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## INTERNATIONAL & COMPARATIVE EDUCATION | RESEARCH ARTICLE

# Bibliometric evidence point to loci of empirical knowledge production in environmental education

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**Abstract:** According to the Organisation for Economic Co-operation and Development (OECD), environmental literacy is the intended outcome of environmental education. Following this postulate, this study aims to investigate the presence of a spatial correlation between the OECD environmental literacy index and the levels of empirical knowledge production in environmental education. In particular, a frequency count of country-specific citations appearing in two leading environmental education journals was used as an indicator of empirical knowledge production. Data analysis showed that countries with higher levels of empirical knowledge production in environmental education (higher frequency of citations in environmental education literature) achieve better outcomes in international environmental literacy tests. Future studies can build on this work to explore the relationship between the production of environmental education knowledge and environmental literacy.

**Subjects:** Educational Research; International & Comparative Education; Middle School Education; Secondary Education; Science; Assessment & Testing



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### ABOUT THE AUTHORS

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### PUBLIC INTEREST STATEMENT

In this meta-analysis, we explored the correlation between international assessments of students' environmental literacy and the intensity of knowledge production in environmental education. The methodology was developed under the assumption that published academic research articles can be used as a reliable indicator for the intensity of knowledge production in the field. We then compared students' environmental literacy performance with the frequency of country-specific publications in the *Journal of Environmental Education* and *Environmental Education Research*—the two leading journals in this specialised field. The result demonstrated a significant correlation between students' environmental literacy level and the intensity of research and empirical knowledge production. This work points to the importance of enabling a national system in environmental education research and practice.

**Keywords: environmental education; education for sustainability; environmental science; environmental literacy; literacy assessment; educational evaluation; comparative education; OECD; PISA**

## 1. Introduction

Current environmental education efforts seek to foster the development of an environmentally literate citizenry (Carleton-Hug & Hug, 2010). Environmental literacy refers to “the capacity to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems” (Disinger & Roth, 1992, p. 2). The promotion of environmental literacy is essential for the well-being of human communities (Orr, 1992; United Nations Educational, Scientific and Cultural Organization [UNESCO], 1990).

Given that environmental literacy is one of the intended outcomes of environmental education, the former can be used as a proxy indicator of the quality of the latter (National Environmental Education Advisory Council [NEEAC], 2015, p. 8). Indeed, a number of researchers have sought to evaluate the effectiveness of environmental education programmes based on the environmental literacy performances of participating students (Erdogan, 2009; Marcinkowski et al., 2014; Negev, Sagy, Garb, Salzberg, & Tal, 2008; Shin et al., 2005). According to their rationale, effective environmental education programmes should be those whose beneficiaries display improved environmental literacy performances. The present research attempts to transfer this rationale to the international level, and explore the potential of a cross-national comparison of environmental literacy outcomes.

To date, the only systematic effort to address environmental literacy on a comparative, international level has been undertaken by the Organisation for Economic Co-operation and Development (OECD) (2009) in the context of the 2006 Program for International Student Assessment (PISA). The Organisation for Economic Co-operation and Development (OECD) environmental literacy survey focused on students’ knowledge of environmental science and geoscience. The organisation justifies its focus by stating that “environmental science literacy is considered the highest-level outcome of environmental education.” (OECD, 2009, p. 19). If, as the OECD postulates, there is indeed a direct relationship between the delivery of environmental education and environmental science literacy, quantitative evidence for this connection should be present in the academic literature.

Following the OECD postulate, this study investigates the presence of a spatial correlation between the levels of empirical knowledge production in environmental education and the OECD environmental science literacy index. As an indicator of empirical knowledge production, we used a count of country-specific citations in international environmental education periodicals. The assumption here is that academic research is not place-neutral; instead, it is more actively interested in places that produce pedagogical innovation. Thus, countries that are more active in environmental education knowledge production are expected to attract the interest of the international environmental education literature, given that the latter has a good sense of how to track, identify, and document pedagogical innovation.

In this study, we hypothesise that countries acting as loci of empirical knowledge production in environmental education a) receive higher citation rates by leading environmental education periodicals, and b) achieve higher performances in international environmental literacy tests. After the establishment of a statistically significant correlation between variables (a) and (b), this research discusses as loci of empirical knowledge production in environmental education those that both attract the interest of international environmental education literature and produce students able to achieve higher performances in international environmental literacy tests.

