4

Learning About Environmental Science and Geoscience

GREEN AT FIFTEEN? – ISBN 978-92-64-06129-3 – © OECD 2009

SCHOOLS AND ENVIRONMENTAL SCIENCE EDUCATION

With the intensification of public concern over the environment, many nations are engaged in extensive public debates. 15-year-olds in OECD countries have access to large amounts of information on the environment and its scientific study. Not only schools, but the media and Internet as well, have become rich sources of material from which students can learn and apply their scientific literacy.

At the same time, science evolves from new discoveries and new theoretical perspectives. Over the past several decades there have been significant advances in scientific understanding of the earth's environment and geoscience (Russell, 2008).

As environmental science and geoscience topics evolve, they present new educational challenges. If environmental science and geoscience education is to keep up with the emerging science, science educators will have to find the most appropriate location for these topics within the overall science curriculum. For example, the United States has witnessed an intense policy discussion about ways to increase the prominence of environmental science and geoscience material within the school curriculum. The National Research Council has included these scientific topics in the nation's standards for teaching science:

> *… the NRC Standards show not only geoscientists, but also physicists, chemists and life scientists all calling for a strong and fully equal earth science presence in the curriculum. This attention to earth science is driven, in part, by the increased focus on the usefulness of science and the recognition that earth science contributes significantly to how we utilise our resources, manage our land and mitigate the effects of natural disasters. Moreover, scientists from other disciplines recognise how the earth sciences provide important context and meaning for acquiring fundamental understandings in their disciplines (Ridky, 2002).*

In addition to the curricular placement of environmental science and geoscience, there is also a lively debate on how to teach this material. Besides classroom lectures and laboratory experiments, there are a number of other activities that school science teachers around the world are using to engage students. Activities such as outdoor education, museum and science centre trips, and extracurricular research offer students opportunities to apply their environmental science and geoscience knowledge to actual problems associated with environmental issues.

Through its school and student questionnaires PISA 2006 asked about the curricular placement of environmental science in schools, about the ways schools used outside-of-classroom activities to teach this material, and about the sources of information used by young people to learn about environmental issues. This chapter reviews the evidence from these data and, for some of these variables, it illustrates their relationship with student performance on environmental science.

MAIN RESULTS OF THIS CHAPTER

Almost all students in the OECD attend schools that teach environmental topics. However, they appear in the curriculum in several different ways. Most commonly, they are part of natural science courses; most schools also include them in geography lessons, and they are frequently parts of other courses too. Only a minority of students in most countries attend schools with stand-alone environmental studies courses.

According to school principals most 15-year-old students attend schools that use at least one out-of-classroom learning activity to teach students about environmental science. Outdoor education is the activity most commonly reported, followed by trips to museums and science centres. There are a few OECD countries in which these activities are not very common, and a number of other countries in which nearly all students enjoy them.

Students learn about the environment from a number of sources: most commonly from schools, followed by the media, the Internet and books, and lastly family and friends. The evidence shows that students using several sources of information about environmental issues tend to be among the higher performers in this field, and in particular that higher performers are more likely to use schools and the media, Internet and books to find out about the environment.

ENVIRONMENTAL SCIENCE AND GEOSCIENCE IN THE SCHOOL SCIENCE CURRICULUM

Environmental science and geoscience are developing dynamically as intellectual fields, and their placement in the science curriculum differs between countries, and often between schools in the same country. PISA 2006 asked school principals about the curricular placement of environmental science material. Box 4.1 contains the actual questions addressed to them. This material was defined as all topics that are related to environmental science including issues such as pollution, degradation of the environment, relationships between organisms, biodiversity and conservation of resources.

Specifically, school principals were asked if any environmental science material was taught in the following four curricular arrangements (Box 4.1, question 21): *i)* As a separate course fully dedicated to this topic, *ii)* As part of a natural sciences courses or within an integrated science course, *iii)* As part of a geography course, and *iv)* As part of another course. Principals were allowed to select as many responses as were appropriate for their school.

Box 4.1 Environmental questions

PISA 2006 School Questionnaire

Q21 – Where do topics on the environment sit in the curriculum received by students in <national modal grade for 15-year-olds> at your school?

Environmental topics include all topics related to environmental science. These may include environmental issues such as pollution or the degradation of the environment. Relationships between organisms, biodiversity and conservation of resources would also be examples of environmental topics.

(Please tick one box in each row. If there are no topics on the environment in the curriculum received by students in <national modal grade for 15-year-olds> please tick "No" in all four rows)

		Yes	No
SC21Q01	a) In a specific environmental studies course	☐1	☐2
SC21Q02	b) In the natural sciences courses – for example as part of biology, chemistry, physics, earth science or within an integrated science course	☐1	☐2
SC21Q03	c) As part of a geography course	☐1	☐2
SC21Q04	d) As part of another course	☐1	☐2

Q22 – Does your school organise any of the following activities to provide opportunities to students in <national modal grade for 15-year-olds> to learn about environmental topics?

