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DO SCHOOLS MAKE A DIFFERENCE IN THEIR STUDENTS' ENVIRONMENTAL ATTITUDES AND AWARENESS? EVIDENCE FROM PISA 2006

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ABSTRACT. The environmental agenda is gaining momentum as an international policy issue. This is reflected in an increase in environmental education research focussing on children's awareness and attitudes toward the environment. In this study, we focused on this issue from a school effectiveness perspective and evaluated (a) which student characteristics predict environmental attitudes and awareness, (b) whether schools make a difference in their students' environmental attitudes and awareness and (c) if school effects are different for students with varying levels of science ability. The cross-sectional Flemish data of the Organisation for Economic Co-operation and Development's Programme for International Student Assessment 2006 (4,999 students in 156 schools) were re-analysed using a multivariate multilevel model to address these issues. Results show that gender, immigrant status, socioeconomic status and educational track are important in explaining students' environmental attitudes and awareness. Furthermore, the results show that schools do matter; schools in which science is taught in a more hands-on manner are associated with higher student environmental awareness whilst environmental learning activities are associated with more pro-environmental attitudes amongst students. After controlling for student characteristics, these school effects do not differ between more science-literate children and their less or average science-literate peers.

KEY WORDS: constructivist teaching, environmental attitudes, environmental awareness, PISA, school effectiveness, scientific literacy

Over the past few decades, rising concerns about the state of the natural environment have led to intensified international scientific debate on environmental issues. The international community has recognised that natural resources are being consumed at a rate faster than they can be restored and that ecosystem preservation is closely related to human health—and even the preservation of the human species (Hassan, Scholles & Ash, 2005). Wilson (1993) pointed out that "in a single life time, humanity is mistreating the natural environment in such a way that we will impoverish our descendants for all time to come" (p. 37). Many believe that environmental problems are due to human behaviour (Maloney & Ward, 1973) and are, thus, anthropogenic of origin (Stern, 1992). Since environmental behaviour is seen as the basis of the environmental crisis, social scientists have long

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been interested in the causation of this behaviour. Researchers (Kaiser, Oerke & Bogner, 2007; Stern, Dietz & Guagnano, 1995) underline that it originates, at least in part, from attitudes—specific and general—toward the natural world. In the 2006 wave of the Organisation for Economic Co-operation and Development's (OECD) Programme for International Student Assessment (PISA), environmental attitudes were incorporated into the definition of scientific literacy, creating an unignorable research opportunity for educational researchers (Anderson, Lin, Treagust, Ross & Yore, 2007).

Background

Environmental Attitudes

A lot of effort in environmental attitudes research focuses on explaining variation in those attitudes; in other words, what causes one individual to display pro-environmental attitudes and another to do just the opposite? Classically, research considered a number of demographic factors to explain variation in environmental attitudes. The following generalisations characterise the literature on demographic correlates of environmentalism: women and girls, high income earning, well educated, city dwelling, politically liberal and autochthon (people born in the country in which at least one of their parents was born) individuals (e.g. Schultz, Oskamp & Mainieri, 1995) tend to display more pro-environmental attitudes than their counterparts do. These stereotypes should, however, not be accepted too quickly. Eagles & Demare (1999), for example, found no differences between boys and girls' environmental attitudes.

Apart from demographics, knowledge of the environment has been shown to affect environmental attitudes (Schahn & Holzer, 1990). Littledyke (2008) indicated that students' enjoyment of science is also relevant in explaining their environmental attitudes. Most environmental topics (e.g. photosynthesis, biodiversity etc.) and issues (e.g. biodiversity loss, habitat fragmentation etc.) have underlying scientific principles drawing from different science fields (e.g. chemistry or mathematics). The extent to which science abilities (i.e. knowledge and skills) contribute to environmental attitudes remains, to our knowledge, a research gap.

Expanding the Focus

As sketched above, the focus of research on environmental attitudes has had the individual as primary explanatory source of his/her own (non-) environmentalism. However, concerning both environmental and general attitudes, the social context should not be neglected (Stern et al., 1995).

People grow up in families, belong to cultural groups, have a group of friends etc. These "cultural settings in which we are born and come to maturity […] influence our behaviour" (Giddens, 1997, p. 41). Though this socialisation process is ongoing, some discrete transition phases, of which adolescence is one, can be discerned (Giddens). An important part of teenagers' social context is the school; students form social networks on the playground, experience friendships etc. Moreover, students' attitudes were found to differ between educational tracks (Klaczynski & Reese, 1990). Therefore, we can expect the school to be an important factor in shaping students' environmental attitudes, which up until now may not have received the attention it deserves.

This focus on the school can be framed within school effectiveness (SE) research. Most SE studies take the schools' input characteristics and context into account in assessing the influence of process factors at the school or classroom level on output measures. Examples of such process factors are educational leadership at the school level or structured teaching at the classroom level (see Scheerens, 1990, for more detail on an integrated SE model). Student achievements on the basic disciplines like mathematics and mother tongue are frequently used as output measures (Scheerens & Bosker, 1997). Davies (1997) emphasised, however, that the choice of output criteria does not play a neutral role and that an excessively narrow operational definition of school effectiveness indicates an overly restricted vision on the goals of education. Given this criticism, some scholars have stressed that SE research should focus on a multitude of output measures (Reynolds & Teddlie, 1999). This includes a plea for broadening the research from solely achievement measures toward attitudes as goals of the socialising function of the school (De Maeyer & Rymenans, 2004). In this study, we focus on environmental attitudes.

School Characteristics

Littledyke (2008) emphasised that active learning through constructivist pedagogy can enhance environmental attitudes. Lester, Ma, Lee & Lambert (2006) specified that teaching science in a personally meaningful way and providing students with authentic learning experiences increases awareness of environmental issues.