However, there are several caveats in using environmental literacy levels as a tool for the direct assessment of environmental education, the most important being the multifaceted and often diverging definitions and conceptualisations of environmental literacy itself. Thus, before proceeding, it is essential to review the relevant literature so as to address the following questions: a) What are the components of environmental literacy? b) Do we have access to a reliable and comparable data resource on international environmental literacy levels? and c) What are the conceptual and methodological limitations in the use of environmental literacy as a quality indicator for environmental education? Drawing on this discussion, we will then turn to the research objective and the methods used in this study.

### **1.1. Defining environmental literacy and its current assessment tools**

Environmental literacy derives from an extension of the traditional conceptions of literacy. The theory of multi-literacies enabled the expansion of the concept of literacy past its original language-based definition (The New London Group, 1996). During the 1990s, a plethora of novel literacy types appeared in the academic literature, including environmental literacy, scientific literacy, technological literacy and others (Gough, 1995). The expansion to multiple forms of literacy has also received criticism. Kress (1997) warned that the overuse and indiscriminate application of literacy has led to the term's degradation. Shamos (1995) has taken a similar line on scientific literacy, arguing that there is no general acceptance of what the concept actually means, but that it is instead only a "dream that has little bearing on society" (p. 215).

The concept of environmental literacy is generally agreed to have emerged from the work of Charles E. Roth, who articulated it as follows:

Environmental literacy should be defined...in terms of observable behaviours. That is, people should be able to demonstrate in some observable form what they have learned- their knowledge of key concepts, skills acquired, disposition toward issues, and the like (cited in Disinger & Roth, 1992, p. 2).

This definition actually suggests the determination of environmental literacy through a set of observable characteristics. Similarly, Hollweg et al. (2011) suggested that

an environmentally literate person is someone who, both individually and together with others, makes informed decisions concerning the environment, is willing to act on these decisions to improve the well-being of other individuals, societies, and the global environment and participates in civic life (pp. 2-3).

That is, environmental literacy represents a multifaceted concept that consists of environmental knowledge, competencies, skills, dispositions and preparedness to act (Green, Camilli, & Elmore, 2012; Hollweg et al., 2011; McBride, 2011). As such, environmental literacy is a resource for linking experience to action and can never be a substitute for either (St.Clair, 2003).

While environmental literacy encompasses environmental knowledge and actions, it is also important to note that the concept itself does not imply a linear progression between people's understanding of environmental issues and their behaviours. In the field of environmental psychology and sociology, there is mounting evidence that increasing people's knowledge and awareness about environmental issues does not directly result in pro-environmental behaviours (see discussion in Kollmuss & Agyeman, 2002). Instead, environmental knowledge acts as a modifier of people's attitudes and values, which play a more direct role in shaping their behaviours (Fietkau & Kessel, 1981). Examples of other determining factors include personality traits and habits, infrastructure (e.g., recycling system, public transportation, incentive policies) and social and cultural norms. Although the question of what shapes pro-environmental behaviours is such a complex and crucial one, this discussion is not the focus of our paper.

In 2001, Stables and Bishop argued that the textual origins of environmental literacy can be used to define two contemporary approaches to environmental literacy, which they coined as weak and strong environmental literacy conceptions. According to the weak conception, environmental literacy is a subset of environmental education mostly connected to scientific understandings of the environment. On the contrary, the strong conception of environmental literacy goes beyond scientific ecology, towards an interdisciplinary practice that includes economic, social and aesthetic perspectives.

Up to the present, the only systematic effort to address environmental literacy on a comparative, international level has been undertaken by the OECD (Bybee, McCrae, & Laurie, 2009; OECD, 2009). In the context of the 2006 PISA, standardised testing was used to assess the comparative level of 15-year-olds' environmental science literacy in 56 OECD member states and partner countries. In the organisation's final report, the scientific component of environmental literacy is explicitly prioritised: "environmental science literacy is considered the highest-level outcome of environmental education" (OECD, 2009, p. 19). Hence, the OECD survey applies a weak conception of environmental literacy, according to Stables and Bishop (2001), which primarily focuses on students' knowledge of environmental science and geoscience.