(Please tick one box in each row)

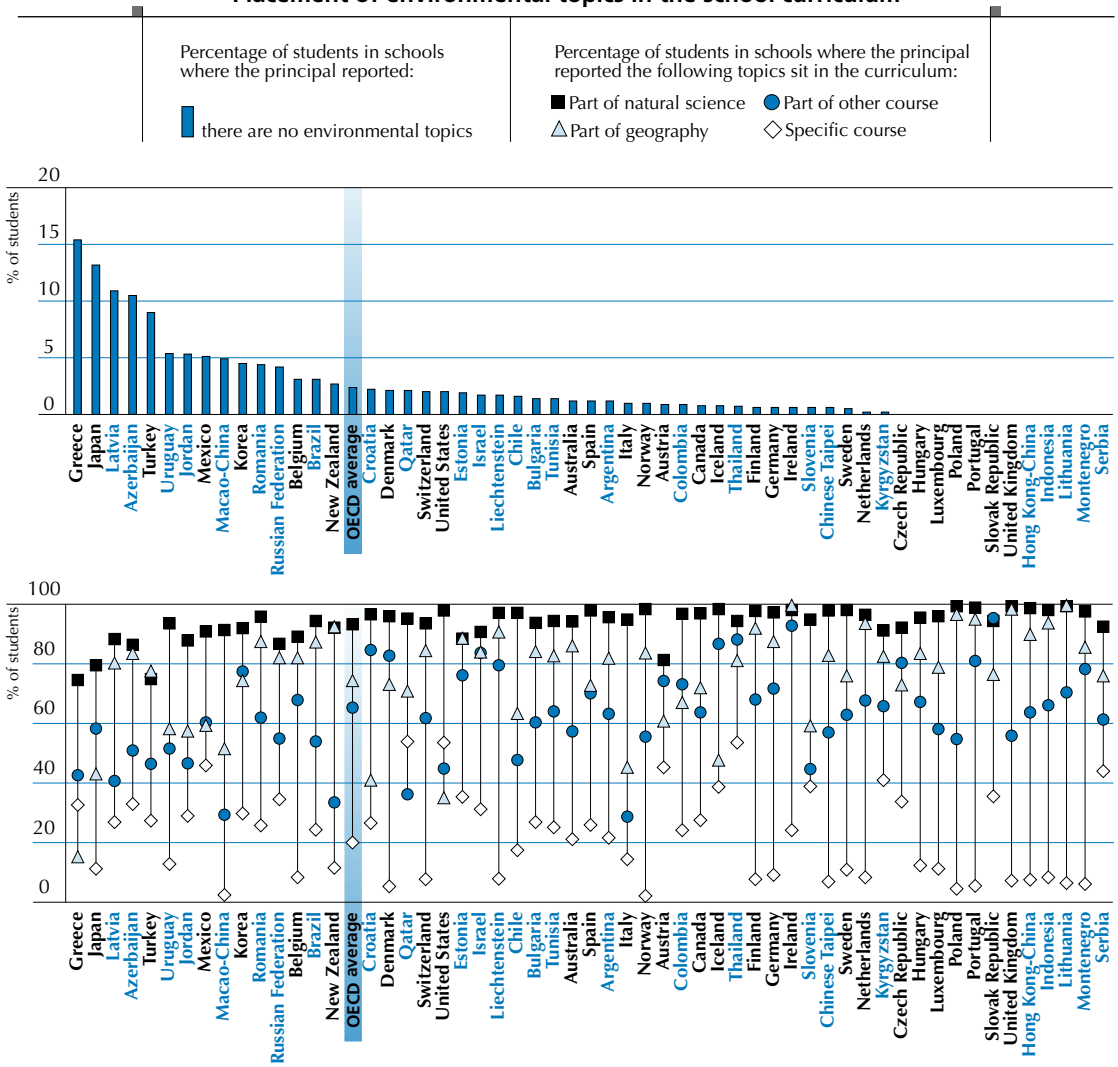
		Yes	No
SC22Q01	a) <Outdoor education>	☐1	☐2
SC22Q02	b) Trips to museums	☐1	☐2
SC22Q03	c) Trips to science and/or technology centres	☐1	☐2
SC22Q04	d) Extracurricular environmental projects (including research)	☐1	☐2
SC22Q05	e) Lectures and/or seminars (*e.g.* guest speakers)	☐1	☐2

GREEN AT FIFTEEN? – ISBN 978-92-64-06129-3 – © OECD 2009

As the upper chart in Figure 4.1 shows, most students in OECD and partner countries and economies are taught environmental topics somewhere in the curriculum. Across OECD countries, for example, only 2% of students on average are in schools that do not include environmental science in their curriculum. Greece and Japan are notable exceptions to this general pattern, having 15 and 13% of students respectively in schools whose principals report that there is no environmental science in the curriculum (Table A4.1).