Widening our view to science awareness and attitudes indicated that constructivist instructional methods had a positive impact on the understanding of scientific concepts and attitudes towards science (Gibson & Van Strat, 2001; Liang & Gabel, 2005). Constructivist learning theory, which was first described by Von Glasersfeld (1989), sees learning not only as an addition of information to existing knowledge but also as a reconstruction of what is already known. Learners are not a blank slate, and knowledge cannot be imparted without their making sense of it through a lens of their current conceptions. According to constructivism, children learn best when they are allowed to construct personal understanding based on experiences and reflecting upon those experiences. A constructivist classroom is characterised by students working in groups and learning as being interactive and dynamic; there is an emphasis on social and communication skills and on the exchange of ideas. In a traditional, non-constructivist classroom, students work alone, learning is primarily achieved by repetition and textbooks guide subjects. According to Baviskar, Hartle & Whitney (2009), constructivist teaching is characterised by four essential criteria: (a) the teaching must elicit prior knowledge and (b) create cognitive dissonance, (c) application of knowledge and (d) reflection on learning. Examples of constructivist methods can be experiments, films followed by a discussion, field trips, classroom discussions etc. The main emphasis of constructivist learning/teaching research is cognitive outputs. DiEnno & Hilton (2005) suggested that, for environmental education, the constructivist philosophy applies for conceptions as well as for attitudes; they showed that a constructivist teaching approach rather than a traditional one positively influenced both environmental knowledge and attitudes. Wright (2008), however, showed that incorporating constructivist methods into the curriculum did not improve students' environmental knowledge or attitudes.

Apart from constructivist teaching, literature points to outdoor education as a school-level factor. The results of Palmer, Suggate, Bajd & Tsaliki (1998) suggest that (learning) experiences in outdoor informal contexts provokes significant life experiences and stimulates children to form pro-environmental attitudes. Though the field of significant life experience research has received critique for, amongst others, focussing on the children of the past rather than on the children of the present, by interviewing adults about their childhood (Cough, 1999), Brody (2005) confirmed that learning outside the classroom stimulates curiosity, improves motivation and attitudes and fosters participation and social interaction. Since informal education activities "commonly involve intellectual or physical tasks of a group[,] it allows learning to have a greater meaning" (Brody, p. 606).

Furthermore, research points toward the need to examine the differential effects of science abilities. Liang & Gabel (2005) found that lower science performers reacted differently to a new teaching method than their higher achieving colleagues. Therefore, it is worthwhile to examine whether the effect of schools on environmental attitudes is different for students with varying levels of science ability.

Research Questions

As research on school and teaching characteristics that stimulate environmental attitudes and awareness is rare, and much of it has been primarily qualitative or of an educational–philosophical nature; this study examined whether these findings can be replicated when taking a quantitative, school effectiveness perspective. Using the Flemish PISA 2006 data on environmental attitudes and awareness, we addressed the following research questions:

1. Which individual-level explanatory variables (gender, socioeconomic status, immigration status) explain variation in environmental attitudes and awareness of 15-year-olds?
2. Do schools matter? That is, do schools stimulate their students toward more pro-environmental attitudes and awareness? If so, are constructivist teaching methods and informal learning environments involved in this school effect?
3. Do schools have a differential effect for students with varying levels of science ability?

METHODS

We chose Flanders (Dutch-speaking region of Belgium) as a case for studying the socialising effect of schools on environmental attitudes and awareness. Flemish formal environmental education (EE)—just as health and citizenship education and social skills—is not organised via a specific course but integrated as much as possible into all subjects (Dutch language, physics, geography etc.). The PISA 2006 data confirmed this: 91% of all Flemish principals declare that environmental topics are a part of natural science subjects, and 85% and 65% of them say they are treated as part of geography or another subject, respectively. Due to this freedom in organising EE, Flemish schools vary in their approach to EE. This political variation provides an interesting case to evaluate which school characteristics are more beneficial in stimulating students' environmental attitudes.

Sample

For this paper, we re-analysed the Flemish PISA 2006 data. Education for Flemish 15-year-olds is provided in four educational tracks: general, technical, vocational and special education. In the first and second year of secondary education (12–14 years old), students gain environmental knowledge and skills through the natural sciences class in all educational tracks. From the third year on (14–16 years old), students from the general track have discipline-specific classes (biology, chemistry, physics and mathematics) whilst students from the technical, vocational and special tracks have an integrated science class in which all scientific topics are combined. From the fifth year on (16–18 years old), students from the general track can choose to specialise in sciences, in which case they will get a complementary ecology class.

Apart from these thematic classes, for which the government has developed specific final objectives (goals that students have to meet at the end of a school year) relative to the content of each class, the Flemish Government also instils cross-curricular final objectives for education regarding sustainable development. These cross-curricular final objectives differ from the specific ones in two ways: their emphasis is on attitudes rather than concepts and skills, and they focus on the interconnectedness of sustainability issues (see European Commission Education, Audiovisual, and Culture Executive Office, 2009, for a complete overview of the Flemish educational system). Since the PISA 2006 student data for the special education track formed only a small group (125 students in six schools) and had substantial levels of missing data, they were omitted from the analysis. The final sample consisted of 4,999 general, technical and vocational students enrolled in 156 Flemish schools. Due to the random selection of schools and the high level of coverage, the data are a representative sample of the Flemish population aged 15 years (OECD, 2007).

Variables

Three types of variables were included in our analysis: output measures, student-level variables and school-level variables. Unless mentioned otherwise, the variables described were used as constructed by PISA but standardised for the Flanders' context. All information on scale construction can be found in the PISA 2006 technical report (OECD, 2009).

Output Measures. After careful examination of the items, two output measures developed for PISA 2006 are the subject of our analysis. We selected the scale on responsibility for sustainable development as a measure for environmental attitudes (ENVATT; OECD, 2007). The scale was documented from students' self-report on seven items (e.g. "I am in favour of having laws that regulate factory emissions even if this would increase the price of products.") on a four-point Likert scale (1 = I have never heard of this, 2 = I have heard of it but would not be able to explain it, 3 = I have heard something about it, 4 = I am familiar with this; see Appendix 1 for all items and response categories; OECD, 2007). The reliability (Cronbach's alpha) of the ENVATT scale for Flanders was an acceptable 0.76.