### **1.2. Rationale and research question**

Over the last decade, a number of environmental literacy assessments have been undertaken in the United States, South Korea, Israel, Turkey and Greece (Erdogan, 2009; Kyriazi & Mavrikaki, 2013; Marcinkowski et al., 2014; Negev et al., 2008; Shin et al., 2005). Cross references between these studies show that their methodologies draw upon a single analytical tool, which was developed at Southern Illinois University at Carbondale over two decades ago (Bluhm, Hungerford, McBeth, & Volk., 1995; Hungerford, Ramsey, Volk & Bluhm, 1993). The Middle School Environmental Literacy Instrument follows a broad conception of environmental literacy that includes the components of environmental knowledge, skills, competencies, dispositions and actions (Hollweg et al., 2011; Hungerford & Volk, 1990; Wilke, 1995). In the most extensive of these national surveys, McBeth, Hungerford, Marcinkowski, Volk, and Cifranick (2011) used environmental literacy measurements as a means to assess the effectiveness of environmental education across North America. Their study showed that increased levels of environmental literacy are associated with effective exposure to environmental education. Based on this result, McBeth et al. (2011) argued that effective environmental education programmes should be those whose beneficiaries display improved environmental literacy performances. The present research attempts to transfer their rationale to the international level, and explore the potential of environmental literacy as a practical index of quality in environmental education practice.

To date, the only systematic effort to address environmental literacy on an international, comparative level has been undertaken by the OECD in the context of the 2006 PISA assessment. In the 2006 PISA assessment, the OECD expanded their evaluation methods to include students' performances in environmental science and geoscience. However, this effort to include environmental science and geoscience in the periodical PISA assessment was discontinued (Hollweg et al., 2011). Hence, the OECD (2009) environmental science performance index is the only currently available international data source on what students know about the environment and environment-related issues. This research uses data from both the science and environmental science performance OECD indexes.

The OECD index can serve as a rigorous resource for environmental science literacy data. However, environmental science literacy represents just one aspect of the composite concept of environmental literacy. Thus, any effort to draw generalised conclusions about environmental literacy from the environmental science performance index could pose threats to validity. In order to protect the validity of the environmental science performance index as a secondary data source, we had to develop an instrument that combines OECD data with information from bibliometric archival sources.

We ought to note the presence of two assumptions in this rationale that may dampen the strength of the explored correlation. The first assumption is that environmental science literacy is a subset of environmental literacy. This postulate is endorsed by the OECD (2009, p. 19). One way to test the validity of this assertion is through the results of the present research design. To our understanding, in case that environmental science literacy is not affiliated with environmental literacy, the establishment of a correlation with environmental education would become improbable due to the introduced source of randomness. If, however, a correlation is indeed shown, this would add validity to the OECD postulate and credibility to the selected academic journals.

The second assumption is that the selected bibliometric sources (academic journals) are authentically international in their scope, without significant editorial biases in featuring themes from specific geographical niches. Although the publicised constitution of the editorial board of the selected journals (*The Journal of Environmental Education* and *Environmental Education Research*) demonstrates substantial geographical diversity in the institutional affiliations of their members, the possibility of an editorial bias taking on geographic characteristics cannot be excluded. The threat to validity represented by a potential editorial bias could be addressed in future research by increasing the geographic diversity of bibliographic sources.

Given that these assumptions are acknowledged, the establishment of a correlation between environmental education and environmental literacy could add validity to parts of the pedagogical theory, add credibility to the data sources and serve as grounds for future explanatory research. Moreover, the presented instrument could be employed as a heuristic method for determining loci of knowledge production, situating environmental education and environmental education research. Eventually, aiming to explore the relationship between environmental education and environmental literacy, we formulated the following research question: Is there a significant spatial correlation between environmental education and environmental science literacy that can be supported through bibliographic evidence?

### **1.3. Instrumentation and hypothesis**

The proposed instrument uses two indicators which are both derived from secondary datasets. The first indicator is the OECD environmental science performance index per se. The second indicator, *frequency of citations by leading environmental education periodicals*, was established through meta-analysis of environmental education literature. The frequency of citations indicator was produced by counting the number of papers mentioning a specific country, which have appeared in environmental education literature. A pilot-test of our method convinced us that the selected on-line search engine identified publications based on the locations that the research was addressing, rather than the locations where the researchers were based. However, we must note that the nuances at the sub-national level cannot be delivered by the instrumentation selected for this research.

A fundamental assumption in this research is that academic publications are not place-neutral; instead, research is more actively interested in hubs of innovation. Countries with active research cultures in environmental education are expected to display a high rate of citations in environmental education literature. Hence, the frequency of citations in environmental education literature can serve as a spatial indicator of innovation in the field (Table 1). Localities of empirical knowledge production in environmental education should be those that both attract the interest of international environmental education literature and deliver students who achieve high performances in international environmental science literacy tests.