In most OECD countries, environmental science material is found in several courses. An overwhelming proportion of the schools include environmental science somewhere in the science curriculum. Many schools teach parts of the topic in a variety of science courses, in geography, and in other (non-specified) courses. At the same time a significant proportion of schools offer a stand-alone course on environmental science. Given that answers were not mutually exclusive, the results, reported in Figure 4.1, include percentages that add to more than 100%.

Figure 4.1
Placement of environmental topics in the school curriculum



Source: *OECD PISA 2006 Database*, Table A4.1.
StatLink http://dx.doi.org/10.1787/562235784260

GREEN AT FIFTEEN? – ISBN 978-92-64-06129-3 – © OECD 2009

By far, most curricular material about environmental science is taught as part of natural science courses, for example as part of biology, chemistry, physics, earth science, or within an integrated science course. Among OECD countries, on average, 94% of students attend schools that teach environmental science this way, according to the reports of school principals (Table A4.1). Partner countries and economies use this approach just as often.

Environmental science is also frequently taught as part of a geography course. About three quarters of students in OECD countries, on average, are in schools that teach material about the environment in a geography course. All Irish students are in schools that do this compared with only 16% of students in Greece and 35% in the United States. Also, on average 63% of students in OECD countries are at schools that teach environmental material in other (non-specified) courses.

The least common way of including environmental science material in the science curriculum is as a stand-alone course fully dedicated to this topic. Across the OECD, on average, one-fifth of students are in schools that have a course dedicated to environmental science, and there is significant variation among countries. The United States has the highest proportion among OECD countries, with 55% of students being in schools reporting such a course. On the other hand, in Norway and Poland 5% of students or less are in schools with stand-alone courses. In partner countries and economies, the proportion of students receiving this type of course is about the same as for OECD countries, with similar amounts of variation among countries.

These results mirror the state of the debate on curriculum placement for environmental science and geoscience. In most countries, there appears to be no consensus on this issue. In some countries, the situation might have changed recently and 15-year-olds might not have experienced a particular way of teaching for a long time. As with other questions from the school principals' questionnaire, generalising from a single source of information for each school is not straightforward. Most importantly, students' performance usually relates to the work of many teachers in various subject areas. It is therefore not surprising that no clear-cut association exists between these measures and student performance in environmental science (Table A4.2).

OUT-OF-CLASSROOM ACTIVITIES TO PROMOTE LEARNING OF ENVIRONMENTAL SCIENCE IN SCHOOLS

Environmental sciences are generally far from being theoretical or abstract. To a large extent they involve learning about humans, their impact on other co-existing organisms, the natural resources they utilise for survival, and all elements of nature that humans employ for their own purposes. This quality makes the teaching of environmental science and geoscience particularly well suited for "hands-on learning" and other approaches that augment the usual in-classroom activities.

One approach in science instruction is to have students actively learn through experiments and projects (*e.g.* Rehorek, 2004; Stamp and O'Brien, 2005). While this overall approach has received much attention in the science education literature, not all studies find it an effective approach (*e.g.* Kirschner, Sweller, and Clark, 2006). PISA 2006 asked principals about their school's use of five different out-of-classroom and extracurricular learning activities to teach 15-year-olds about environmental issues (Box 4.1, question 22): *i)* Outdoor education, *ii)* Trips to museums, *iii)* Trips to science and/or technology centres, *iv)* Extracurricular environmental research projects, and *v)* Lectures and/or seminars.

As shown in the upper chart of Figure 4.2, across the OECD and partner countries and economies most students are in schools that report using at least one of these activities to teach students about environmental science. On average, only 6% of students in OECD countries are in schools that do not organise out-of-classroom or extracurricular activities to teach environmental science. In Japan, though, 55% of students are

