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ASSESSING NATIONAL DATA ON THE RELATIONSHIP BETWEEN SCIENCE EDUCATION AND ENVIRONMENTAL PERFORMANCE

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By

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INTRODUCTION

1.1 Introduction

Environmental knowledge and action are necessary to create a future based on sustainable development. Sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987). The importance of sustainable development can be seen, for example, in the need to control infectious diseases such as West Nile virus, Dengue, and Influenza. These diseases are triggered by climate variability, changes in the environment, biodiversity, and human behavior (Mathis, 2015), which are addressed within sustainability education. Addressing health epidemics and environmental problems such as disposal of waste and environmental impact involves significant changes in policy and consequent human behavior. Such transformation begins with education. Children and adolescents in our current school system will soon become active citizens in the political process, which gives them the power to create a sustainable future.

How do we know if schools are proficiently educating children to move towards a sustainable future? One way is to assess their scientific literacy, which encompasses environmental scientific knowledge. Scientific literacy is defined as the ability to identify questions and draw evidence-based conclusions in order to understand, make decisions about the environment, and the changes made to it through human activity (Schleicher and Tamassia 2000). Scientifically literate students understand the skills needed to investigate a scientific subject, have knowledge of underlying environmental principles, and know how to apply them (OECD 2009). Students who have high performance in environmental science are also more likely to demonstrate concern about environmental issues and have positive regard for environmental stability (OECD 2009). They are also more likely to engage in environmentally responsible behaviors (Müller, Kals, and Pansa 2009; Frantz and Mayer 2014; Hinds and Sparks 2008).

One ideal program that teaches students environmental science and how to become scientifically literate is Education for Sustainable Development (ESD). ESD allows every human being to acquire the knowledge, skills, attitudes, and values necessary to shape a sustainable future, while using participatory teaching and learning methods to motivate and empower students to change their behavior (UNESCO, 2014).

Altering internal individual behavior is not the only way to support the global shift towards a sustainable future, Behavior could also be affected by a government's environmental policies. The ability to fund environmental policies, however, could be influenced by a country's level of wealth, which is often measured by Gross Domestic Product (GDP).

Building on the power of science education, this research investigates how student science test scores and Gross Domestic Product (GDP) have an effect on a country's actual environmental performance. Understanding the relationship between these variables can contribute to existing literature on ESD.

1.2 Background

Many topics within ESD can be linked to science education. These topics include climate change, biodiversity, sustainable lifestyles, water, disaster risk reduction, and sustainable urbanization (UNESCO 2014), all of which enhance skills within science education and have been long known to provide students with an understanding of the workings of the environment.

There has been a variety of goals within science education, including teaching students to be informed citizens and learning about science as a particular way of examining the natural world (DeBoer 2000).

1.3 Purpose of study and justification

This research attempts to describe a relationship between environmental performance and a country's level of science education, as well as curriculum topics used to increase environmental knowledge in students. This study is intended to advance the efforts of countries to help educators become more aware of the importance of topics taught within science education, and how to teach those topics. This research could also help educators attain knowledge to assist children in becoming environmentally conscious throughout their lifetime.

1.4 Research Questions

1. Is science education correlated with a country's environmental performance? Within science education, a typical middle school student will learn natural sciences, physical sciences, and earth science. This includes learning about how the natural world works, as well as how living systems are codependent. Students who perform proficiently within these topics are known as scientifically literate. Students, whether they perform well in science or not, will become active citizens within their country, and therefore will have the choice to make decisions regarding moving towards a more sustainable future. This research question investigates whether students who are scientifically literate are part of countries which perform higher environmentally.

2. Is there a relationship between Gross Domestic Product (GDP), science education, and environmental performance? A country which has a higher GDP is known to have more wealth than countries with a lower GDP. Countries with a higher GDP typically have more money to allocate for school systems, and therefore to spend on science materials, qualified teachers, and sufficient spaces for students to learn in. This could also include funding for trips outside of school where there can be hands on learning that would not normally take place inside the classroom. This research question investigates whether countries that have a higher GDP have students that perform higher in science education and are therefore part of a country that performs high environmentally.

3. What are common curriculum topics within the top Programme for International Student Assessment (PISA) and environmental performers? PISA is a triennial international survey which aims to evaluate education systems by testing real world application of skills and knowledge of 15-year-old students. This study used 2006 data. This research question investigates the common curriculum topics taught within the top ten performers of PISA 2006. This could indicate topics that countries could strive to teach within their school systems in order to perform better environmentally.

CHAPTER 2
LITERATURE REVIEW

2.1 Overview

Students must be able to apply learned science outcomes to real-life challenges, be aware of environmental and socio-political issues, acquire environmentally responsible behavior, and encompass cognitive skills and affective qualities (OECD 2009). Countries that produce a high performance in scientific literacy teach their children curriculum topics which connect the student to sustainable lifestyles.

The beginning of this chapter discusses Education for Sustainable Development (ESD) which is not typically included in science education. However, high quality science education does include educating for Sustainable Development, it is a subject that is a stepping stone to apply science education to current wicked problems. Topics of discussion within this section include diversity of ESD and challenges within ESD.

The next section of this chapter discusses education, including whether a school includes environmental courses, socio-scientific courses, and discussion on when a school demonstrates the importance of having a relationship with nature. What is included in the curriculum defines what students learn throughout their time in the education system. When students are taught new disciplines in science education, such as sustainability, they could have more empathy towards the way they treat the environment, as well as them being more conscious of how their behaviors affect it.

In section three, different teaching methods are discussed: conventional and experiential. Conventional teaching methods focus on textbooks as their main source of information conveyed to the students, while experiential education focuses on students building a connection through experience, and therefore forming a relationship with nature which could affect environmental behavior.

Section four briefly discusses how environmental policy can have an effect on environmental performance. Environmental policy can be influenced by different variables, one of these being the amount of education within the country (Gallego-Alvarez et al. 2014).

Lastly, this chapter focuses on students' attitudes towards the environment. This includes whether children believe in improving value of the environment, what influences pro-environmental action, their willingness to protect the environment, their priorities, and outlook of the future of the environment. All of these topics discussed within this section could have a relationship with how a student will act once they become active citizens within their country.

2.2 Education for Sustainable Development.

Fundamental sustainable development issues are incorporated in teaching and learning sustainable development, including climate change, disaster risk reduction, biodiversity, poverty reduction, and sustainable consumption. It also includes methods that motivate and empower learners to change their behavior and take action towards sustainable development (UNESCO 2014). ESD is not a term which focuses on one discipline, rather it can take place in all subjects. But many teachers believe ESD is an additional burden and they do not have the resources or time for it (Wheeler and Byrne 2003).

"Educating for a sustainable future is focused on how to get beyond reduction and analysis to the synthesis and integration of what we know and can know. The education community has not found it easy to shift from specific, discrete educational topics to a more integrated systems approach" (Wheeler and Byrne 2003, pg. 3).

2.2.1 Diversity in ESD. According to Sauvé (1996) there are four ways to achieve sustainable development: first, technological innovation using education as training or as an information transfer process; second, ESD is to be dependent on world order with a similar educational paradigm as the first noted; third, a need for a complete global shift in social values with an educational paradigm of a community-led process of critical investigation toward the transformation of social realities; and lastly, via cultural values, with the paradigm constructing contextual significance and useful knowledge, taking into account traditional values and know-how. These four concepts could be used as a map to achieve sustainable development, but there is still much ambiguity with the term. Discourse among scholars and educators is still needed to define the goals of ESD (Sauvé 1996; Connelly 2007).

The understanding of sustainable development is lacking a simple, visualizable organizing principle to establish the relationship between competing ideals (Connelly 2007). The fact that the definition of the term is still being contested makes one think about "the struggle over the direction of social and economic development, and the utility of simple messages in mobilizing opinion" (Connelly 2007, pg. 4). ESD needs to consider an interdisciplinary approach that can shed light on the education systems lack of addressing current environmental crises (Kopnina 2012; Bögeholz et al. 2014).