The correlation between the OECD environmental science performance index and the frequency of citations indicator was explored. The hypothesis is that effective environmental education programmes might be expected to produce enhanced environmental science

**Table 1. Indicators**

Indicator Name	Data Source	Analytical Method	Numerical Value
Environmental science performance index	OECD (2009)	Secondary data analysis of standardised testing results	Student scores in environmental science
Frequency of country-specific citations by leading environmental education periodicals	<i>The Journal of Environmental Education &amp; Environmental Education Research</i>	Country-specific count of academic papers	Number of citations divided by the country's population

literacy levels (as measured by the OECD) as well as to attract a considerable interest on part of the international research community. A meaningful correlation between the two parameters would compensate for the missing components of environmental literacy and help identify national systems<sup>1</sup> that have fostered innovation in the field of environmental education. This finding would suggest the presence of a meaningful correlation between environmental education and environmental science literacy, and concur to the heuristic value of this method in pointing towards loci of empirical knowledge production in environmental education.

As a caveat, it must be noted that a correlation between the two indicators does not imply causation in their in-between relationship. However, both environmental science literacy and frequency of citations by leading environmental education periodicals are plausible causal consequences of the general quality of environmental education in a nation. Countries with effective environmental education programmes are expected to:

- (a) achieve higher performances in international environmental science assessments, and
- (b) receive higher citation rates in international environmental education literature.

A strong correlation between (a) and (b) opens the way for the international assessment of environmental education programmes. The statistical alignment of both indicators adds to the validity of the proposed instrument, which can be useful in gauging the effects of environmental education in diverse international contexts. The establishment of a significant positive correlation can be also seen a justification of the OECD choice to consider environmental science literacy as the “highest-level outcome of environmental education” (OECD, 2009, p.19). Not only does it add credibility to both the OECD results and environmental education literature, but also helps reinforce environmental literacy as a concrete concept that can have measurable effects through multilevel educational processes. The research question leads to the following null and alternate hypotheses.

H<sub>0</sub>: There is no significant correlation between OECD environmental science literacy scores and the frequency of country-specific citations in leading environmental education periodicals.

H<sub>1</sub>: There is a significant correlation between OECD environmental science literacy scores and the frequency of country-specific citations in leading environmental education periodicals.

## 2. Method

Students' performances in environmental science were correlated with country-specific citations by leading environmental education periodicals (Table 1). Secondary data were retrieved from two prominent academic journals in environmental education. *The Journal of Environmental Education* and *Environmental Education Research* were selected as the two most influential journals in the field of environmental education based on rankings of academic literature<sup>2</sup> (SCImago, 2014; Scopus, 2018). Furthermore, these journals have maintained an

international approach and display a continuous publication record over the focus period of this research. Using the on-line search engine provided by Taylor & Francis Group for the two journals, the number of articles with country-specific references was counted. Thus, each country (or economy) mentioned in the OECD report was associated with a single number that represented its number of citations in both journals. Subsequently, the number of country-specific citations was divided by the population of each country to produce the respective weighted indicator. The search was conducted on 22 and 23 March 2014 by making use of the open access browsers of the official websites <http://www.tandfonline.com/toc/vjee20/current#.U0rOenRzbIU> & <http://www.tandfonline.com/toc/ceer20/current#cited>

Countries were searched using their formal titles. In the cases of Chinese Taipei, the Netherlands, the United States and the United Kingdom, the alternative titles Taiwan, Holland, the USA and Great Britain were also used so as not to lose information. Conversely, results on Jordan had to be filtered to make sure the articles were about the country and not the name, for example, James R. Jordan. Furthermore, political or economic entities of less than one million inhabitants were uniformly excluded for statistical reasons. Specifically, it was noticed that the small population of these entities would have produced artefact values due to the fact that their citations are close to 0. The generated error could not be mathematically remedied since a decimal number of citations would be devoid of meaning. On that basis, Liechtenstein, Macao-China, Luxemburg and Iceland, which have participated in the OECD assessment, were excluded from this study as they have less than one million inhabitants.