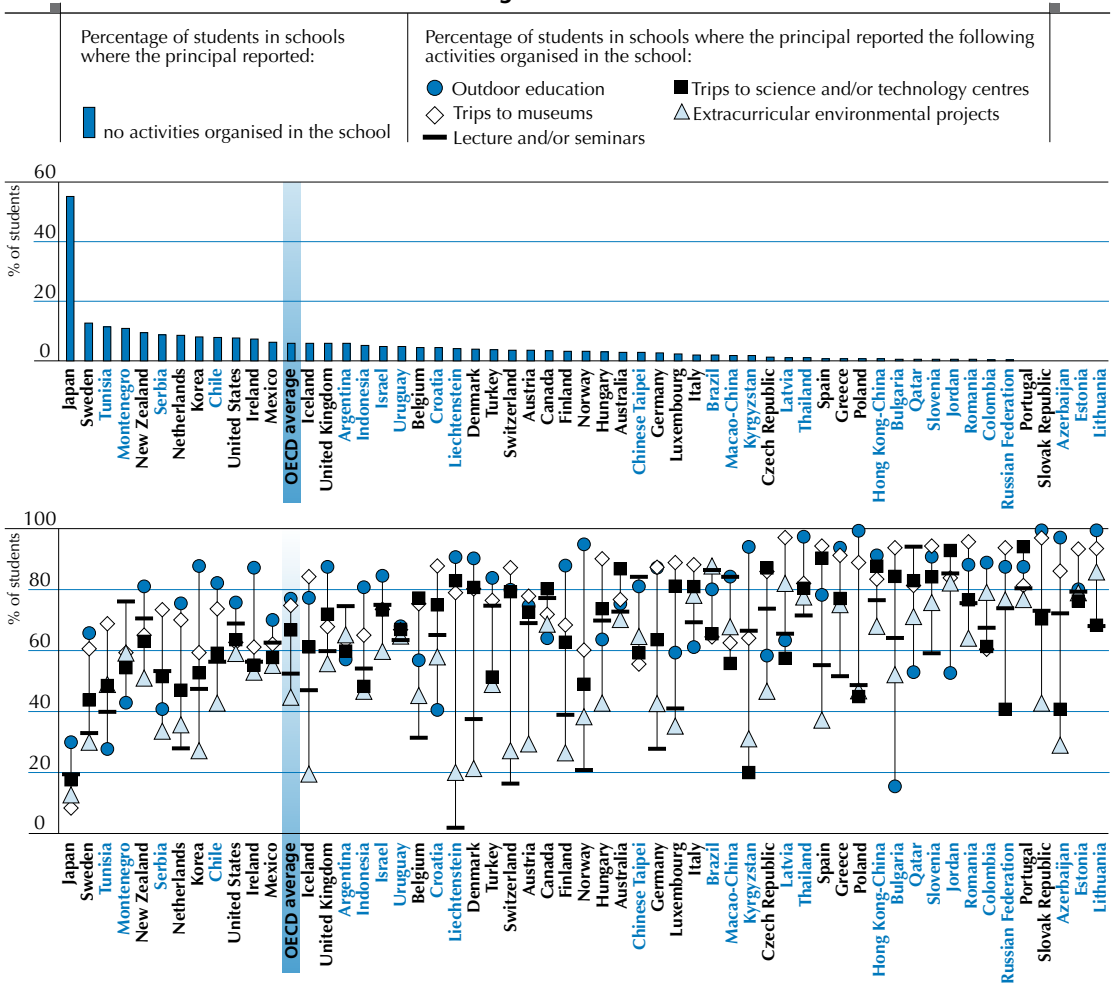
GREEN AT FIFTEEN? – ISBN 978-92-64-06129-3 – © OECD 2009

in schools whose principal report organising none of these. In Portugal and the Slovak Republic all schools use at least one of these activities. In partner countries and economies, according to school principals, these activities are if anything even more common than among OECD countries.

The most commonly used outside classroom learning activity for teaching about environmental science is outdoor education: almost eight out of ten students in OECD countries on average attend schools that use this approach. In Greece, Poland and the Slovak Republic, and in partner countries Azerbaijan, Colombia, Kyrgyzstan, Lithuania, Slovenia and Thailand, 90% or more of students attend schools that use outdoor education.

The next most frequently used activities outside of the classroom to learn about environmental science, according to school principals, is trips to museums. On average 77 and 75% of students in the OECD attend schools that report using these activities. In Poland and the Slovak Republic 99% of student enjoy outdoor education to learn about environmental science. In Hungary, Greece, Slovak Republic, and Spain 90% of

Figure 4.2
Outside classroom learning activities for environmental science



Source: *OECD PISA 2006 Database*, Table A4.3.
StatLink http://dx.doi.org/10.1787/562235784260

students or more enjoy trips to museums to gain knowledge about environmental science. Compared to other OECD countries, Japan has a considerably lower proportion of students at schools reporting the use of museum trips (8%) and outdoor education (30%). Outdoor education is similarly popular in partner countries and economies and the proportion of students enjoying them to learn about environmental science ranges from 16% in Bulgaria to 99% in Lithuania. Trips to museums are also very common activities among students in partner countries and economies, as the proportions range from 56% in Chinese Taipei to 97% in Latvia. Trips to science and/or technology centres are reported somewhat less among OECD countries with an average of 67% of students in schools using this activity, with similar variation across countries. The same is true for partner countries and economies, where the range is between 93% of students in Jordan to 20% in Kyrgyzstan.

Guest lectures and seminars are used even less frequent: 52% of students on average attend schools in OECD countries that report using guest lectures or seminars. In Portugal (80%), Canada (77%) and Turkey (75%) more students are in schools that report this approach. Switzerland (16%) and Japan (19%) have the lowest proportion of students at schools that report using guest lectures and seminars. Among partner countries and economies, there is a large range in the proportion of students that enjoy these outside-the-classroom lectures with 94% of students in Qatar receiving them to 40% in Tunisia and just under 2% in Liechtenstein.