2.2.2 Challenges in ESD. It is the educator's personal theory within the classroom as to how they will teach curriculum to children on a day to day basis (Sauvé 1996). Within the classroom sustainable development merges with environmental education to interface with other educational dimensions such as peace education and equity, media education, and more (Sauvé 1996). However, some scholars view ESD differently, stating much of the global curriculum lacks to include environmental education (Chowdhurry 2014; Hopkins 2013; Bögeholz et al. 2014).

Global education has long been a topic of conversation within the United Nations Educational, Scientific, and Cultural Organization (UNESCO). A report authored by UNESCO in 1992 titled *The Earth Charter* was a result of the Earth Summit in Rio de Janeiro. The document stated a formal call to include the tools for students to be able to take part in a sustainable lifestyle. This included providing children with educational opportunities to actively take part in a sustainable lifestyle, enhancing the role of mass media of raising awareness of ecological and social threats, and promoting the arts, humanities, and sciences in sustainability education (Clugston, Calder, and Corcoran 2002). The report made an attempt to bring countries together regarding the importance of the interrelationship between humanity and the Earth. There was, then, a summit in South Africa in 2002 where it was hoped the United Nations would adopt *The Earth Charter*, where instead the summit closed with an announcement that $235 million worth of public-private partnerships had been achieved, and no action regarding educating students on sustainability had taken place (Kahn 2008). This shows an underlying challenge for

ESD that includes collaborations between corporations, rather than taking action to educating students on sustainable development.

2.3 Education

In order for students to succeed as citizens, an international definition is needed to explain the qualities within the education system to teach our children how to solve complex problems and have decision making skills regarding environmental issues (Bögeholz et al. 2014; Hopkins 2013). Success also depends on the mission and goals of the education system as a whole, including sustainability education (Hopkins 2013).

2.3.1 Environmental courses. Eighteen schools in Texas agreed to allow their students to be part of a 10 day environmental science course in a study performed by Texas A&M. Students completed a pre and post-test of environmental knowledge. After completing the environmental science course students' environmental knowledge scores increased by 22%, as well as their attitudes towards the environment (Bradley, Waliczek, and Zajicek 1999).

Sweden involves learning about the environment throughout their curriculum of primary and secondary schooling. "Pupils apply well developed and well informed reasoning about how people and technology affect the environment and show from different perspectives the advantages and limitations of some measures that can contribute to sustainable development" (The Swedish National Agency for Education 2011, pg. 114).

2.3.2 SSI and STSE Education. "Socio-Scientific Issue (SSI) education is equated with the consideration of ethical issues and construction of moral judgments about scientific topics via social interaction and discourse" (Zeidler et al. 2005, pg. 4). In Germany, a main focuses within their science education includes an emphasis on socio-scientific reasoning and decision making (Bögeholz et al. 2014).

Extending on the ideals within SSI, many scholars also recognize the need to extend Science, Technology, and Society (STS) education. This includes the subject of the environment (Zeidler et al. 2005; Hodson 2003), which is sometimes called Science, Technology, Society, and Environmental education (STSE).

Hodson calls for "extending the definition of scientific literacy to encompass a measure of political literacy, prioritizing the affective, and making much greater use of informal and community-based learning opportunities" (Hodson 2003, pg. 5). In 2010, Hodson then, called for a more radical form of SSI education where "learning in which students not only address complex and often controversial SSI, and formulate their own position concerning them, but also prepare for, and engage in, sociopolitical actions that they believe will make a difference" (Hodson 2010, pg. 4).

A study performed by Colucci- Gray (2006) used role-play in order to teach students about different socio-scientific issues. The goal was to introduce students to complex issues, and to development different competencies such as dialogue, active listening, empathy, respect for others, and identification of basic common needs. This taught students about the importance of the intertwining of multiple sciences (biology, physics, chemistry, and earth sciences) and aspects of social, economic, and political disciplines. Students were asked to role-play different scenarios on how to produce a cooperative plan and reach a positive outcome. Students who were involved in the study learned the importance of connectedness, relationships, and systems thinking in order to solve problems (Colucci-Gray et al. 2006).

2.3.3 Nature as a relationship. Environmental ethics is defined as the "systematic investigation of the moral relationships between people and the natural environment" (DesJardins 2013 pg. 17). Some of the main objectives of environmental ethics are actions that negatively affect all living things should be avoided, and responsibility for compensation action should be taken when human behavior does have this negative affect, as well as people taking responsibility for living things that will live after them (Under, H. 1996).

2.4 Teaching Methods

2.4.1 Conventional. The United States curriculum, in particular, varies from state to state, but many have no standards that involve environmental education. Teachers are taking their children outside less and less, with at least 19 states cutting funding for trips outside of the classroom by at least 5% between 2011 and 2013 (Ginn 2012).

Adding to the diminishing opportunities for learning outdoors, many science education textbooks do not include topics regarding why it is important to build a relationship with the environment. Texts include why the environment is important to us, and some also include the responsibility that humans have to the environment, but this lacks the need for children to understand why a relationship must be built (Lacin Simsek 2011).

Students who learn through textbooks are not able to see living complex systems in motion they would be able to during outside of the classroom experiences such as visiting zoos, environmental centers, and more. "The classroom is in itself a good example of a complex system consisting of people with interests, abilities, and values, all very different from each other. Many traditional teaching practices tend to simplify this system, in an artificial way, and miss the opportunity to realize its full potential. The top–down lecture is carried out at the expenses of the interaction amongst peers, the close-ended questioning prevents the expression of new and creative ideas, disciplinary teaching is an obstacle to the creation of transversal links, and the emphasis on memorizing facts and information interferes with possibilities for meta-reflection" (Colucci-Gray et al. 2006, pg. 23).

2.4.2 Experiential. In 1949 Aldo Leopold stated environmental problems could ultimately be traced back to the lack of human connection to nature (Leopold 1949). The more affective connections with nature, the greater one's intentions to engage with it, and therefore the more likely to have environmental concerns (Müller, Kals, and Pansa 2009; Hinds and Sparks 2008).

"At the heart of all learning is the way we process our experiences, especially our critical reflections on our experiences. Experiential education is a key approach to student-centered learning for a sustainable future. Experiential learning engages students in critical thinking, problem solving, and decision making in contexts that are personally relevant to them. This approach to learning also involves making opportunities for debriefing and consolidation of ideas and skills through feedback, reflection, and the application of the ideas and skills to new situations" (Cox, Calder, and Fien 2010, pg. 1).

The 'extinction of experience' is a term deemed in 2009 as the "reduced contact with nature which leads to a life of apathy and lack of concern for ecological issues" (Pyle 1978).

There are many factors that contribute for an absence of concern for the environment including students who lack an experience with the outdoors (Muller, Kals, and Pansa, 2009). A comparison of emotional affinity towards nature in German and Lithuanian students from both rural and urban areas revealed the more affinity to nature, as well as the awareness to risks to nature, largely influenced the willingness for pro-environmental commitments. But, contact with nature did not act alone, as the study revealed it acts as an indirect factor. One also needs an awareness of environmental risks in order for experience in the outdoors to have an effect on environmental behaviors (Müller, Kals, and Pansa 2009). The importance of personal experience is highlighted when environmental education offered hands on experience in addition to classroom theory (Mifsud 2012).

As a part of UNESCO Teaching and Learning for a Sustainable Future Program, experiential learning is included as a tool in order to reach goals of Sustainable Development. "Experiential learning engages students in critical thinking, problem solving and decision making in contexts that are personally relevant to them. This approach to learning also involves opportunities for consolidation of ideas and skills through feedback, reflection, and application of the ideas and skills to new situations" ("UNESCO | Teaching and Learning for a Sustainable Future | Module 20: Experiential Learning" 2010).

2.5 Environmental Policy

Policy has been one of the causes of shifts in attitudes towards the environment. One could have seen the United States as a pioneer for the environmental movement with the formation of the Environmental Protection Agency and passing the National Environmental Policy Act in the 1970s, but as time went on the U.S. quickly fell behind. The arrival of the energy crisis of 1973 caused a movement in which shifting our need to secure energy supplies became the most pressing issue. Interest groups were formed and had a large effect on policy from then on, causing many presidents to opt out of more environmental friendly policies. (Dryzek, Hunold, and Schlosberg 2002).