This research went further in considering the impact of social and economic inequality on environmental literacy, as a possible confounding variable. It has been shown that inequalities in wealth distribution within countries have negative effects on educational outcomes (Sahlberg, 2006). Previous analysis by the Organisation for Economic Co-operation and Development [OECD], (2010) has shown that cross-national economic inequalities can also affect educational outcomes (p. 35). We extended this rationale to investigate the impact of socioeconomic factors on environmental literacy levels. Statistically speaking, economic affluence is a possible confounding variable for the correlation between environmental science literacy and frequency of country-specific citations.<sup>3</sup> As a post-hoc test, a correlation analysis between environmental science literacy scores and national GDP per capita was performed. A least squares regression was used to correlate student performances in environmental science and their countries' economical background. Educational outcomes were juxtaposed with World Bank data for countries' GDP per capita in the year 2000. This particular year was chosen to be in the mean of the schooling path for students who here tested by PISA 2006 at the age of 15. Note that Taiwan does not appear in Figure 2 because it is absent from the World Bank data for the year 2000.

### 3. Limitations of the research design

An important blind spot of the methodology is that some countries with extended environmental education programmes are not OECD members or partner countries, and therefore not counted in the data. For example, Cyprus, despite being a country with high human development index has not been offered membership to the OECD on political grounds (Anand & Sen, 1994). Consequently, Cyprus is not represented in the environmental science literacy index even as the country is top performing in terms of citations by leading environmental education periodicals, with 13 citations per million inhabitants. It is also theoretically possible that other countries that are advanced in environmental education can be found among the 138 countries that were not included in the PISA 2006 assessment. However, this possibility is diminished by the correlation between national incomes and environmental literacy that is explained in Figure 2. The provision of extensive environmental education frameworks appears to be challenging for developing, non-OECD member states.

A methodological issue of different nature is that the proposed research design cannot track locations of empirical knowledge production on a sub-national scale. This may be important for federal systems such as Canada or the United States, which have diverse and very distinct educational systems and curricula nationwide. In order to track nuances of environmental literacy at the local, provincial and state levels, one could use the present instrument with a reference shift from the global scale to the national scale. In an analogy with an optical microscope, it is possible to focus at different levels of magnification using the same instrument, but not at the same time.

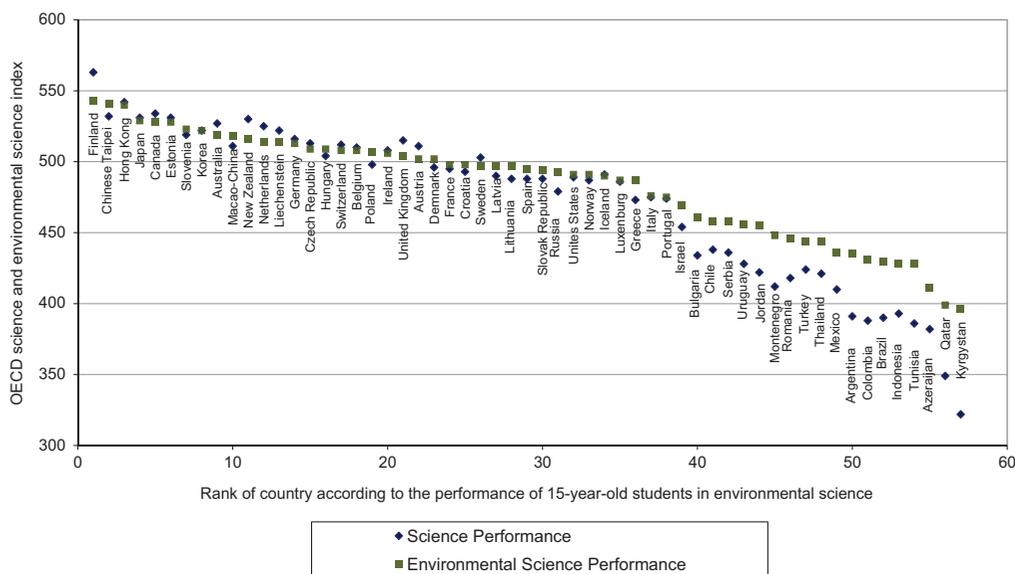
Another issue has to do with a possible linguistic bias as a special case of editorial bias (Rothstein, Sutton, & Borenstein, 2006). By using two English language periodicals to measure research intensity, there is a threat to validity through bias against non-English-speaking countries. Albeit the frequency of citations dimension in Figure 3 shows two predominantly English-speaking countries that top the rankings, other English-speaking countries perform at average levels (for example, the UK and the USA). Overall, while presence of a language bias cannot be dismissed, it appears far less significant than the influence of economic factors (Figure 2).