Extracurricular environmental projects tend to involve the lowest proportion of students among these outside-the-classroom learning approaches, and they are reported less frequently than any of the activities apart from environmental projects. On average across OECD countries, about 45% of students are in schools reporting this activity, and slightly fewer in the partner countries and economies (Table A4.2). Among OECD countries the use of projects is most common among schools in Greece, Portugal, and Italy all with 75% of students or more enjoying this type of activity. In Japan, at the other end, only 13% of students do so.

Finally, opportunities for environmental education also arise from the school infrastructure, with the school building itself seen as a source and environment for learning about the environment (see Box 4.2).

As with the curriculum placement question, there is no apparent association between student performance in environmental science and school activities to promote environmental science (Table A4.4). It could be that these types of activities are not effective in promoting learning or simply that school principals interpreted this question very differently across and even within countries.

SOURCES FOR LEARNING ABOUT ENVIRONMENTAL ISSUES

Unlike more abstract scientific topics, the environment is widely covered in the media, on the Internet, and is a topic of everyday discussion to which youth have wide access. PISA therefore asked students about the information sources from which they "mainly learned" about each of the six selected environmental issues described in Chapter 3 (Box 3.2, question 23). Students were given five sources and they could tick as many as they wished: *i)* School, *ii)* Media (TV, radio, newspapers, magazines), *iii)* Friends, *iv)* Family, and *v)* Internet or books, for each of the environmental issues.

Schools appear to play a central role as a source for learning about environmental issues. As shown in Figure 4.3, 15-year-olds report that they mainly learn about the environment from schools, followed by the media, then the Internet and books, and lastly family and friends. This pattern is common across all six of the issues. The average proportion of students in OECD countries responding that they mainly learn from school ranges from 58% for "nuclear waste" to 76% depending for "air pollution" (Table A4.5).

Box 4.2 The school building as a teacher

Schools buildings are more than just a backdrop for teaching students about the environment, more and more the buildings and landscapes are becoming teachers too. Jamieson *et al.* (2005) have found that curriculum and facility design are related; their findings demonstrate that the physical learning environment has an influence on students' social and scholastic behaviour. Safe, comfortable school facilities can motivate students to learn and create an atmosphere where children enjoy attending school (Rudd *et al.,* 2008). Environmental education tends to focus on a textbook approach, adapting curriculum to teach students about current issues surrounding environmental sustainability. However, the physical environment has a role to play in raising students' environmental awareness and knowledge. Findings from an online survey on sustainable school buildings showed that students were more eager to participate and performed better under the direction of school leaders committed to sustainable development practices (Wilkinson, 2008). The building can serve as a tool for instruction, in which students can learn from doing, seeing and experiencing, thus gaining a greater perspective of environmental issues.

Recycled construction materials, alternative energy sources, rainwater collection for irrigation and sanitary flushing, and maintenance and management of local nature preserves surrounding grounds are all modern responses that address pressing environmental dilemmas by changing how the school facility interacts with the environment. From newly-constructed to retrofitted construction choices, the varied possibilities demonstrate how education and relevant facilities can develop and expand students' environmental knowledge and its application.

Schools have taken various approaches to systematically incorporate environmental education via the facilities. There exists a range of potential approaches that are being used by schools to propel environmental education in the classroom, from one-time initiatives to larger scale. Some projects have started out as grassroots initiatives, in which a simple idea to implement recycling or to clean the forest behind the school has spiralled into whole-school adoption of sustainability concepts. This method engages students and staff to become more involved in 'greening' the school and increases consciousness of environmental issues. Schools can shape strategies to the existing space and facility. At the other end of the spectrum is an approach implemented from the conception of the school, where schools are designed and built to include as many sustainable features as are available and affordable. Increasingly, students are being included in the design process and contributing ideas which the architects are able to incorporate into the plan. This collaboration stimulates students' engagement and encourages broader thinking.

Case Study: Evolving environmental responsibility

Esquimalt High School, British Columbia, Canada

Environmental awareness started with a 'Waste Weigh-in' that displayed the amount of refuse produced within the school and cafeteria that could be recycled rather than thrown away. This prompted a new commitment to recycling and composting, thus creating an atmosphere of zero waste in the cafeteria as well as a more long-term commitment to the concept for the entire school. The compost is used in the school for food production and has reduced dependence on petroleum-based fertilisers. School educators and administrators believe that this effort has resulted in increased awareness of climate change among students, and that they are more mindful of the consequences of increased CO_2 emissions due to dumping refuse as opposed to recycling and reducing waste.