The research above shows just one of the variables that can affect environmental policy. Other variables include the quality and implementation of policies, dedication within the private sector, relationships with international environmental bodies, a country's institutional foundations, population density, GDP, and education (Gallego-Alvarez et al. 2014; Esty and Porter 2001).

2.6 Students' attitudes towards the environment

Students concerned with environmental issues will likely become adults who exhibit environmentally responsible behavior. According to a Harvard poll completed in 2015 55% of students believe global warming is real and due to human activity (Harvard Public Opinion Project 2015). There is also a lack of concern from youth regarding conservation behaviors (Wray-Lake, Flanagan, and Osgood 2010).

2.6.1 Improving value of the environment. In 2011, the Nature Conservancy conducted a poll of over 600 youth aged 13-18 in ongoing efforts to strengthen connections between youth and the outdoors. The poll revealed if American youth were given the opportunity to engage personally with the environment they would be more likely to have a valuable and meaningful experience. Sixty six percent of students said when "they had a personal experience in nature" it made them appreciate it more. As a result, they would be more likely to significantly express concern about water pollution, air pollution, global warming, and the condition of the environment (The Nature Conservancy 2011).

2.6.2 Influences. A study conducted in 2002 analyzed influences of environmental sensitivity within Wisconsin high school students (Sivek 2002). Environmental sensitivity is defined within this study as ‘an empathetic or understanding view of the environment’ (Sivek 2002, pg. 1). One hundred-fifty students from high schools around Wisconsin were placed in different focus groups for an environmental action conference. Three influence categories were assessed in each focus group interview: environmental, role model, and personality. The highest influences on going outdoors include accessibility to or frequency of visits to outdoor areas, opportunities for in depth learning and/or involvement, and freedom of choice and/or thought. Of role model influences, the highest value was placed on male teachers, parents, relatives, and friends. Personality influences of environmental sensitivity include locus of control, interpersonal communication style, and future orientation (Sivek 2002). This study concluded that high school teachers and environmental programs greatly influence a student’s environmental awareness and can increase concern for conservation of natural and wild areas (Sivek 2002).

The lack of concern for the environment could also be caused by the high amount of daily television and internet usage, with 88% of young people saying they spend time daily watching television or spending time online (The Nature Conservancy 2011). Some other reasons include bugs, heat, and no transportation to and from natural spaces (The Nature Conservancy 2011).

Despite the obstacles, much can be done to get youth outdoors such as social interaction. In fact, four in five children reported when they went outdoors it was regularly with friends, and nine in ten students pay attention to a friend’s encouragement to go outdoors (The Nature Conservancy 2011).

2.6.3 Willingness to Protect. A 1992 study revealed a healthy environment was a top concern for the majority of teens (Koenenn 1992). A 2004 national Gallup poll also indicated teens were more pessimistic about the quality of the environment, with 43% of 18-29 years olds stating they were worried a great deal about the quality of the environment (Gallup 2003). This outlook may lead to teens who are more willing to engage in proactive environmental behavior.

On the contrary, a survey conducted annually since 1976 of nearly 100,000 high school seniors showed students' attitudes have become more negative toward all environmental concerns within the past thirty years, and are continuing to do so. The measurements used within this study included environmental conservation behaviors, environmental responsibility, attitude toward pollution, resource scarcity, materialism, and belief in technology. The results indicated a decline in all environmental behaviors measured within the test, with conservation behavior suffering the largest loss (Wray-Lake, Flanagan, and Osgood 2010).

With student outlook wavering, government action could curb behavior a poll in 2007 showed. The majority of nine-hundred U.S. high school students expressed they were more willing to support the government if they would make lowering greenhouse gas emissions a priority (Arscott et al. 2007; Wray-Lake, Flanagan, and Osgood 2010; Harvard Public Opinion Project 2015). However, in 2011, teens did not have faith that the government would make it a priority, with only one-third believing that government leaders are doing a "good job to address this or any other major problem" (The Nature Conservancy 2011, pg. 2).

Many students believe the current state of the environment is a result of the lack of concern exhibited by previous generations, and most teens do not believe that adults see resolving environmental issues as a priority (The Nature Conservancy 2011).

2.6.4 Priorities. Research shows that students see air pollution as the most important environmental problem, followed by hazardous waste, water pollution, loss of biological diversity, and population increase in cities (Said, Yahaya, and Ahmadun 2007; Tuncer et al. 2005; Gigliotti 1992; Wray-Lake, Flanagan, and Osgood 2010).

2.6.5 Outlook. U.S. students' concern for climate change is lacking, with only 28% of 900 high school students polled that they felt climate change would affect them personally. African-American students are 12% more likely to believe it will affect them, and students who engage with their friends about environmental topics are 18% more likely to think climate change will have personal effects (Arscott et al. 2007).

CHAPTER 3
RESEARCH METHODS

3.1 Overview and Research Questions

This research adds to existing international analyses of science educations' effect on environmental performance. It also investigates the relationship between GDP and environmental performance. Environmental Performance is measured within this research by the Environmental Performance Index (EPI), a joint project between Yale and Columbia Universities which is measured by two objectives: ecosystem vitality and environmental health.

The goal of this research was to answer the following questions:

1. *Is science education correlated with a country's environmental performance?*
2. *Is there a relationship between Gross Domestic Product (GDP), science education, and environmental performance?*
3. *What are common curriculum topics within top PISA and environmental performers?*

This chapter will discuss the research methods employed to answer the above questions.

3.2 Background of PISA.

The Programme for International Student Assessment (PISA) is a triennial international survey which aims to evaluate education systems by testing real-world application of skills and knowledge of 15-year-old students (OECD, 2000). Within PISA reading, science, and mathematics is measured. This research uses PISA 2006 where science was the main domain. When a subject matter is a "main domain" the tests distributed are 2/3 of the questions related to that main domain, there were a total of 108 science questions in PISA 2006 (Bybee, McCrae, and

Laurie 2009). Each 1000 point test includes multiple choice and open-ended questions that apply their knowledge and skills to meet real-life challenges. Experts from participating countries serve on working groups which connect the program policy objectives with the best internationally available technical expertise in the assessment areas (Adams 2009).

PISA was first administered in 2000 with 43 countries involved. In 2003, 41 countries took part, and in 2006, 57 countries **(**Table 3.1). Together these 57 countries make up 90% of the global economy. PISA's framework is designed by the PISA Governing Board (PGB). The PGB is composed of representatives of participating OECD members and PISA associates. PISA associates are titled economies which are not OECD members but have membership rights and obligations in regard to specific OECD bodies and programs (OECD, n.d.) Countries that participate in PISA but do not have associate status are welcome to be involved as observers.

Table 3.1 Participating countries in PISA 2006

OECD Countries	Non-OECD Countries
Australia	Argentina
Austria	Azerbaijan
Belgium	Brazil
Canada	Bulgaria
Czech Republic	Chile
Denmark	Colombia
Finland	Croatia
France	Estonia
Germany	Indonesia
Greece	Israel
Hungary	Jordan
Iceland	Kyrgyzstan
Ireland	Latvia
Italy	Liechtenstein
Japan	Lithuania
Korea	Lithuania
Luxembourg	Montenegro
Mexico	Montenegro
Netherlands	Romania
New Zealand	Russia
Norway	Serbia
Poland	Slovenia
Portugal	Slovenia
Slovak Republic	Thailand
Spain	Tunisia
Sweden	Uraguay
Switzerland	
Turkey	
United Kingdom	
United States	

Participating countries appoint a National Project Manager who manages all implementations of the tests. National Project Managers not only ensure the tests are implemented correctly, they also verify and evaluate the test results, analyses, reports, and publications. The tests are designed by the PISA Consortium which is composed of international contractors led by the Australian Council for Educational Research. Other partners include the

National Institute for Education Measurement in the Netherlands, a national statistical survey research corporation called WESTAT from the United States, and the National Institute for Educational Policy Research in Japan (Organisation for Economic Co-operation and Development, 2006).

