}$

Level 3 (Country level): $\gamma_{00k} = \gamma_{000} + V_{00k}$

$\beta_{mk} = \gamma_{m0} + V_{mk}$, where the subscript $m = 1, 2, \ldots, 6$.

Model 2 (Random intercept and slope model with student- and country-level covariates)

Level 1 (Student level): $(\text{Environmental responsibility})_{ijk} = \beta_{0jk} + \beta_{1k}(\text{Gender})_{ijk} + \beta_{2k}(\text{Parents' education})_{ijk} + \beta_{3k}(\text{Family wealth})_{ijk} + \beta_{4k}(\text{Cultural possessions})_{ijk} + \beta_{5k}(\text{Home educational resource})_{ijk} + \beta_{6k}(\text{Science knowledge})_{ijk} + \beta_{7}(\text{Ecological footprint})_{k} + \beta_{8}(\text{GDP per capita})_{k} + \beta_{9}(\text{Country mean environmental knowledge})_{k} + e_{ijk}$

Level 2 (School level): $\beta_{0jk} = \gamma_{00k} + U_{0jk}$

Level 3 (Country level): $\gamma_{00k} = \gamma_{000} + V_{00k}$

$\beta_{mk} = \gamma_{m0} + V_{mk}$, where the subscript $m = 1, 2, \ldots, 6$.

We weighted the scores of each individual student using the weights provided by PISA 2006. Unlike single-level regression analysis where students' final weights are used, in multilevel modeling the weights require complicated readjustment calculation. We followed the weighting guideline specific to multilevel modeling described in the PISA technical manual (OECD, 2009a, p. 219), where we made the sum of the 49 countries' weights equal to the total number of students in the 49 countries, and ensured that each country represents the same amount of contribution to the models.

To gauge the effect of each country-level variable, we examine the statistical significance and practical significance of the fitted model coefficients in Model 2. In addition, we computed a global effect size using the R^2 values as recommended by Lorah (2018). First, we computed the R^2 values for Model 1 and Model 2 as compared against the null model (Model 0) following Snijders and Bosker (2012) to represent to proportional reduction in prediction error at the individual level:

$$R^2 = 1 - \frac{\sigma^2_{F,L1} + \sigma^2_{F,L2} + \sigma^2_{F,L3}}{\sigma^2_{N,L1} + \sigma^2_{N,L2} + \sigma^2_{N,L3}} \quad (1)$$

where the subscript F denotes the fitted model (Model 1 or Model 2), and N denotes the null model (Model 0); "*L1*", "*L2*", and "*L3*" denote the student, school, and country levels, respectively; and σ^2 denotes the random error variance at the specific level of the specific model. Then we computed the global effect size of all three country-level variables in Model 2 using f^2 as described in Aiken and West (1991):

$$f^2 = \frac{R_2^2 - R_1^2}{1 - R_2^2} \quad (2)$$

where R_1^2 is the R^2 value for Model 1 (without the country-level effects), and R_2^2 is the R^2 value for Model 2 (with the country-level effects).

Findings

Model 0

Our Model 0 is the intercept-only model, also called the null model or the empty model because in this initial step the model does not include any independent variable yet. This model shows the variance of the dependent variable as decomposed into the three levels (student, school, and country). The first row in Table 3 below reports the estimated mean intercept for each model. For Model 0, the estimated mean intercept is –0.03, and it is because the dependent variable was standardized. This null model allows us to calculate the intraclass correlations (ICC), the proportion of the total variance of the dependent variable that can be explained at each of the higher levels (i.e., school or country). In this analysis, student-level variance is 1.44, which takes almost 92% of the total variance of the students' feeling of environmental responsibility, while the school and the country level each takes about 4% of the total variance. This means that students' affiliation to a certain country explains about 4% of the students' feeling of environmental responsibility. Albeit the small ICC score less than 10%, we decided to use multilevel analysis methods considering the significance of the country-level variance entailing cultural, systematic, or even policy differences among countries. Also, we considered some arguments that the nested data structure needs to be counted even with the small ICC score (Arceneaux & Nickerson, 2009; Huang, 2016).