The second output measure is awareness of environmental problems (ENVAW). This scale was documented from students' beliefs regarding their awareness of environmental topics. Students answered the question, "How informed are you about the following environmental issues?" (e.g. acid rain) on a four-point Likert scale (1 = strongly agree … 4 = strongly disagree). The ENVAW scale had an acceptable reliability ($\alpha = 0.78$).

Explanatory Variables at the Student Level. Three variables related to students' background were included in the analyses: gender, immigrant status and socioeconomic status. PISA discerned three groups on immigrant status: native (or autochthon) students born in the country of assessment or who had at least one parent born in that country ($N = 4{,}642$, 93.7%), second-generation students born in the country of assessment but whose parents were born in another country ($N = 161$, 3.3%) and first-generation students born outside the country of assessment and whose parents were also born in another country ($N = 149$, 3.0%; OECD, 2007). The groups of first- and second-generation immigrants in Flanders are quite diverse, but a large proportion has Moroccan and Turkish roots. The scale of economic, social and cultural status (ESCS) is composed of five subscales: students' home possessions, highest occupational status of parents, highest educational level of parents, cultural possessions at home and family wealth (OECD, 2007). The ESCS scale was standardised for Flemish students.

We also included three variables relating to the students' science education. First, science abilities were measured by a 30-min assessment on knowledge of physical, living and technology systems, earth and space, scientific enquiry and scientific explanations. The questions were distributed over items identifying scientific issues, explaining phenomena scientifically and using scientific evidence (OECD, 2007). PISA 2006 reported five plausible values for science abilities, which were highly correlated (all $r(4{,}997) > 0.93$, $p < 0.001$). We selected plausible value 1 as a measure for science ability and computed a z-score for this scale using only the Flemish students (SCIABIL). Second, we included students' enjoyment of science (JOYSCIE), measured by a four-point Likert scale (1 = strongly agree … 4 = strongly disagree; sample item: "I like reading about science in general"). JOYSCIE had a good reliability ($\alpha = 0.91$), and the scale was standardised for Flemish students. Third, educational track (general, technical or vocational) was included; dummies were created for technical and vocational education.

Explanatory Variables at the School Level. At the school level, constructivist science teaching methods and informal learning were included. PISA 2006 did not survey teachers about their science instruction. However, students were asked to what degree four constructivist science teaching methods (interaction, investigation, hands-on and application) occurred. "When learning school science topics at school, how often do the following activities occur?" was answered on a four-range scale (in all lessons, in most lessons, in some lessons and never or hardly ever; see Appendix 1 for a list of all items; OECD, 2007). The first variable on constructivist teaching methods was the scale interaction in science teaching and learning (SCINTACT), indicating the frequency with which different elements of interactive teaching occurred in their classroom. The SCINTACT scale had an acceptable reliability (α=0.75). The second and third constructivist teaching methods were occurrence of opportunities for scientific investigation (SCINVEST, α=0.76) and hands-on learning (SCHANDS, α=0.73). The fourth constructivist science teaching method focused on applying science to real-life contexts (SCAPPLY) and showed acceptable reliability as well (α=0.76).

The second research question required us to aggregate constructivist teaching methods at the school level. Due to the large respondent numbers at the lowest level, scale measurement error is reduced and reliability increased (Snijders & Bosker, 1999). Moreover, when concepts measured at the individual level are nearly identical to concepts aggregated at the higher level (e.g. quality of instruction), the reliability can be assumed to be greater (Griffith, 2002). Therefore, the mean on each of the four scales for constructivist teaching was calculated for each school and standardised at the Flemish school level. A positive score on, for example, hands-on learning indicates that, according to the students, science in their school is taught in a more hands-on way than in the average school.

In the PISA 2006 school questionnaire, school principals were asked whether activities such as trips to science and/or technology centres, extracurricular environmental projects (including research), outdoor education, trips to the museum or lectures and/or seminars (e.g. guest speakers) were organised. Using this information, PISA constructed a scale of school activities for learning of environmental topics (ENVLEARN), which we standardised for Flanders.

Multivariate Multilevel Regression Analysis

Due to the data's hierarchical structure (students nested within schools) and in order to estimate the effect of schools, a multilevel approach was required. Since the dependent variables (or output measures) ENVATT and ENVAW correlated significantly (0.60 and 0.28 on the school and student levels, respectively) and to attain more statistical power, we opted for a multivariate multilevel analysis (Thum, 1997) using MLwiN 2.02. Both dependent variables are modelled simultaneously, controlling for the effect of the other.

Therefore, the multivariate model contains three levels: dependent variables, student and school. The underlying assumption is that the output measures (the dependent variables, level 1) are nested within students (level 2), who in turn are nested within schools (level 3). Formula 1 shows how the multivariate model was constructed.

$$\begin{aligned} Y_{ijk} = & \left[(\beta_0 + v_{0k} + u_{0jk})X_{0jk}\right] + \left[(\beta_1 + v_{1k} + u_{1jk})X_{1jk}\right] \\ & + \beta_2 X_{2jk} + \beta_3 X_{3jk} + \alpha_1 W_{1k} X_{ojk} + \alpha_2 W_{2k} X_{1jk} \end{aligned} \tag{1}$$

Y_{ijk} stands for the score on one of the two dependent measures (a) of student j in school k. The model includes two intercept dummies (X_{0jk} and X_{1jk}), one for each dependent variable. When estimating the score for ENVAW for example, X_{0jk} has the value one whilst X_{1jk} is zero. Besides the intercepts, the model also includes student level variables (X_{2jk} and X_{3jk}). The estimates for these variables (β's) indicate the effect of a predictor on the output measure. Due to the multivariate model, the inclusion of one student-level variable will yield two estimates (one for each dependent variable). Our analysis will also add school-level predictors, denoted by $W_{1k}X_{0jk}$. Their estimates (α's) give the effect of the school-level predictor on one of the two dependent variables. Appendix 2 provides further detail on this multivariate multilevel model.