Each of the two hour tests are given to students via paper and pencil with 4,500-10,000 students from at least 150 schools being measured within each country. Tests include multiple choice items, open-ended questions, and close-constructed questions (Adams 2009)**.**

After the framework of tests have been developed they are reviewed by expert panels in each of the participating countries. A *double-translation and reconciliation procedure* takes place in order to ensure quality translation, this is defined as, "two independent translators first translating the source material into the target language; then a third person reconciling these two translations into a single national version" (Bybee, McCrae, and Laurie 2009, pg. 874). The tests are scored on a 1000 point scale, with staff members from the OECD scoring each student test that comes through the program.

Within the assessment of scientific literacy there are four categories in which content is selected to gauge scientific knowledge: physical systems, living systems, earth and space systems, and technology systems. These will be discussed more in depth in section 3.5.

Tests completed by students do not use any information from their specific curriculum, but gauges their knowledge on application to real life situations. One of the examples of a test question is based on knowledge of clean drinking water:

FIT FOR DRINKING: It is important to have a source of good drinking water. Water found underground is referred to as ground water. Give one reason why there is less bacteria and particle pollution in groundwater than in water from surface sources such as lakes and rivers (OECD 2006, pg. 40).

3.3 Background of EPI 2006.

The Environmental Performance Index (EPI) is a joint project between the Yale Center for Environmental Law and Policy (YCELP), the Center for International Earth Science Information Network (CIESIN) at Columbia University, the Samuel Family Foundation, and the World Economic Forum. This 150 country initiative was started in 2006. It ranks how well countries perform on environmental issues in two broad policy areas: environmental health and ecosystem vitality (Angel Hsu 2016). Within the 2006 EPI there were six broad categories measured: environmental health, biodiversity, energy, water, air quality, and resource management. EPI focuses on current policy action as opposed to historical trends and endowments (A. Hsu, A. Johnson, and A. Lloyd 2013).

2006 was the pilot year for the EPI, with 149 countries' providing data for this overarching policy performance indicator. Each objective represented (environmental health and ecosystem vitality) account for 50% of the total EPI score, countries are then scored on a 100 point scale with zero being the furthest away from reaching a country's goal and 100 if the country has achieved their target goal. Each dataset is based on a "proximity to target" method which assesses how close a country is to meeting its policy target. The targets are based upon international treaties, scientific thresholds, and an analysis of best performers. Within the pilot project there were 25 environmental indicators measured within six broad categories (Table 3.2). These are discussed more in depth in section 3.6.

Table 3.2 Environmental indicators EPI 2006

Environmental Health	**Air Pollution (effects on ecosystems)**	**Water**	**Biodiversity & Habitat**	**Productive Natural Resources**	**Climate Change**
• Environmental Burden of • Disease • Local Ozone • Adequate Sanitation • Drinking Water • Indoor Air Pollution • Urban Particulates • Local Ozone	• Regional Ozone • Sulfur Dioxide Emissions	• Water Quality Index • Water Stress	• Conservation Risk Index • Effective Conservation • Critical Habitat Protection • Marine protected areas	• Growing Stock • Marine Trophic Index • Trawling Intensity • Irrigation Stress • Agricultural Subsidies • Intensive Cropland • Burnt Land Area • Pesticide Regulation	• Emissions/ capita • Emissions/ electricity generated • Industrial carbon intensity

3.4 Process of analysis.

Individual variables including identifying scientific issues, explaining phenomena scientifically, and using scientific evidence were used from PISA 2006 and compared to the overall EPI 2006 score to investigate research question number one, whether science education is correlated with a country’s environmental performance. For research question number two, is there a relationship between Gross Domestic Product (GDP), science education, and environmental performance, a multiple regression analysis was completed in order to determine if there was a relationship between the three datasets. For research question number three, what are common curriculum topics within top PISA and environmental performers, a curriculum analysis was performed to determine whether there are common curriculum topics taught within the top performers of PISA and EPI. This curriculum analysis consisted of an online examination into each of the top ten performers' national curriculum of both PISA 2006 and EPI.

3.5 Variables within PISA.

Individual variables were chosen within 2006 PISA in order to best capture indicators of science scores. In PISA 2006 there are six proficiency levels within three scientific competency scales: identifying scientific issues, explaining phenomena scientifically, and using scientific evidence.

Identifying scientific issues (also known as knowledge about science) and explaining phenomena scientifically (also known as knowledge of science) were individually assessed on a competency scale within PISA 2006. Using scientific evidence encapsulates knowledge of science and knowledge about science. Knowledge of science includes earth and space systems, living systems, and physical systems and are therefore not gauged individually within competency levels (OECD 2007). Below are justifications for chosen variables in order to gain knowledge of how well students performed in each category within science education.

3.5.1 Mean score in student performance on the identifying scientific issues scale. This variable was chosen to investigate if student test scores in identifying science issues are correlated to their country's environmental performance. If a student is moderately proficient in identifying scientific issues they achieve level three within the proficiency scale. These students are able to "identify the quantities able to be scientifically measured in an investigation, distinguish between the change and measured variables in simple experiments, and recognize when comparisons are being made between two tests (but are unable to articulate the purpose of a control)" (Adams 2009, pg. 296).

3.5.2 Mean score in student performance on the explaining phenomena scientifically scale. This variable was selected to infer if student test scores in explaining phenomena scientifically are correlated to their country's environmental performance. If a student is moderately proficient in explaining phenomena scientifically they achieve level three within the proficiency scale. This is defined as students being able to "understand the central feature(s) of a scientific system and, in concrete terms, can predict outcomes from changes in that system (e.g. the effect of a weakening of the immune system in a human). In a simple and clearly defined context they can recall several relevant, tangible facts and apply these in developing an explanation of the phenomenon" (Adams 2009, pg. 298).

3.5.3 Mean score in student performance on the earth and space systems scale. This variable was chosen to identify if student test scores in earth and space systems are correlated to their country's environmental performance. If students are proficient in this scale they are knowledgeable in the structures of earth systems, the energy in the earth systems, the change of the earth systems, the earth's history, and earth in space (OECD 2009).

3.5.4 Mean score in student performance on the living systems scale. This variable was selected to identify if student test scores in the living systems scale are correlated to their country's environmental performance. The "living systems scale" includes the knowledge of cells, ecosystems, biosphere, populations, and humans (OECD 2009).

3.5.5 Mean score in student performance on the physical systems scale. This variable was chosen to investigate if student test scores in the physical systems scale are correlated to their country's environmental performance. This includes the structure of matter, motions and forces, interactions of energy and matter, properties of matter, chemical changes of matter, and energy and its transformations (OECD 2009).

3.6 Variables within EPI.

Within the EPI there were 25 environmental indicators in 2006. Ecosystem health is defined as reducing environmental stresses to human health and ecosystem vitality is defined as promoting ecosystem strength and sound natural resource management (Etsy et al. 2008).

These two objectives funnel into six categories: environmental health, air pollution, climate change, biodiversity & habitat, water, and productive natural resources (Etsy et al. 2008). There are then 25 specific environmental indicators (Table 3.2). Each of the indicators were reported on by each country involved in EPI 2006. The EPI uses primary and secondary data from multilateral organizations, government agencies, and academic collaborations. Primary data is comprised of information gathered directly by human or technological monitoring, including satellite-derived estimates of forest cover and air quality. Secondary data include national-level statistics subject to the reporting and quality requirements established by data collection entities, such as the International Energy Agency (IEA) ("Methods | Environmental Performance Index - Development" 2016).

3.7 Method of Data Analysis

3.7.1 Regression Analysis. In order to properly assess each individual variable, each country that took part in PISA and EPI 2006 were compiled into a table (Figure 3.1). A multiple regression analysis was run with each chosen variable from PISA 2006, GDP, and a country's overall EPI score.

3.7.2 Curriculum Analysis. An examination of the top ten performers in PISA 2006 was completed in order to identify consistencies within the top ten performers of EPI 2006. After identifying the top ten countries in EPI and PISA 2006, an identification of each of the country's curriculum took place. This consisted of identifying key curriculum topics of each country's curriculum. Common curriculum components consisted of inclusion of responsibility to the environment, experiential learning, and sustainability.