#### 4. Results

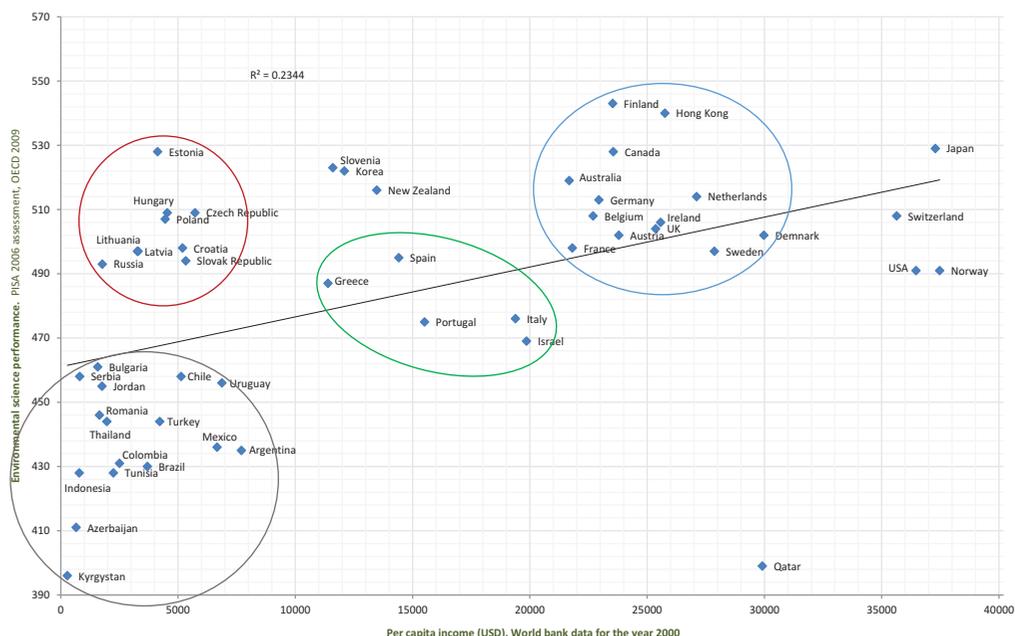
A comparison between *science* and *environmental science* performance as measured by the OECD in the 2006 PISA reveals a disparity between the two indexes (Figure 1). An explanation could be that the science performance index is a representative of the general standing of a country's educational system, whereas the environmental science index is indicative of focused initiatives that have specifically affected the environmental literacy component. This difference that produces different country rankings in environmental science performance than in science performance can be attributed to the impact of environmental education.

A number of observations can be extracted from the juxtaposition of the environmental science performance index with national GDPs per capita (Figure 2). First, the trend line (with a coefficient of determination of  $R^2 = 0.2344$ , significant at the 99.9% level of confidence) denotes that wealthier countries are somewhat more likely to display higher levels of environmental science literacy. However, this is not to be taken as an argument for economic determinism because there are serious positive and negative deviations such as Estonia and Qatar, respectively. So, apart from economies, educational system initiatives could help develop

**Figure 1. National performances in science and environmental science. Countries are ranked according to performances in environmental science. Data source: OECD (2009).**



**Figure 2. Linear correlation of environmental science performance index with GDP per capita. Data sources: OECD (2009), World Bank (2000).**