Before entry into the analysis, we tested the normality of all scale variables. The absolute values of the skewness and kurtosis for all scales were 1.5 or lower and, following Miles & Shelvin (2001) and DiStefano & Hess (2005), indicated no reason for concern. The multicollinearity between the predictor scale variables (SCIABIL, JOYSCIE, ESCS) and the five scales at the school level was tested with a linear regression on the ENVAW scale (using SPSS). All variance inflator factor diagnostics were 2.6 or lower. Since these results were well below the threshold of 10 suggested by Lomax (2007), the absence of multicollinearity assumption was met.

In the analysis, a five-step strategy was used. First, the zero (or null) model is estimated, indicating whether a multilevel approach is necessary. Second, outliers on the dependent variables are examined and excluded. Since the relation between science abilities and pro-environmental attitudes was identified as a research gap, our third model looks closer at this relation. Fourth, student-level explanatory variables are added. Fifth, the school-level explanatory variables are inserted in the final model.

We report the deviance of each model, indicating how well the model fits the data. Based on the maximum likelihood estimation method, the deviances can be used to test whether a more advanced model fits significantly better than a simpler model. The difference between deviances approximates a chi-square distribution with degrees of freedom as the difference in the number of parameters of both models (Hox, 2002). In our analyses, we work with a 95% confidence interval (CI), corresponding to 1.96 times the standard error. Regression coefficients have to be at least 1.96 times larger than their standard error to be considered significant (Hox).

Results

The results are presented for each model that was estimated (Table 1). We start with the zero model (including no explanatory variables), exclude outliers (model 1), then add science abilities (model 2), student-level explanatory variables (model 3) and finally school-level explanatory variables (model 4).

Zero (Null) Model

The estimated zero model shows that a multilevel analysis is the proper technique for exploring the data. Schools explain a significant proportion in students' variability in environmental awareness and attitudes (17% of the variation in ENVAW and 6.5% of the variation in ENVATT).

Model 1: Outliers

Visual inspection of the residuals revealed one school as a positive outlier to the intercept for ENVATT (more than 3 *SD* above the *M*). This was not due to outliers at the student level, and the school would remain an outlier throughout higher order models. Therefore, a dummy for this school was created, having its separate estimation for the ENVATT intercept and, thus, improving model 1 significantly (decrease in deviance, 16.23; $p<0.001$). The interpretation of the intercept and random terms for ENVATT changes: they represent the estimates for all schools except the outlier school (Rasbach, Steele, Browne & Goldstein, 2005). Since the school was no outlier for ENVAW, we did include it for the estimation of this output measure.

TABLE 1

Fixed and random coefficient estimates and standard errors

	Zero model		Model 1		Model 2		Model 3		Model 4	
	ENVAW	*ENVATT*	*ENVAW*	*ENVATT*	*ENVAW*	*ENVATT*	*ENVAW*	*ENVATT*	*ENVAW*	*ENVATT*
Fixed part										
Intercept	−0.022 (0.036)	−0.010 (0.025)	−0.022 (0.036)	−0.016 (0.024)	−0.041 (0.017)[a]	−0.034 (0.018)	0.124 (0.030)[a]	−0.064 (0.034)	0.129 (0.031)[a]	−0.067 (0.035)
Dummy outlier				0.931 (0.224)[a]		0.987 (0.209)[a]		0.943 (0.199)[a]		1.097 (0.211)[a]
Student level										
SCIABIL					0.596 (0.015)[a]	0.255 (0.019)[a]	0.441 (0.020)[a]	0.186 (0.023)[a]	0.444 (0.020)[a]	0.188 (0.023)[a]
JOYSCIE							0.191 (0.014)[a]	0.224 (0.016)[a]	0.190 (0.014)[a]	0.225 (0.016)[a]
Technical education[b]							−0.048 (0.035)	−0.076 (0.039)[a]	−0.054 (0.039)	−0.061 (0.043)
Vocational education[b]							−0.151 (0.050)[a]	0.126 (0.056)[a]	−0.153 (0.054)[a]	0.141 (0.060)[a]
Girl[c]							−0.239 (0.025)[a]	0.093 (0.029)[a]	−0.244 (0.025)[a]	0.089 (0.029)[a]
2nd gen. immigrant[d]							0.115 (0.074)	0.202 (0.081)[a]	0.109 (0.074)	0.206 (0.081)[a]
ESCS							0.087 (0.015)[a]	0.058 (0.018)[a]	0.088 (0.015)[a]	0.057 (0.018)[a]
School level										
SCINTACT									−0.021 (0.021)	−0.034 (0.023)
SCINVEST									−0.004 (0.024)	0.029 (0.025)
SCHANDS									0.059 (0.025)[a]	−0.007 (0.027)
SCAPPLY									−0.029 (0.025)	0.008 (0.026)
ENVLEARN									0.002 (0.017)	0.036 (0.018)[a]

TABLE 1

(continued)

	Zero model		*Model 1*		*Model 2*		*Model 3*		*Model 4*	
	ENVAW	*ENVATT*	*ENVAW*	*ENVATT*	*ENVAW*	*ENVATT*	*ENVAW*	*ENVATT*	*ENVAW*	*ENVATT*
Random part										
Student level										
Intercept variance	0.838 (0.017)[a]	0.935 (0.019)[a]	0.838 (0.022)[a]	0.939 (0.019)[a]	0.674 (0.014)[a]	0.864 (0.023)[a]	0.630 (0.013)[a]	0.864 (0.018)[a]	0.630 (0.013)[a]	0.864 (0.018)[a]
Intercept covariance	0.209 (0.013)[a]		0.209 (0.013)[a]		0.141 (0.011)[a]		0.111 (0.011)[a]		0.111 (0.011)[a]	
Covariance SCIABIL -intercept					−0.043 (0.007)[a]		−0.045 (0.007)[a]		−0.045 (0.007)[a]	
Variance SCIABIL						0.041 (0.017)[a]				
School level										
Intercept variance	0.171 (0.022)[a]	0.065 (0.011)[a]	0.171 (0.022)[a]	0.057 (0.010)[a]	0.025 (0.005)[a]	0.020 (0.006)[a]	0.018 (0.004)[a]	0.013 (0.005)[a]	0.016 (0.004)[a]	0.012 (0.005)[a]
Intercept covariance	0.080 (0.013)[a]		0.077 (0.012)[a]		0.009 (0.004)[a]		0.006 (0.003)[a]		0.006 (0.003)[a]	
Variance SCIABIL						0.012 (0.006)[a]				
Deviance	26,777.364		26,761.130[a]		25,385.050[a]		24,390.100[a]		24,376.400	