3.8 Limitations of Study

Of the 196 countries, only 52 countries were examined during this study because of data availability. The Environmental Performance Index of 2006 includes 149 countries, while PISA 2006 focuses on 57. Because data was not available through EPI 2006 these countries/regions were omitted from the study: Indonesia, South Korea, Japan, Hong-Kong China, Macao-China, and Taipei-Thailand. Thus the 52 countries that had both EPI and PISA data available were used for this study.

Secondly, this study uses data from 2006. This was chosen because this was the last year PISA focused on science as its main domain. Very recently, science was also the main domain in 2015, but data was not available at the time of this study. It will be accessible December 2016.

Experiential education can be taught in many different forms and is not always documented within countries. This study was only able to access pedagogical techniques which were made public online within each country.

CHAPTER 4
RESULTS

4.1 Introduction to Results

Data from 2006 was used for this study. The beginning of this chapter describes analysis of the secondary data revealing indications of science education and its effect on environmental performance. The next section shows the result of GDP, science test scores, and their effects on environmental performance. The last section focuses on common curriculum topics that are included in both top PISA and EPI 2006 performers. These topics are: responsibility to the environment, experiential education, and sustainability education. Responsibility to the environment is defined within this research as terminology geared towards students learning about humans and their interactions with the environment. For the countries identified, some of the language within the national curriculum included: protecting nature, respecting nature, improving the environment, humans and their interactions with nature, and working together with nature.

4.2 Science Education and Environmental Performance

4.2.1 Mean score on identifying scientific issues scale. A regression analysis using PISA 2006 mean scores on identifying scientific issues scale and a country's environmental performance revealed a positive relationship. The highest performer in this scale were students from Finland, scoring a mean of 555 on PISA 2006, followed by an EPI score of 76% (the tenth performer in EPI 2006). The lowest performer of PISA 2006 is Kyrgyzstan with a mean score of 321, and EPI score of just over 40% (the lowest in EPI 2006).

With a p-score < .01 and an adjusted R squared of .68, this shows almost 70% of the variance of environmental performance is explained by how proficiently students perform in identifying scientific issues (Figure 4.1).

Students who are able to identify scientific issues are able to articulate scientific design through a complex investigation technique. Students can use key words to search for scientific information and recognize key features of a scientific investigation (Bybee, McCrae, and Laurie 2009). An example of performing this competence includes a question regarding acid rain. Students are given a picture of marble statues in ancient Greece that states acid rain had damaged the statues. Students are given an experiment that explores the effects of acid rain which includes scientists placing marble in vinegar water and another set of marble chips in distilled water. Students are then asked to explain why the experiment involved putting the marble chips in vinegar water and distilled water (Zeidler and Sadler 2009). This competency allows students to designate the importance of experimental design and the use of controls within an experiment. Students who are knowledgeable within this area can design an experiment thoroughly and ask the associated questions to complete the experiment. This could affect their ability to identify environmental issues and then design an experiment to answer the question posed because of the problem. These results support prior research which states science education does affect a students' environmental attitudes (Boeve-de Pauw and Van Petegem 2010; OECD 2009; Anna Uitto, Jelle Boeve-de Pauw, and Seppo Saloranta 2013).

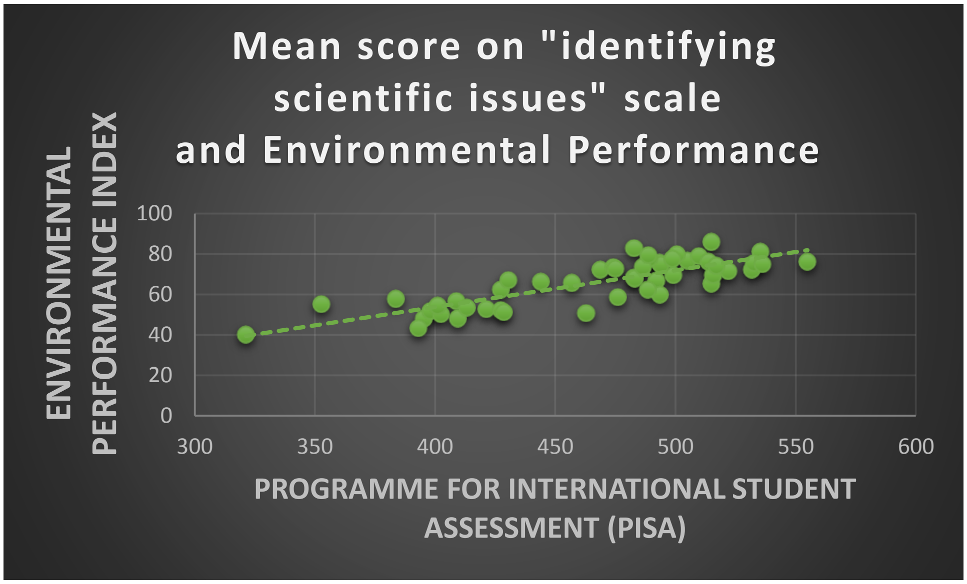

Figure 4.1 Relationship between identifying scientific issues and environmental performance

4.2.2 Maps displaying relationship between identifying scientific issues and environmental performance. Below are maps that indicate visual relationships between identifying scientific issues and environmental performance. These will be discussed further in chapter 5.1.

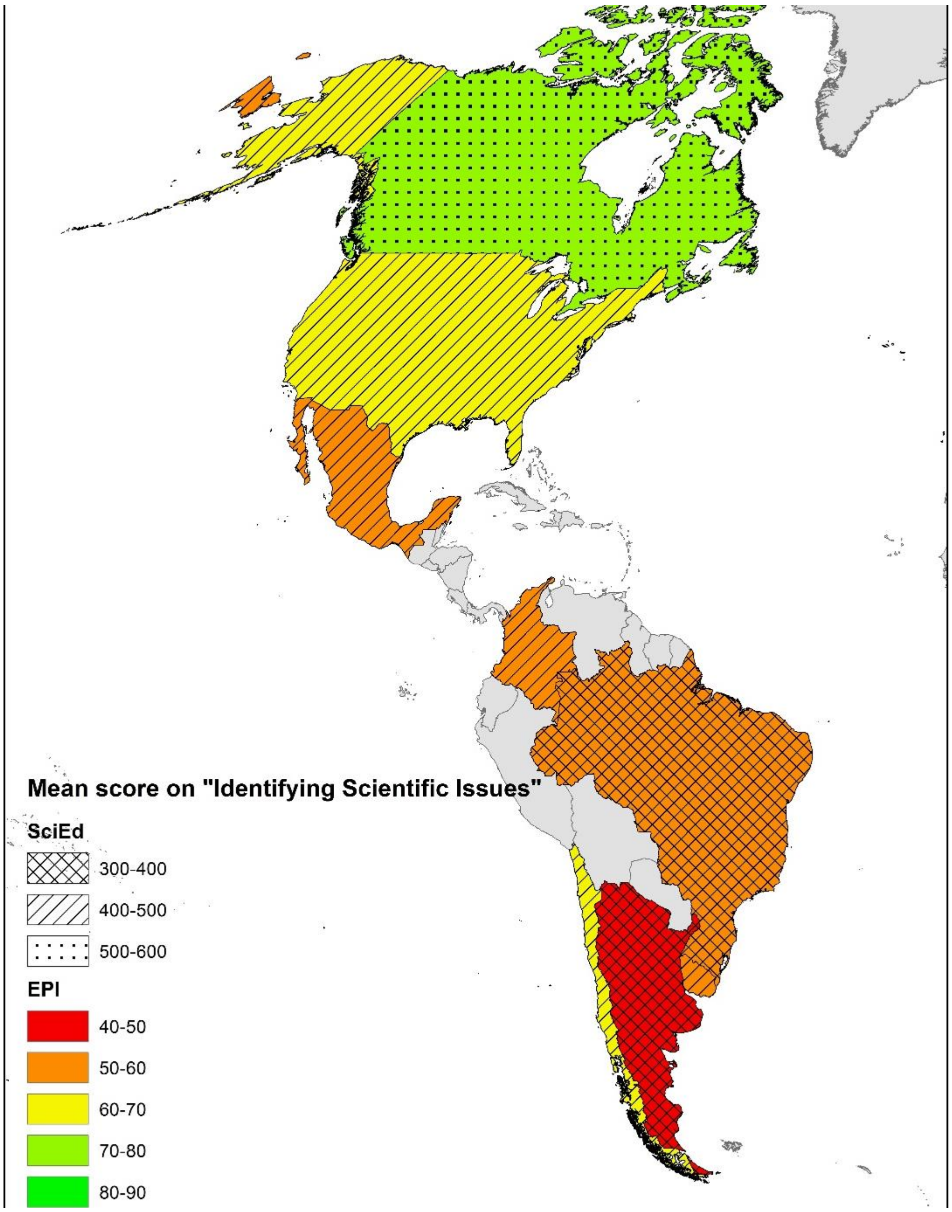

Figure 4.2 Relationship of identifying scientific issues and environmental performance in North and South America