GREEN AT FIFTEEN? – ISBN 978-92-64-06129-3 – © OECD 2009

Canning Vale College, Perth, Australia

The school grounds and buildings are designed to be environmentally friendly in a way that exposes students and teachers to new environmental technologies. The recently constructed lower and upper secondary school incorporate exemplary features, including a wetland 'living stream' learning resource and 'solar chimney' passive ventilating elements. The school was built to be environmentally sustainable, but the commitment to these values has extended beyond construction features. As part of the school's philosophy, environmental responsibility has been given a high priority. The school aims to ensure that all students are aware, respectful and reactive to environmental issues. Drawing upon the adjoining wetlands and bush area, academic studies are augmented through the maintenance and monitoring of this natural area.

As the Canning Vale College example demonstrates, the exterior can provide an invaluable supplement to the curriculum. Gardens, forests, lagoons, parks, coastal zones and farms encourage students to move outside and experience nature and ecology firsthand. Gardens demonstrate ecosystem complexity and introduce students to local sustainable food sources and extensive recycling through composting (Blair, 2009). Engagement in the local environment and outdoor surroundings prompts encourages interactive learning beyond the classroom walls. Furthermore, Vaske and Kobrin (2001) found that individuals' exposure to and interaction with the natural environment through recycling, garden maintenance and discussion of related issues culminated in environmentally responsible attitudes and behaviours.

Case study: Biodiversity preservation and tending gardens

Williamstown High School and Sixth Form, Victoria, Australia

The school has adopted a whole school approach to sustainability and environmental education, including specific programmes within the curriculum, recycling, and student environmental groups, each of which encourages students to learn through action. The school website includes a downloadable chart of daily energy consumption, thus permitting students to monitor the amount of energy expended (*www.willihigh.vic.edu.au/).* The use of the infrastructure and the nearby marina are integral components of the school's environmental emphasis, which encourages students to engage in scientific experiments in water quality and coastal degradation and also preserve biodiversity through indigenous planting and composting. The school believes that direct student involvement in local concerns has raised overall awareness of environmental issues.

Buildings provide an opportunity for students to learn by examining the details of the design and construction. In this sense, the building becomes an interactive, animated textbook used to supplement traditional activities, offering students another perspective into environmental subjects and topics.

Case Study : Sustainable construction

Lycée Emmanuel HÉRÉ, Lorraine, France

The primary architectural aim of this secondary school is to reconstruct the building using innovative environmentally sustainable techniques and features. Currently still under construction, this facility will include solar panels, a green roof for improved insulation and acoustics, rainwater collection and photovoltaic panelling to supply sufficient electricity for the needs of the establishment. However, it is not just the materials and design of the building but also the construction process itself that is of notable educational value, especially since the students at this school are pursuing studies leading to future careers in the construction professions. Throughout the construction process, students can

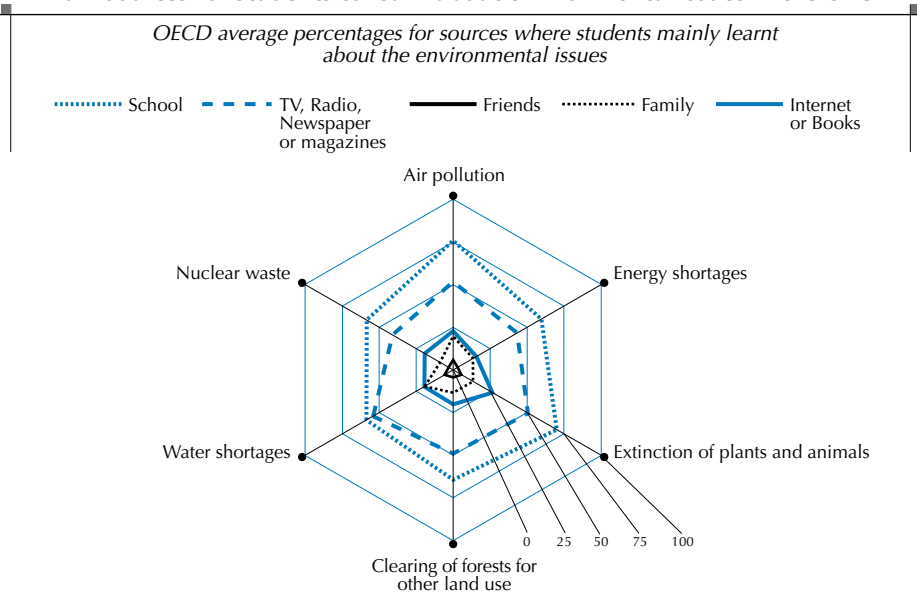
visit the site and survey the installation of the environmental technologies, greatly contributing to their understanding of how such technologies can be used, as well as about the industry many of them hope to enter. In addition, students can monitor the progress online through a webcam.[1]

These examples offer an insight into how secondary schools are developing students' relationships with the environment, also suggesting strategies for engaging students with these issues. The examples also show how students interact with the physical environment by doing, seeing, and experiencing. The case studies described above have not collected quantitative data elucidating the link between school facilities and environmental education outcomes. However, in each of the examples, observations from educators and teachers predict a positive influence between the school spaces and environmental knowledge. Repeated exposure to and interaction with the natural environment seems to generate greater comprehension and awareness of the environmental issues that continue to affect the planet.