For the fixed part, effect sizes are shown with their standard error (between brackets)

[a]Significant values at the 5% level

[b]Reference category is general education

[c]Reference category is boy

[d]Reference category is natives + first generation immigrants

Model 2: Science Abilities

Do more science-able students show more pro-environmental attitudes? Model 2 shows a rather strong effect; students that score 1 standard deviation higher on SCIABIL attain on average almost 0.600 standard deviation higher on ENVAW (Table 1). For ENVATT, this is 0.255 standard deviation. This effect could be due to other variables at the student level, like ESCS or JOYSCIE. But before controlling for this (in model 3), we examined the random part of model 2 for both dependent variables to determine whether schools have a differential effect for students with varying levels of science ability.

Science Abilities—Environmental Awareness. The random part of this model revealed that the effect of SCIABIL on ENVAW does not vary between schools. In other words, the impact of schools on ENVAW is the same for less, average or more science-literate students. The variation within schools, however, is significantly different for varying levels of science ability (cov = −0.043, *SE* = 0.007; Table 1). Figure 1a illustrates this fanning pattern. The solid line represents the estimated regression of SCIABIL on ENVAW. It shows a positive trend, indicating that environmental awareness increases with an increase in SCIABIL. The soft lines under and above this regression line represent the 95% CI and illustrate the variance in students' scores: 95% of all students scored between these two lines. When students are more variable in their score of ENVAW, these lines are further apart. It can be seen that the CI lines are further apart at the start than at the end (indicating heteroscedacity in the data). The less and average science-literate students are more variable in their awareness of environmental issues than their more able peers. To put it differently, for average and less science-able students, science ability is a less accurate predictor of environmental awareness.

Science Abilities—Environmental Attitudes. Our results indicated that schools have an impact on the relation between SCIABIL and ENVATT (var = 0.012, *SE* = 0.006; Table 1). Figure 1b shows that schools are of little difference in stimulating pro-environmental attitudes in students with average science abilities. Where the *x*-axis is at zero (the average for standardised variables), the CI lines are quite close. However, for less and more science-literate students, the impact of schools on ENVATT varies more. Some schools manage to stimulate their low science-able students in such a way that they attain the average pro-environmental attitudes level (*y*-axis value=zero); in other schools, those students on average score 1.5

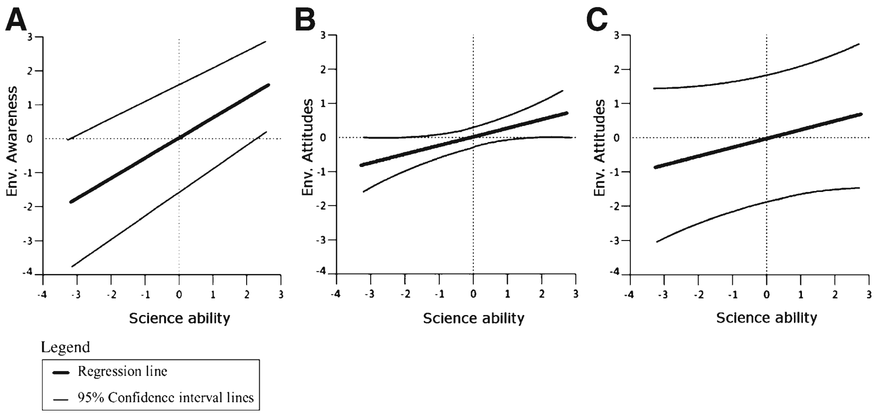

Figure 1. Significant variation between and within schools: **A** within-school variation in science ability on environmental awareness (95% CI); **B** between-school variation in science ability on environmental attitudes (95% CI); **C** within-school variation in science ability on environmental attitudes (95% CI)

standard deviation lower. The same diversity is noted for more science-able students. Figure 1c shows that within schools, students with an average score on the science abilities test vary less in the score on ENVATT than their less or more able science peers (var = 0.041, *SE* = 0.017).

Model 3: Student-Level Explanatory Variables

In model 3, student-level variables on background and science education were added. Looking at the fixed part, we note that the effect of SCIABIL, though decreased, remains quite large (0.441 and 0.186 *SD* for ENVAW and ENVATT, respectively, with an increase of 1 *SD* in SCIABIL). Students' enjoyment of science was also an important predictor for ENVAW and ENVATT (an increase of 0.191 and 0.224 *SD* for an augmentation of 1 *SD*, respectively, in JOYSCIE). Students in the vocational track tended to have lower awareness levels but more pro-environmental attitudes than their general track peers. Students in the technical track did not score differently on ENVAW, but their ENVATT score was significantly lower than their general track peers.

Regarding students' background characteristics, results indicated that, on average, girls scored lower on ENVAW than boys but higher on ENVATT. Native Flemish students do not differ from their first-generation immigrant peers (for parsimonious sake, the dummy for first generation was not retained in the model). Second-generation immigrants do not differ from their native and first-generation peers on awareness either but do show more pro-environmental attitudes. ESCS has a moderate but significant influence on both ENVAW and ENVATT (an increase of 1 *SD* in ESCS provokes an augmentation of 0.087 and 0.058 *SD*, respectively).

Model 2 revealed three effects in the random part: within-school variation for ENVAW and within- and between-school variation for ENVATT (Fig. 1). Examining the random part of model 3, we note that only the within-school covariance between ENVAW and SCIABIL remained significant (cov = −0.045, *SE* = 0.007). Within schools, more science-able students scored more alike with respect to awareness of environmental issues than their average or less science-able peers, even after controlling for student characteristics (Fig. 1a). The between-school variation for ENVATT has disappeared, mainly due to the inclusion of educational track into the analysis. Finally, the within-school variation for ENVATT falls out of the boundaries of significance as well, indicating that within schools the more science-literate children are as variable in their environmental attitudes as their average or low science-able peers.