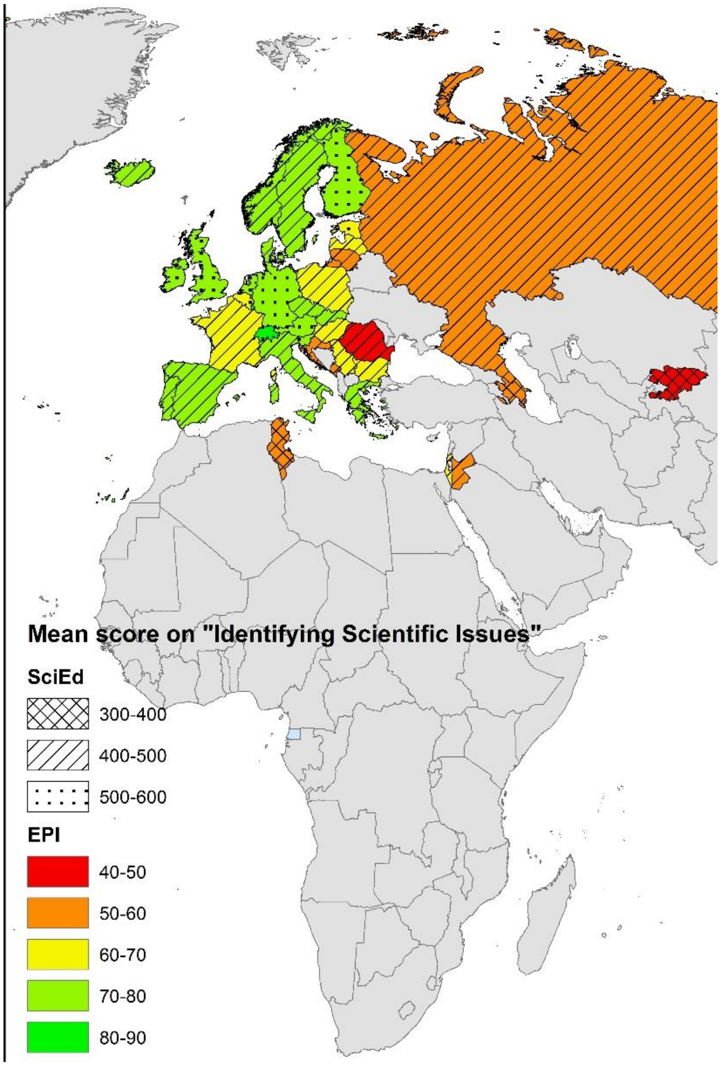

Figure 4.3 Relationship between identifying scientific issues and environmental performance in Europe and Middle East

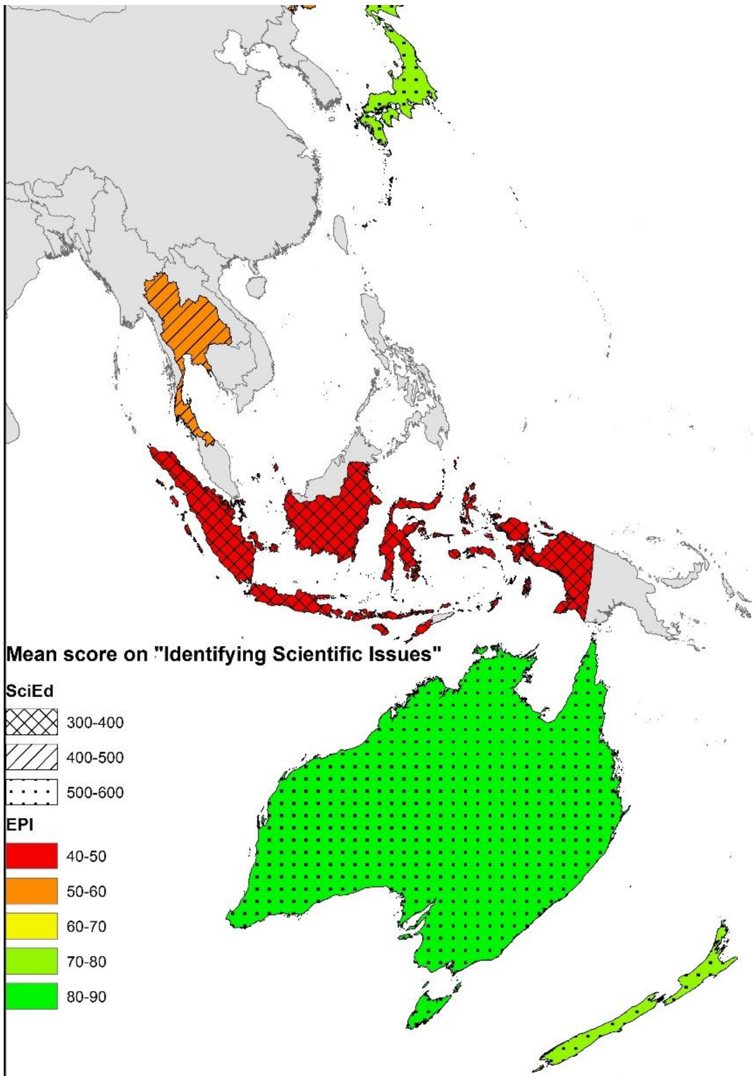

Figure 4.4 Relationship between identifying scientific issues and environmental performance in Southeast Asia and Australia

4.2.3 Mean score in student performance on the explaining phenomena scientifically scale. A positive relationship is shown between students explaining phenomena on the scientific scale and environmental performance. The top performer of students being able to explain phenomena is Finland as well, with a mean score of 566 per student and an EPI score of 76%. The lowest performer again being Kyrgyzstan with a mean score of 334 and an EPI score of 40%.

With a p-value <.01 and an adjusted R squared value of .67, explaining 67% of the variance of environmental performance is explained by the proficiency of students explaining phenomena scientifically (Figure 4.5).

Students who are able to explain phenomena scientifically are able to apply knowledge of science to a given situation. An example of utilizing this competency could be when individuals read about a health-related issue, they can separate scientific from non-scientific aspects of the text, and apply knowledge and justify personal decisions. Or students are able to identify evidence-based explanations versus personal justifications (Zeidler and Sadler 2009). This competency gives students the tools to decipher different areas of information presented to them and therefore may be able to make sound environmental decisions as active citizens of their countries.