For further information on the work of the OECD's Centre for Effective Learning Environments (CELE) on sustainable education facilities see *www.oecd.org/edu/facilities.*

The next most frequently cited source is print and electronic media. From 41% for "nuclear waste" to just over 52% of students for "air pollution" say they learn about environmental issues from TV, radio, newspapers and magazines. Although the Internet was less widely used in 2006 than it is now, between 19 and 27% of youth on average in OECD countries report using it and books to learn about environmental issues. On average between 9 and 20% of young people in OECD countries claim to learn about environmental issues from their family, while between 3 and 6% learn about these issues from their friends. The cross-country variation on these patterns is remarkably low.

Figure 4.3
Main sources for students to learn about environmental issues in the OECD



Source: *OECD PISA 2006 Database,* Table A4.5.
StatLink http://dx.doi.org/10.1787/562235784260

GREEN AT FIFTEEN? – ISBN 978-92-64-06129-3 – © OECD 2009

Sources of knowledge and performance in the environmental science index

The variation in students' sources of knowledge is associated with student performance in environmental science and geoscience. In general, using additional sources is associated with higher performance. This section presents two sets of results. First, the unadjusted association between student's source of knowledge and performance. Second, the same relationship adjusted for student and school demographic and socioeconomic characteristics, using the same model as for the attitudinal indices (Figure 4.4). Detailed results are provided in Table A4.6.[2]

The strength of the relationship between sources of knowledge on environmental issues and performance varies across sources. In general, the best performing students are those that use not just one but several sources to learn about environmental sciences. These students rely on the school, media, and the Internet and books. The results suggest that they are combining information from all these sources.

Compared with students who did not check any source of knowledge or reported mainly learning from family or friends, across OECD countries, using solely the media or Internet and books as the main sources of knowledge is associated with an increase of 57 score points on the environmental science performance index before background variables are considered and 41 score points when the background variables are taken into account. The corresponding results for relaying solely on schools as the main source of knowledge is 27 score points before background variables are considered and 17 score points when the background variables are taken into account. Students claiming that they combine these sources of knowledge, namely schools, media, Internet and books, score 71 score points higher before accounting for background variables and 51 score points after accounting for background variables (Table A 4.6).

LEARNING ABOUT THE ENVIRONMENT: CONCLUSIONS AND IMPLICATIONS

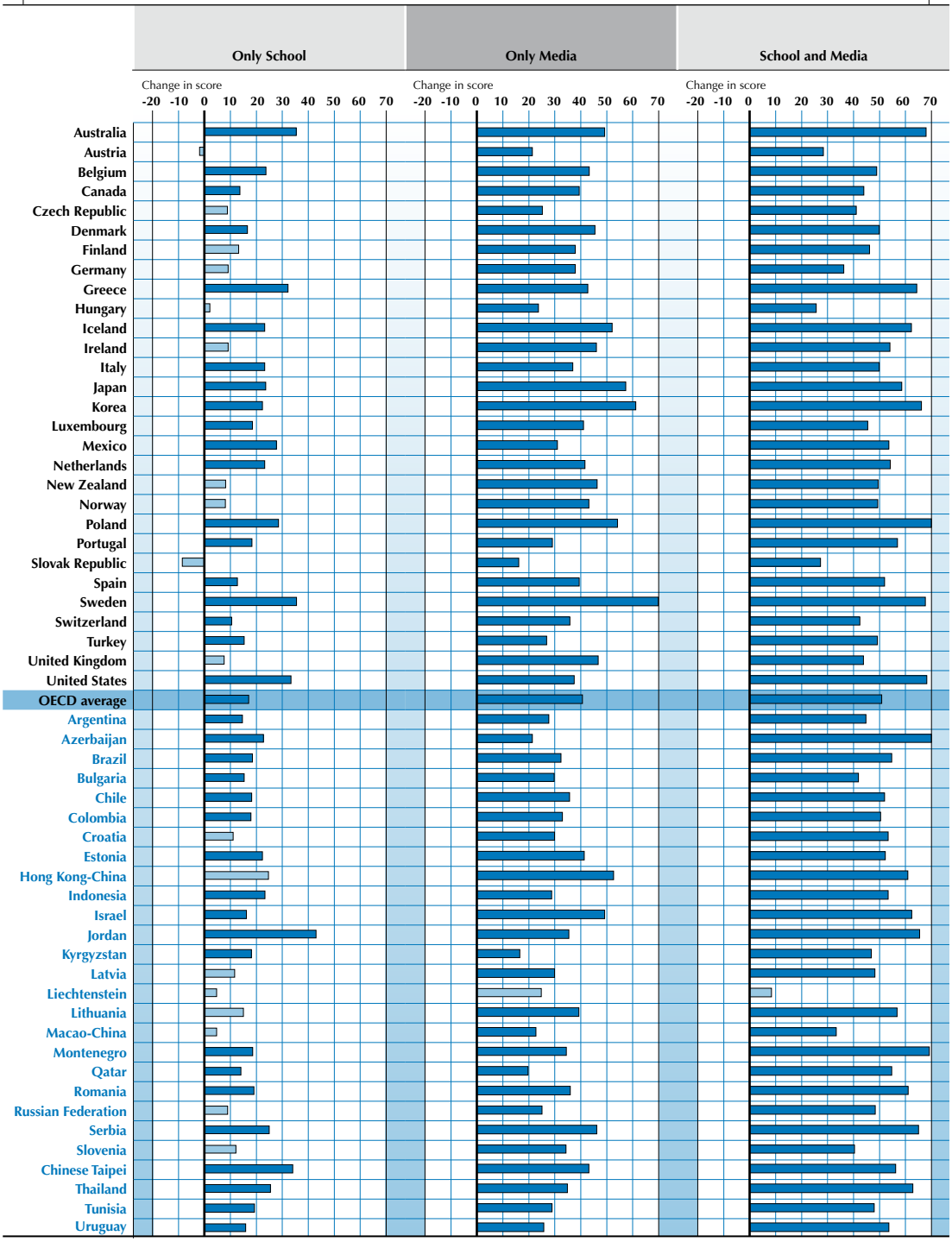
The above evidence makes it clear that there is no single way in which students learn about the environment. While school is the most common source of such learning, many students are also using the the media and, to a lesser extent, other sources such as books and the Internet, to gain such knowledge.