Model 4: School-Level Explanatory Variables

Model 4 examined how schools can foster awareness and sustainable attitudes towards the environment. Results indicated that teaching using more interaction, investigation or application does not improve ENVAW or ENVATT. More hands-on teaching, however, tends to go together with slightly higher ENVAW (0.059 *SD* by 1 *SD* increase in SCHANDS). School environmental learning activities have a small positive effect on ENVATT (0.036 *SD* by 1 *SD* increase in ENVLEARN). Adding these school characteristics alters few coefficients at the student level. Only the effect of the technical track on ENVATT falls outside the boundaries of significance, implying that when taking into account constructivist teaching methods and schools' efforts on environmental learning students from the technical track do not differ from their general track peers.

Discussion

To examine whether schools influence students' environmental awareness and attitudes, the Flemish data of PISA 2006 were analysed from a school effectiveness point of view. Results indicate that both the level of the individual student and that of the school are important to explain variance in students' environmental attitudes and awareness.

The Individual Level

The first research question asked which individual-level variables explain variation in environmental attitudes and awareness of 15-year-olds. Our results revealed that, in Flanders, girls are more pro-environmentally orientated but less aware of environmental issues than boys. This could partly be because the ENVAW scale is largely cognitive in nature and girls commonly score lower on science-related cognitive tests (Spelke, 2005). An alternative explanation could be in the construction of the self-reported scale: perhaps girls tend to underestimate their level of knowledge.

We found a small but significant effect of ESCS on environmental attitudes. Although socioeconomic status is often described as one of the key explicators of differences in environmental attitudes, our results indicate that it influences environmental attitudes and awareness only to a limited extent. A possible explanation might lie in the fact that the ESCS variable, as constructed by PISA, catches diverse aspects of the students' background. It is possible that the subdomains of the ESCS variable have a differential effect on environmental attitudes and awareness in Flanders. Future research could consider partitioning the ESCS variable into three status variables (economic, social, cultural) and assessing the influence of each one separately.

Students from the technical track showed equal environmental awareness as their general track peers but slightly less pro-environmental attitudes. Students from the vocational track were less aware of environmental issues but held more positive environmental attitudes even after controlling for gender and ESCS. Vocational students scoring higher on environmental attitudes than their technical and general peers was an unexpected result; since in Flanders these students mainly come from families with limited socioeconomic opportunities, they would be expected to score lower. Their more pro-environmental attitudes might be explained in part by the fact that their vocational education exposes them to real-life environmental topics related directly to the profession they are learning in school. The pro-environmental attitudes of vocational students are an interesting finding for their teachers and schools. More and more, in Flanders, schools that provide vocational education are considering creating environmental vocational curricula, in which their students learn professions related to sustainable housing, living and building. Vocational students, who show high pro-environmental attitudes, as our results show for Flanders, are key to the success of such curricula.

Furthermore, our results at the individual level show that second-generation immigrants are significantly more pro-environmental than their native (i.e. Flemish) and first-generation immigrant peers. These are surprising findings, given that previous research suggested the opposite to be true (e.g. Hunter, 2000). Further research seems appropriate since these findings might be specific for the Flemish context.

Do Schools Matter?

For environmental attitudes, about 6.5% of the variation can be attributed to the school; for environmental awareness, schools explain 17% of the variation. Though Flemish 15-year-olds do not follow specific formal environmental programs, schools do influence students' environmental awareness and attitudes. One possible explanation is that certain schools attract more environmentally aware students with more pro-environmental attitudes. However, controlling for student characteristics diminished the school effect but did not eliminate it. An alternative reason is that other courses (e.g. natural science or geography courses) indirectly address environmental issues. This characterises the cross-curricular approach of EE in Flanders, in which schools are encouraged to include environmental topics in all classes.

As to precisely which elements in the schools' EE cross-curricular approach are of importance, our results are consistent with Brody's (2005) findings on informal learning. Students from schools emphasising environmental learning activities show more positive environmental attitudes, though the effect is rather small. Littledyke's (2008) claim that constructivist teaching enhances environmental awareness and attitudes was confirmed to a certain degree. We examined the school-level effect of four different constructivist teaching methods, one of which (hands-on teaching) influenced students' environmental awareness. Note that this effect, though significant, was small. Lester et al. (2006) conclusions were partially overturned by our findings: students' science literacy and environmental awareness and attitudes are positively associated, but emphasising personal meaning when teaching science did not increase awareness of environmental issues. Students in schools stressing the relevance of science to society and the world outside (the science application scale) did not denote more pro-environmental attitudes.

Looking at the four items underlying the scale for hands-on teaching, students frequently reported (a) having to conduct experiments following the instructions of the teacher, (b) having to draw conclusions from them, whilst reporting less often, (c) designing their own laboratory investigation and (d) doing practical experiments in the laboratory. A possible explanation for why drawing their own conclusions and conducting an experiment stimulates students' awareness can be found in research on constructivist learning (e.g. Gijbels, Van de Watering, Dochy & Van den Bossche, 2006). Compared to the investigation and application scale, the hands-on scale stresses the students' construction of knowledge and active participation, thus possibly measuring a stronger learning experience.

A question that arises from our results is why none of the constructivist teaching methods influenced students' pro-environmental attitudes, in line with Liang & Gabel (2005) and Wright (2008) but contrary to DiEnno & Hilton's (2005) results. One explanation could be that the effect of constructivist teaching on attitudes only manifests after a certain time. In our study, it is unclear how long students had been consistently taught using constructivist methods. For future research, we plead for a longitudinal approach to assess changes in environmental attitudes and awareness.