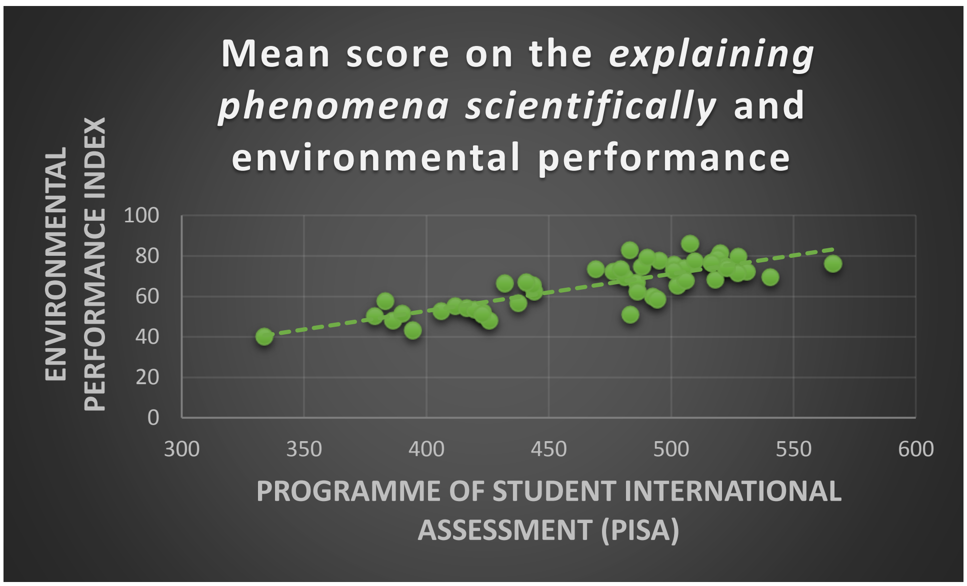

Figure 4.5 Relationship between explaining phenomena scientifically and environmental performance

4.2.4 Mean score in student performance in earth and space systems. A regression analysis found a positive relationship with student performance in earth and space systems and environmental performance for countries in this study. The top performer of proficiency in the living systems is Finland with a mean score of 574, and EPI score of 76%. The lowest performer is Kyrgyzstan with a mean score of 330 and EPI score of 40%. The analysis showed a p-value <.01 and an adjusted R-squared value of .63, or 63% of the variance of environmental performance explained by the proficiency in explaining earth, space, and systems (Figure 4.6).

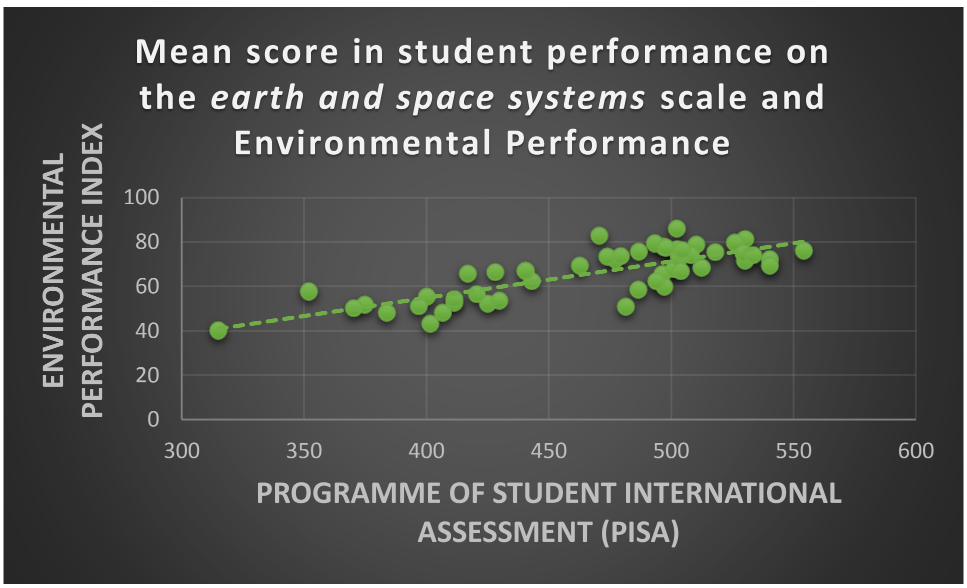

Figure 4.6 Relationship between student performance on the earth and space systems scale and Environmental Performance

4.2.5 Mean score in student performance on the living systems scale. There is a positive relationship between knowledge of the living systems scale and higher environmental performance. The top performer in the earth and space systems scale is Finland with a mean score of 554, and EPI score of 76%. The lowest performer is Kyrgyzstan, with a mean score of 315, and an EPI score of 40%. With a p-value <.01 and an adjusted R squared value of .68 or

68% of the variance of environmental performance explained by the proficiency on the "living systems" scale (Figure 4.7).

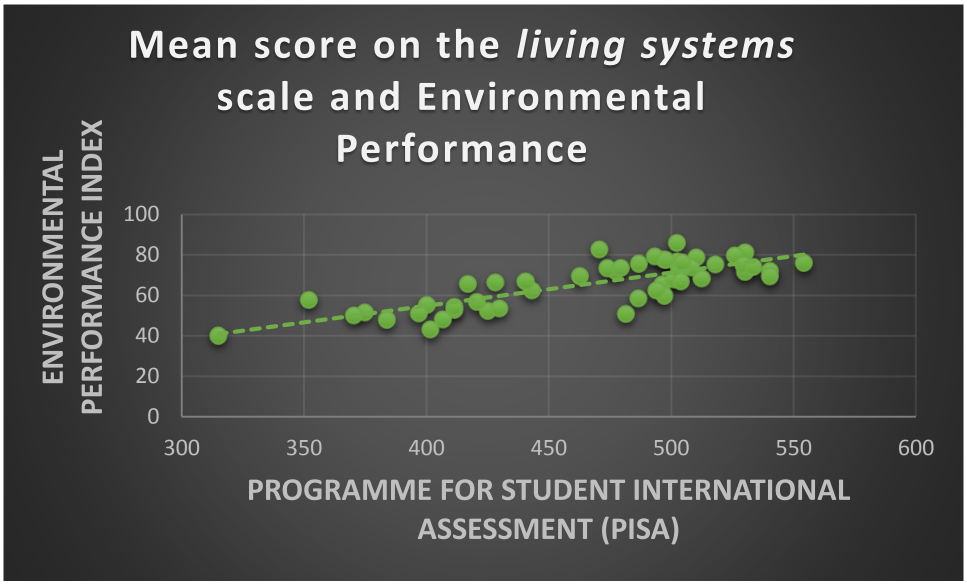

Figure 4.7 Relationship between student performance on the living systems scale and environmental performance

4.2.6 Mean score in student performance on the physical systems scale. Students who perform high on the physical systems scale in PISA 2006 are from countries that have high environmental performance (Figure 4.8). The top performer of students in the physical systems scale is Finland with a mean score of 560, and EPI performance of 76%. The lowest performer is Kyrgyzstan with a mean score of 349, and EPI score of 40%. The analysis shows a p-value <.01 and an adjusted R squared of .65, explaining 65% of the variance of environmental performance, this shows a significant relationship.

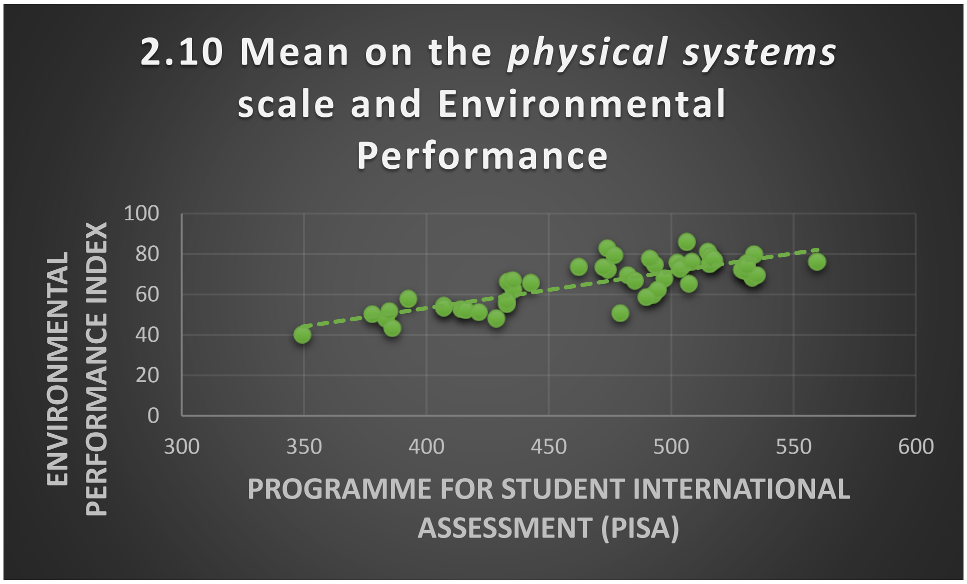

Figure 4.8 Relationship between student performance on the physical systems scale and environmental performance

4.3 Relationship between GDP, PISA 2006, and Environmental Performance

Results of the regression analysis show a positive relationship between mean science scores on identifying scientific issues scale, GDP, and EPI. The data results show a p-value <.01 and an adjusted R-squared of .76, indicating 76% of the variation in the environmental performance index is attributed to students being able to identify scientific issues and GDP.