Model 1

Model 1 includes the student-level independent variables, that is, gender, science knowledge, home educational resource, parents' education, family wealth, and cultural possessions. Model 1 includes random intercepts and random slopes across countries for all student-level covariates. This means that we allow data in each country to form a unique functional relationship between the dependent variable and the student-level covariates. Given the cultural, systematic, and policy differences across the countries, it is reasonable to assume that those student-level covariates have a different effect on students' feeling of environmental responsibility in each country.

The analysis result indicates that girls tend to show more feeling of environmental responsibility with a statistically significant ($p < .001$) regression coefficient ($b = –.065$[1]). This means that when the other covariates are held constant, boys tend to feel less responsible for the environmental problems than girls, with a predicted difference of .065 standard deviation of the outcome score (note: all independent variables were standardized). Students with more science knowledge ($b = .277$), home education resource ($b = .081$), cultural possession ($b = .081$) also show more feeling of environmental responsibility at the statistically significant level ($p < .001$). In contrast, students with more family wealth present less feeling of environmental responsibility, having a regression coefficient of –.077 ($p < .001$). This finding corresponds with the study of Boeve-de Pauw and Van Petegem (2010) indicating that individual wealth negatively associates with pro-environmental attitudes while contradicting some other multilevel analysis studies such as Marquart-Pyatt (2012) and Franzen and Meyer (2010). Note that the variance inflation factors (VIFs) of all covariates in this model are close to 1, which indicates that this regression model is free of the multicollinearity problem, and hence each estimated coefficient value and their signs are fairly trustworthy for interpreting the true effects of the independent variables.

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[1] The math notation b denotes the estimated regression coefficient of an independent variable, corresponding to the β in the model specification. Following common rules in Statistics, Greek letters are used to denote unknown population parameters and matching English letters are used to denote the estimated value obtained using the sample data, or the sample statistics.

Model 2

Model 2 adds, on top of Model 1, the country-level independent variables of the ecological footprint per capita, country average environmental knowledge score from PISA 2006, and GDP per capita. This model is designed to estimate the effects of the country-level variables while controlling the student-level variables. The country-level variance decreased from 0.17 to 0.12, indicating that the three country-level variables account for about 30% of the country-level variation in the feeling of environmental responsibility. The R^2 against the null model is 0.035, which increases by 0.027 from Model 1. The f^2 effect size (Aiken & West, 1991) is 0.028, which means the three country-level variables explain 2.8% of the variance in students' feeling of environmental responsibility relative to the unexplained variance. Although this is considered a small effect by Cohen (1992), the inclusion of country-level variables in Model 2 provided a better fit to the data than Model 1. The country-level variable ecological footprint per capita has a negative and statistically significant coefficient of –.148 (p = .005). This result suggests that the national consumption and environmental degradation level is negatively associated with the feeling of environmental responsibility level after controlling for the individual-level covariates and the other two country-level variables. As we hypothesized, this result may indicate that students in the countries with higher consumption levels tend to show lower levels of feeling of environmental responsibility. The presence of the individual-level covariates and the other two country-level variables in the same model strengthens the potential for such an association to imply a causal inference by ruling out alternative explanations.

For the country average environmental knowledge score, the regression coefficient is –.096 and statistically significant (p = .007). It means that when all other covariates are held constant, every one-standard-deviation increase in the country average environmental knowledge score in PISA 2006 is associated with a *decrease* of .096 standard deviation of individual students' feeling of environmental responsibility. This result counters some previous studies that supported the knowledge deficit model, claiming that more knowledge on environmental problem positively associates with pro-environmental attitudes.

Lastly, the coefficient of GDP per capita shows no statistically significant association with the dependent variable (p = .59), countering the findings reported in the previous Postmaterialist' studies. The result indicates that the national income level may not be a meaningful predictor of students' pro-environmental attitudes after controlling for all the other student-level and country-level covariates in Model 2. This result aligns with the other previous studies that counter the Postmaterialist thesis. In general, the analysis result so far indicates that typical characteristics assigned to the advanced countries such as higher consumption resulting in more environmental harm, higher environmental knowledge, and higher personal income are not significant or even negatively significant for more feeling of environmental responsibility of the students.