A strengthening of student attitudes and performance in environmental science is likely to come from multiple sources of learning. Students who have the interest and initiative to learn about the environment through the media and through the Internet tend to be the students with higher environmental science proficiency. While this does not show directly that such extracurricular learning has contributed to this proficiency, it does suggest that encouraging students to take a wider interest is an important part of environment education.

The evidence points to the important role that schools play in teaching environmental science. Within school, such learning can occur in many parts of the curriculum and there are notable variations in the extent to which environmental education pervades school curricula. While schools typically address the environment in both science and geography, there is greater variability in whether it appears elsewhere in the curriculum, and particularly strong difference across countries in the extent to which it is addressed through outdoor activities and school trips. Countries with fewer students enjoying a wide range of such activities should consider whether they need to widen young people's exposure to environmental issues.

Figure 4.4

Relationship between sources of students' knowledge about extinction of plants and animals and environmental science performance after accounting for background variables



Note: Statistically significant values are marked in darker colour.
Source: *OECD PISA 2006 Database*, Tables A4.6.
StatLink http://dx.doi.org/10.1787/562235784260

GREEN AT FIFTEEN? – ISBN 978-92-64-06129-3 – © OECD 2009

Notes

1. The webcam is available here: *http://www3.ac-nancy-metz.fr/lyc-emanuel-here-laxou/articles.php?lng=fr&pg=120*

2. The analysis of the association between sources of information and the environmental science performance index focuses on one of the six environmental issues. The issue selected was the extinction of plants and animals, because it is the issue most students claimed to be familiar with (less than 3% of all students were unfamiliar with it). Three dummy (0/1) variables were constructed based on student responses. The first variable equals 1 when the student reported that is mainly learning from schools, but not from media or Internet and books. The second variable equals 1 when the student claimed that is learning mainly from media and/or Internet and books, but not from schools. The third variable equals 1 for students who learn mainly from schools but also from the media and/or Internet and books. This way we could separate the different effects on environmental science performance for students relying solely on schools, students relying solely on the media, Internet, or books, and students combining information from these two broadly defined sources. These three dummy variables were included in the model at the same time, so estimated associations are net of their effects on the environmental science performance index. The reference category is a student who claimed that is using none of the sources mentioned in the question or is learning mainly from family and friends. The small number of missing data was coded as zeroes. Similar analysis was then conducted for the other five environmental issues. Analogous results were found and are not reported here. It could, however, be legitimately assumed that the findings presented in the chapter could be generalised to other environmental problems.

Table of contents

GREEN AT FIFTEEN? – ISBN 978-92-64-06129-3 – © OECD 2009

GREEN AT FIFTEEN? – ISBN 978-92-64-06129-3 – © OECD 2009

LIST OF BOXES

LIST OF FIGURES

LIST OF TABLES

GREEN AT FIFTEEN? – ISBN 978-92-64-06129-3 – © OECD 2009

GREEN AT FIFTEEN? – ISBN 978-92-64-06129-3 – © OECD 2009