It is possible that the fact that we did not find substantial effects of constructivist teaching methods is due to how they were measured. The PISA survey did not include the view of science teachers regarding their use of constructivist teaching methods. Therefore, we constructed a scale using the students' opinion on how frequently a certain method is applied in their sciences classes. This is a proxy of the degree of constructivist teaching in the school, but what the PISA items on these methods do not include is to what extent the approach in which the applied methods are really constructivist. It is so that experiments, hands-on experiences, interaction and application of knowledge are methods that are common in constructivist classrooms, but this does not automatically mean that such methods are, when applied, constructivist. For example, experiments could be conducted without connecting prior knowledge to new knowledge and eliciting cognitive conflict. This focus on constructivist methods, without a control for the criteria that define constructivist teaching, is a limitation to the current study, intrinsic to the use of the PISA data. An experimental study could test such constructivist characteristics more directly, and such a study might reveal more substantial effects of constructivist teaching methods on environmental awareness and attitudes. Nevertheless, our results do suggest that a constructivist science teaching approach is associated with environmental awareness.

Some schools take on more EE activities than others do. This is important since environmental learning activities influence students' attitudes. Studying the items underlying the PISA scale ENVLEARN, we noted that 80% of Flemish schools organised outdoor education, 66% organised at least one trip to a science and/or technology centre and 69% declared that their students went on a trip to a museum. Extracurricular environmental projects and lectures and/or seminars were less frequent (52% and 25%, respectively). Thus, we can conclude that environmental learning activities were situated predominantly outside the actual classroom. Research on significant life experiences in the formation of environmental attitudes suggests that such learning initiatives can influence attitudes (Palmer et al., 1998). Our results support these findings and add that this can be done without necessarily stimulating awareness. This may clarify why 15-year-olds from the vocational track tended to have more pro-environmental attitudes than their general track peers: education in the vocational track is provided through a more project-based approach than in the technical and general tracks. This approach might be more activating, resulting in more pro-environmental attitudes. Yet the full extent of the differences between the educational tracks can only be understood through further research.

The school effects are small, certainly when compared to the impact of individual characteristics. However, this could be because we controlled for science abilities before adding school characteristics into the model. Perhaps there is an indirect link: constructivist teaching influences students' science abilities and, subsequently, science abilities stimulate environmental awareness and attitudes. Future research should consider testing a multilevel path model with a multilevel structural equation analysis.

Finally, including school characteristics does not nullify the effect of schools themselves. Although a large amount of school-level variation is explained by the subsequent models, a significant portion of school-level variation in both dependent variables remains. From the school effectiveness perspective, we expect that classical process characteristics (e.g. educational leadership, school climate or degree of achievement-oriented policy) are also key in explaining variation (Scheerens, 1990). However, PISA 2006 did not include measures to assess the effects of these elements.

Science Abilities, Environmental Attitudes and Awareness

The last research question considered whether schools have a differential effect for students with varying levels of science ability. Our findings suggest that students' science ability and environmental awareness and attitudes are positively associated. Students with higher scores on SCIABIL tend to score higher on both ENVAW and ENVATT. Our results indicated the school effect to be different for students with varying levels of science ability; however, the differential effect of schools did not maintain after controlling for student characteristics. This implies that the school is less important in stimulating environmental awareness and attitudes for an average science-able student than for a less or more science-able student. When examining the variation within schools, we noted that more science-able students scored alike with respect to awareness of environmental issues than their average or less science-able peers. This effect remained significant even after controlling for student characteristics. One possible explanation is a ceiling effect on the environmental awareness scale. This occurs when scale items are insufficiently difficult for environmentally aware students, resulting in a large number of students scoring near the upper limit. Another reason is that students scoring higher on science abilities are provided extra information on environmental issues in their science classes. Due to the socialising function of school, we would expect students to score more alike on environmental attitudes as well, yet we did not observe this. A third explanation could be that high-achieving science students seek extra information on science-related issues outside the school.

Advantages and Limitations to Working with the PISA Data

Although the large and nationally representative dataset we were able to work on was an advantage, a number of limitations of our study need to be acknowledged. First, the multivariate multilevel analysis does not allow for causal inferences. For example, JOYSCIE and ENVATT are positively related but the direction of influence is unclear. Experimental or longitudinal data or multilevel structural equation modelling are needed to clarify this. What could be established is that the association between JOYSCIE and ENVATT differs between schools: the school effect. Second, as discussed above, the constructivist teaching methods were assessed by PISA without explicitly incorporating characteristics of constructivist teaching. Third, the Flemish PISA data lacked the parent-level information. Schools as well as the home environment are known to play an important role in stimulating students' awareness and attitudes. In spite of these limitations, the PISA 2006 data offer unique opportunities to examine environmental attitudes and awareness of young people. Our focus was on the PISA 2006 data from Flanders, which is an interesting case because of its compulsory, cross-curricular objectives for EE focussing on attitudes and its specific objectives focussing more on concepts and skills. International comparative research is necessary to confirm the results in other educational, cultural and economical settings.

In conclusion, despite the limitations of this study, the following recommendations for practise are put forward. First, schools do have an impact on students' environmental awareness and attitudes and can be drawn upon by EE policy makers as means for fuelling student environmental awareness and attitudes. Second, our results suggest that schools can stimulate students' environmental awareness by teaching in a more hands-on manner. For example, letting students do practical experiments and drawing conclusions from them seems beneficial to students' environmental awareness. Third, schools can engender more pro-environmental attitudes in their students by focussing on environmental learning projects like outdoor education or trips to the museum.