Table 3
Multilevel Analysis Indicating Effects of Country-Level Factors on the Students' Feeling of Environmental Responsibility

	Model 0	Model 1	Model 2
Estimated regression coefficient (standard error)			
Intercept	–.030 (.360)	.002 (.964)	.006* (.912)
Individual-level variables			
Gender		–.065*** (.000)	–.073*** (.000)
Science knowledge		.277*** (.000)	.277*** (0.000)
Home educational resource		.081*** (.000)	.080*** (.000)
Parents' education in year		.008 (.158)	.007 (.232)
Family wealth		–.077*** (.000)	–.076*** (.000)
Cultural possessions		.081*** (.000)	.081*** (.000)
Country-level variables			
Ecological footprint per capita			–.148 *** (.005)
Environmental knowledge			–.096** (.007)
GDP per capita			.027 (.590)
Variances			
Individual: Level 1	1.438	1.340	1.348
School: Level 2	0.062	0.044	0.044
Country: Level 3	0.066	0.170	0.120
R^2 against Model 0		.008	.035
f^2 of the country-level covariates			.028

*p= .05, **p=.01, ***p=.001

Discussion

The findings of this multilevel analysis are rich and complex. We found a negative association between the countries' ecological footprints and the students' feeling of environmental responsibility. Regarding the relation between environmental knowledge and pro-environmental attitudes, we observed opposite directions of the association at the student and country levels. With GDP per capita representing national affluence levels, we did not observe a statistically significant association between national affluence and the students' feeling of environmental responsibility. We now discuss the implication of these results in more detail.

First, the results of this multilevel analysis indicate that students in the countries most responsible for the climate crisis, as indicated by larger ecological footprints per capita, ironically report lower levels of the feeling of responsibility. It means that, unlike the Postmaterialist thesis, countries with consumption-driven cultures tend to underestimate the urgency of the environmental crisis. One possible explanation of this finding is that the advanced countries' consumption levels do not correlate with their local environmental degradation as they trigger pollution in the developing countries that function as their supply base. Another possible explanation is that the countries with higher consumption levels may be reluctant to transition into low-consumption societies, abandoning their privileged lifestyle and carbon-heavy infrastructure. The US's decision to opt out from global climate treaties is an example of such reluctance and resistance to the transition. One of the presidential debate statements made by former U.S. President Trump reflects such an attitude clearly: "Look at China, how filthy it is. Look at Russia. Look at India. It's filthy. The air is filthy. I walked out of the Paris Accord as we had to take out trillions of dollars and we were treated very unfairly…We have the best environmental numbers, ozone numbers, and so many other numbers. In the meantime, China, Russia, India all these countries they're spewing stuff into the air" (Rev, 2020).

Second, our model included two variables on students' knowledge: one was a student-level PISA 2006 science test score, another was the country-level ESPI score. They showed opposite signs of the coefficients—a positive coefficient for the science test but a negative coefficient for the ESPI. The opposite coefficients may suggest a significant theoretical underpinning: for individuals within a country, more environmental knowledge leads to pro-environmental attitudes, but comparing countries with higher levels of average environmental knowledge show lower pro-environmental attitudes. Hence, our findings seem to vindicate that the enlightenment model of environmental education is partially met. On the one hand, the enlightenment model still works at the individual level within the same country or culture. On the other hand, the analysis results may imply that the ESPI, "the highest level outcome of environmental education" according to the OECD (p. 19), is not an educational outcome that is positively related to entail responsibility. Besides, previously, the OECD PISA also indirectly admitted that the ESPI score did not correlate with the feeling of environmental responsibility in some country cases (OECD, 2009b)—and this study is the first case to confirm it at the international level. Nevertheless, such a finding has never been appropriately highlighted. As a consequence, this mixed finding indicates that future research is required to clarify the relationship between scientific environmental knowledge and feeling of environmental responsibility with individual students' ESPI or other environmental science testing data.

Third, the non-significant impact of the national affluence level on pro-environmental attitudes seems to support the previous studies that countered the Postmaterialists thesis, such as Dunlap and Mertig (1995, 1997), Dunlap and York (2008), and Givens and Jorgenson (2011). This result suggests that adolescents in more affluent countries do not show better pro-environmental

attitudes than their peers in developing countries. There are two possible interpretations of this finding. First, adolescents may be different from the adults who acquire Postmaterialist value as their material condition improves. Students may acquire a different level of pro-environmental attitudes with maturity, education, and socialization later on in their life. Second, the adolescents' responses may reflect the general social sentiment. Hence, according to this study's findings, the discrepancy of pro-environmental attitudes across the developed and developing countries, which was previously assumed by the Postmaterialist thesis, may not exist anymore.