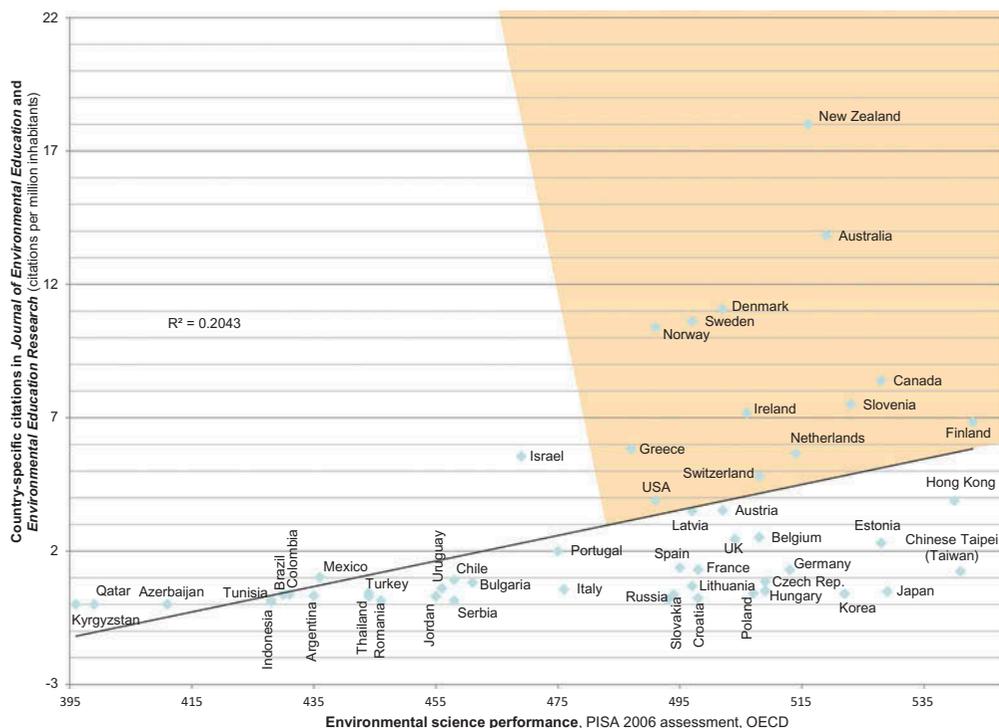


high levels of environmental science literacy in student populations. It would be interesting to explore the qualitative characteristics that have enabled certain countries to stand above the trendline and perform better than expected based on their economic capabilities.

Observing qualitatively, this graphic representation produces geographical and socioeconomical conglomerations of countries, which are noted by coloured circles. The blue line designates a group of high-income countries with high educational performances that used to be called “the first world”. The red circle designates a group of lower-income central and northern European countries, which declared themselves socialist for much of the twentieth century, when they were referred as “the second world”. These countries have experienced a suppression of their GDP per capita but were able to maintain high educational performances. Finally, in the black circle we can see that poor educational outcomes form a loop cycle with economic disparity in what we once called “the third world”. The green circle represents a group of Mediterranean countries that stand socioeconomically (and geographically) between the three major groups. It is interesting to see how the post WWII social and political order is still in effect today and able to manifest itself through this analysis of educational outcomes.

Figure 3 presents the application of the methodological tool that was developed for the needs of this research. It shows a statistically significant (at the 99.9% level, with  $R^2 = 0.2043$ ) positive correlation between students’ environmental science performance and the frequency of citations that their countries receive by leading environmental education periodicals. Countries that achieve lower performance in environmental science assessments tend to receive fewer citations in environmental education literature. Furthermore, the science performance index is less dependent on the frequency of citations by environmental education periodicals than the environmental science index, with a  $\tan\theta = 0.0409$  for the science/frequency of citations by environmental education periodicals correlation and  $\tan\phi = 0.0478$  for the environmental science/frequency of citations by environmental education periodicals correlation. This gradation is consistent with the research rationale and adds credibility to the OECD indexes.

**Figure 3. Linear correlation of environmental science performance index (OECD, 2009) with weighted country-specific citations in Environmental Education (EE) literature.**



According to the rationale of the methodological instrument, the countries that display a high value for both parameters occupy the top right quadrant of the diagram and are considered to have developed the most effective environmental education programmes. These countries are, in order: New Zealand, Australia, Finland, Canada, Denmark, Slovenia, Sweden, Norway, Ireland, the Netherlands, Switzerland, Greece and the USA. Although economic affluence plays a part (Figure 2), it is not an imperative for the development of effective and extensive environmental education frameworks.

### 5. Discussion

In this study, we sought to establish a meaningful connection between OECD environmental literacy data and the effectiveness of environmental education programmes. Data validity was established through the correlation of environmental science literacy outcomes with frequency of citations by leading environmental education periodicals, both being plausible causal consequences of the general quality of environmental education in a nation. A high value for both variables indicates national systems that may have actively engaged in environmental education and fostered innovation in the field.

The correlation of environmental science literacy with frequency of citations by leading environmental education periodicals is significant at the 99.9% level of statistical confidence. However, the moderate coefficient of determination value ( $R^2 = 0.2043$ ) allows for the presence of a multi-variable system. This may suggest that the two parameters (environmental education and environmental science literacy) are not directly linked. Rather, a correlation of this order is consistent with the two parameters having an indirect link, both being common effects of the general quality of environmental education in a nation. On the other hand, a steeper slope for the environmental science performance/frequency of citations in environmental education literature regression line (Figure 3) in comparison to the science performance/frequency of citations in environmental education literature regression line defends the validity of both the present research design and the OECD indexes.