APPENDIX 1

ITEMS OF PISA SCALES (OECD, 2007)

Scale	*Item*	*Response category*
Environmental awareness	How informed are you about the following environmental issues? 1. Increase in greenhouse gases in the atmosphere 2. Use of genetically modified organisms 3. Acid rain 4. Nuclear waste 5. Consequences of clearing forests for other land use	1. I have never heard of this 2. I have heard about this but I would not be able to explain what it is really about 3. I know something about this and could explain the general issue 4. I am familiar with this and I would be able to explain this well
Environmental attitudes	How much do you agree with the statements below? 1. It is important to carry out regular checks on the emissions from cars as a condition of their use 2. It disturbs me when energy is wasted through the unnecessary use of electrical appliances 3. I am in favour of having laws that regulate factory emission even if this would increase the price of products 4. To reduce waste, the use of plastic packaging should be kept to a minimum 5. Industries should be required to prove that they safely dispose of dangerous waste materials 6. I am in favour of having laws that protect the habitats of endangered species 7. Electricity should be produced from renewable sources as much as possible, even if this increases the cost	1. Strongly agree 2. Agree 3. Disagree 4. Strongly disagree
Science enjoyment	How much do you agree with the statements below? 1. I generally have fun when I am learning science topics 2. I like reading about science 3. I am happy doing science problems 4. I enjoy acquiring new knowledge in science 5. I am interested in learning about science	1. Strongly agree 2. Agree 3. Disagree 4. Strongly disagree

ITEMS OF PISA SCALES (OECD, 2007)

(continued)

Scale	*Item*	*Response category*
Constructivist teaching methods	When learning science topics at school, how often do the following activities occur?	1. In all lessons 2. In most lessons 3. In some lessons 4. Never or hardly ever
Interaction	1. Students are given opportunities to explain their ideas 2. The lessons involve students' opinions about the topics 3. There is a class debate or discussion 4. The students have discussions about the topics	
Investigation	1. Students are allowed to design their own experiments 2. Students are given the chance to choose their own investigations 3. Students are asked to do an investigation to test out their own ideas	
Hands-on	1. Students spend time in the laboratory doing practical experiments 2. Students are required to design how a science question could be investigated in the laboratory 3. Students are asked to draw conclusions from an experiment they have conducted 4. Students do experiments by following the instructions of the teacher	
Application	1. The teacher explains how a science idea can be applied to a number of different phenomena (e.g. the movement of objects, substances with similar properties) 2. The teacher uses science to help students understand the world outside school 3. The teacher clearly explains the relevance of science concepts to our lives 4. The teacher uses examples of technological application to show how science is relevant to society	

Appendix 2—The Multivariate Multilevel Model

Five models are estimated in this study. Here, we discuss the last, most complex one. Formula 1 shows the final multivariate multilevel equation for the fifth model.

$$Y_{ijk} = \left[\left(\beta_0 + \upsilon_{0k} + u_{0jk}\right)X_{0jk}\right] + \left[\left(\beta_1 + \upsilon_{1k} + u_{1jk}\right)X_{1jk}\right] + \left(\beta_2 X_{2jk}\right) + \ldots \\ + \left(\beta_{17} X_{17jk}\right) + \alpha_1 W_{1k} x_{ojk} + \alpha_2 W_{2k} X_{0jk} + \ldots + \alpha_{11} W_{11} X_{1jk} \tag{1}$$

The intercept β_0 represents the mean score on the environmental awareness scale for a boy in the general track with average science ability and enjoyment, of an average economic, social and cultural status and in a school with average hands-on learning (a zero on all the significant predictors for ENVAW, see Table 1). The β_1 gives the mean score on the pro-environmental attitudes scale for a native or first generation boy in the general track in any but the outlier school with average science ability and enjoyment, of average economic, social and cultural status and in a school with average environmental learning activities (significant predictors for ENVATT, see Table 1).

The model also includes 16 student-level variables: $X_{2jk} \rightarrow X_{17jk}$. The estimates for these variables (β's) indicate the effect of a predictor on the output measure, for example, the effect of being a girl (as opposed to being a boy) on environmental awareness or the impact of a one standard deviation increase in science enjoyment on environmental attitudes. The model contains 11 school level predictors as well ($W_{1k} \rightarrow W_{11k}$): five predictors per dependent variable and one dummy for an outlying school on the environmental attitudes scale (see "Results" section).

The model assumes that the average score of one particular school on both output measures can deviate from the average score of all schools combined. These deviations are represented in the model by the residuals v_{0k} and v_{1k}. The variance of these residuals is labelled between school variance and denoted by σ^2_{v0} and σ^2_{v1} (formula 2). Variances deviating significantly from zero indicate that schools differ from each other with regard to their scores on the output measure concerned. This suggests that a multilevel model is necessary to estimate accurately the regression coefficients.

$$\begin{bmatrix} v_{0k} \\ v_{1k} \end{bmatrix} \sim N(0, \Omega_v) \ : \ \Omega_v = \begin{bmatrix} \sigma^2_{v0} & \\ \sigma_{v0\,1} & \sigma^2_{v1} \end{bmatrix} \tag{2}$$

Besides variances between schools, the covariance between the residuals at school level is calculated (σ_{v01} in formula 2). If this measure is significant and positive, it can be concluded that schools performing well on one dependent variable (ENVAW) on average score well on the other (ENVATT) dependent variable.

Besides between-school variance, there is also within-school variance. Not all students in the same school perform equally well. For this reason, students' deviations from the school average are included in the multivariate model: u_{0jk} and u_{1jk} (formula 1). The variance components of these estimates are labelled σ^2_{u0} and σ^2_{u1}, respectively (formula 3). The covariance between the two error terms is estimated as well (σ_{u01}). Analogously, a significant positive effect indicates that students scoring higher on the first dependent variable tend to score higher on the second as well.

$$\begin{bmatrix} u_{0jk} \\ u_{1jk} \\ u_{13jk} \end{bmatrix} \sim N(0,\ \Omega_u)\ :\ \Omega_u = \begin{bmatrix} \sigma^2_{u0} & & \\ \sigma_{u01} & \sigma^2_{u1} & \\ \sigma_{u0\,13} & 0 & 0 \end{bmatrix} \tag{3}$$

Finally, the heteroscedacity in the effect of science ability on environmental awareness was modelled. This heteroscedacity can be modelled by two parameters (a variance and covariance component) although formula 3 suggests three. The middle one cannot be estimated; it is a structural zero. Since the variance of science ability did not result significant, this was put to zero (Rasbach et al., 2005), leaving the covariance between the intercept of environmental awareness and science ability (σ_{u013}). A significant negative score suggests a fanning in pattern in the residuals within schools for science abilities on environmental awareness (Rasbach et al.). Scoring higher on science abilities goes together with less heterogeneity in the errors of environmental awareness at the student level.

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