Of course, there are remaining challenges and limitations in this study. The students' survey on the feeling of environmental responsibility may be subject to construct-irrelevant variations due to different cultures across countries (Boeve-de Pauw & Van Petegem, 2010). This means that students in different countries might interpret the question items in different ways because of their distinctive socio-cultural context. This potential measurement error of the dependent variable may confound the findings from the statistical analysis. In addition, one challenge of this study was to obtain an individual-level environmental knowledge score in PISA. Now that the PISA did not make the individual students' ESPI score publicly available, we had to use individual students' science test score to substitute individual-level ESPI, and only use the aggregated country-level ESPI averages. Future studies may attempt to obtain individual-level ESPI scores to improve the accuracy of the models. Lastly, the feeling of environmental responsibility data are only available in the 2006 PISA students' survey, and it has been more than a decade since this survey was conducted last. As the climate crisis continues to accelerate and more directly affects our daily lives, adolescents' feeling of environmental responsibility may have changed over the past decade. Hence more recent data are in demand to reveal the most up-to-date status on this topic.

The results of this study have further educational implications. Primarily, the lesser feeling of responsibility in the countries with more ecological debts may indicate that the students are not educated to know how much their countries contribute to climate change through indirect consumption of carbon-heavy imported products. Thus, to initiate an alleviation of the global environmental impact of human societies, it is imperative to raise a better sense of environmental responsibility proportional to the amount of ecological footprint the countries produce (Rodrigues et al., 2006; Running, 2013). Komatsu et al. (2019) assumed and proved that countries where people do not recognize their responsibility for environmental harm, tend to have a large ecological footprint compared to other countries. This indicates that having a feeling of responsibility and showing a willingness to act upon a problem is related to pro-environmental behavior and real changes.

We may reconfigure the socio-cultural fabric through education to address the discrepancy between consumption and environmental responsibility. Meanwhile, there are some alternative ways to raise an environmentally responsible future generation. Ecological citizenship is an ethical consideration suggesting "a normative account of how citizens should conduct their lives, reducing their environmental impact" (Wolf et al., 2009, p. 503). The sense of global justice is the key to this concept. Dobson (2003) emphasized that the advanced countries' citizens need to take more environmental responsibility than the rest. He also argued that the liberal concept of individual rights in Western society needs to be replaced with a non-contractual moral responsibility in the face of an environmental crisis. Some studies found that a more egoistic, individualistic, and competitive worldview is negatively associated with the level of pro-environmental attitudes, while a more holistic view understanding the world as more densely interdependent to each other tends to be positively associated (Arnocky et al., 2007; Davis & Stroink, 2016; Komatsu et al., 2019).

Another idea is using the ecological footprint measure to provide corrective feedback to individuals on their ecological debt. Costanza (2000) stated that ecological footprint is an effective

measure to communicate to broad audiences the real ecological impact. Dobson (2003) and Middlemiss (2010) also saw an ecological footprint as an intuitive measure to raise a sense of individual and collective environmental responsibility. Inspired by this idea, Gottlieb, Vigoda-Gadot, Haim, and Kissinger (2011) implemented a project that educated students on the real impact their lifestyle has on the environment. Their results indicated that students became more self-reflective in their ecological impact and recognized the issues of environmental justice and global politics. These study outcomes suggest that the students who are more conscious of their ecological footprint per capita and recognize it not as their right to pursue but rather as ecological debt would be more environmentally responsible.

This study added to the research literature a sophisticated understanding of the relationship between students' feeling of environmental responsibility and country-level factors. The findings showed that the countries with more national affluence, ecological footprint, and environmental knowledge level do not necessarily raise their adolescents to be more environmentally responsible, despite their more capability and required responsibility to ameliorate environmental degradation. It implies that our environmental education policy requires new approach that can match the feeling of environmental responsibility with their national capability and ecological debt level. Future research may suggest new environmental education models and show how they contribute to raising environmentally responsible students.

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Volume 29 Number 125 September 27, 2021 ISSN 1068-2341