Furthermore, there are some interesting patterns arising from the heteroscedastic distribution of countries in Figure 3. Essentially, there appear to be three groups: low alpha and beta, high alpha with low beta, and high alpha and beta. The fact that there are no countries with low alpha but high beta, i.e. with relatively poor PISA scores but often cited in the literature, suggests that a country's PISA score (alpha) is indeed a reliable indicator of the quality of environmental education in that country. Every country with a high frequency of citations in environmental education literature has an above-than-average environmental science literacy performance. On the other hand, frequency of citations (beta) is reliable in only one direction: strong academic interest in a country is significant, since it always aligns with a high PISA score, but weak interest may well be a fluke. For instance, the fact that Chinese Taipei (Taiwan) has not attracted very strong research attention is not a reliable signal that the quality of environmental education found there is low (the opposite is likely true).

It is important to note that we are aware of socioeconomic and educational inequalities in the development of environmental education, and the tension arising from conflicting levels of social, political and economic development. Therefore, we addressed this issue at the outset to improve the quality of environmental education. In the first stage of data analysis, we found a positive relationship between students' proficiency in environmental science and a country's GDP per capita. A higher percentage of students from countries with a high GDP per capita (e.g., Finland, Hong Kong, Japan and Canada) achieve the highest level in the PISA assessment for environmental science. Along with increased environmental awareness, these countries often invest more in scientific research and educational development in order to create alternative, advanced technologies and innovative talents to respond to environmental issues.

However, socioeconomic and educational inequalities may not be the only factors affecting quality in environmental education and environmental science literacy. Our data show that students in some nations with relatively lower per capita income demonstrate high environmental science proficiency. In particular, students in New Zealand, South Korea, and Slovenia outperformed their counterparts in other countries with higher or similar levels of economic development (e.g., Portugal, Italy and Israel). According to the OECD report, children in the aforementioned countries are highly literate in environmental science, judging by their knowledge of complex environmental issues and their willingness to take responsibility in building a sustainable society at local and global levels. We suspect that a focused policy on cross-sector environmental activity between schools, society and the means of production could be the key to environmental innovation and improvement of the quality of environmental education.

## 6. Conclusion

This research concurs to the potential of environmental literacy as an indicator of quality in environmental education. A positive correlation was established between the frequency of citations by leading environmental education periodicals and environmental science literacy among the 56 OECD member states and partner countries. Countries that received frequent citations in environmental education literature were unequivocally shown to produce enhanced environmental science performances. Although a country's economic affluence plays a part, it is not an imperative for the development of effective environmental education frameworks. Instead, countries with a high standing in environmental literacy are those that have implemented consistent, long term policies focused on environmental education.

## 7. Contribution and implications

For the needs of this research, an instrument was developed that combined the OECD environmental science performance index with bibliometric evidence from the literature of environmental education in an effort to produce an empirical assessment of environmental education programmes. The presence of a statistically significant correlation between these two indicators adds credibility to both OECD results and the discussed environmental education journals (i.e. *The Journal of Environmental Education* and *Environmental Education Research*). It also helps to reinforce environmental literacy as a concrete

concept that can have measurable effects through multilevel educational processes. Future research can demonstrate if these results can be reproduced through a broader sample of the academic literature featuring environmental education. Further, explanatory research can help us shed light on the specific cognitive paths that lead from environmental education to environmental literacy.

#### Supplementary material

Supplemental material for this article can be accessed here <https://doi.org/10.1080/2331186X.2018.1542961>

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#### Notes

- Note that the term system is used here to describe a set of connected elements and does not always imply a centralised, hierarchical structure. Thus, a country's environmental education system refers to the aggregate of institutional, formal, informal, governmental, non-governmental, grassroots, public and private entities involved in the field.
- Over the last decade, *The Journal of Environmental Education* and *Environmental Education Research* led the group of periodicals addressing environmental education, as demonstrated by the metrics employed by Scopus: CiteScore, SJR and SNIP (Scopus, 2018).
- The coefficient of determination ( $R^2 = 0.2043$ , Figure 3) suggests that 20.43% of the variability in the OECD environmental science literacy scores can be predicted from the relationship with country-specific citations. This value allows for the presence of confounding variables.

#### Correction

This article has been republished with minor changes. These changes do not impact the academic content of the article.

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