This finding supports GDP as a known to contributor to higher educational attainment, as well as environmental performance with Gallego-Alvarez et. al (2014) and Esty (2001) stating economic wealth is a determinate factor of environmental performance in countries.

4.3.1 Maps displaying relationship between Gross Domestic Product (GDP) and environmental performance. Below are maps indicating visual relationships between the Gross Domestic Product (GDP) and environmental performance (Figures 4.10-4.12). These will be discussed further in chapter 5.3.1.

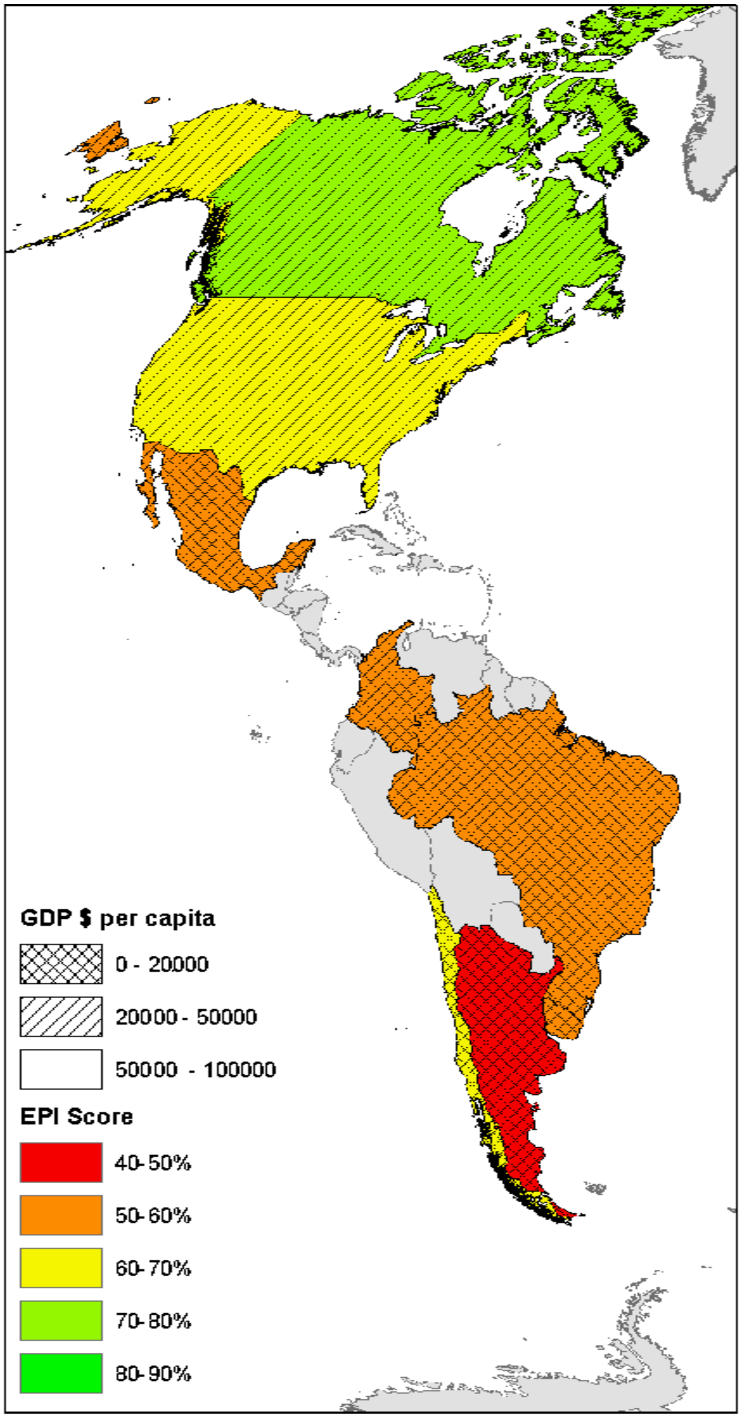

Figure 4.9 Relationship between GDP and environmental performance in North and South America

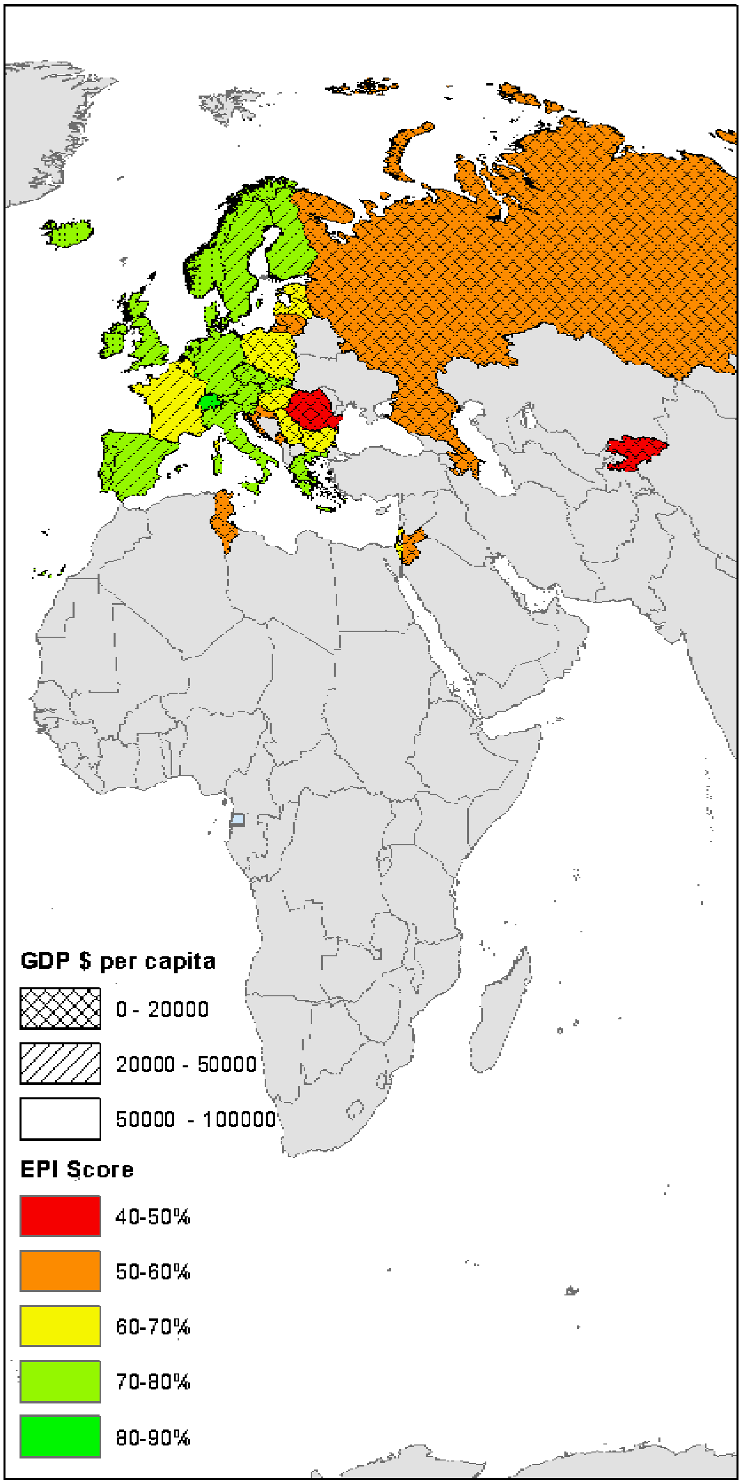

Figure 4.10 Relationship between GDP and environmental performance in Europe

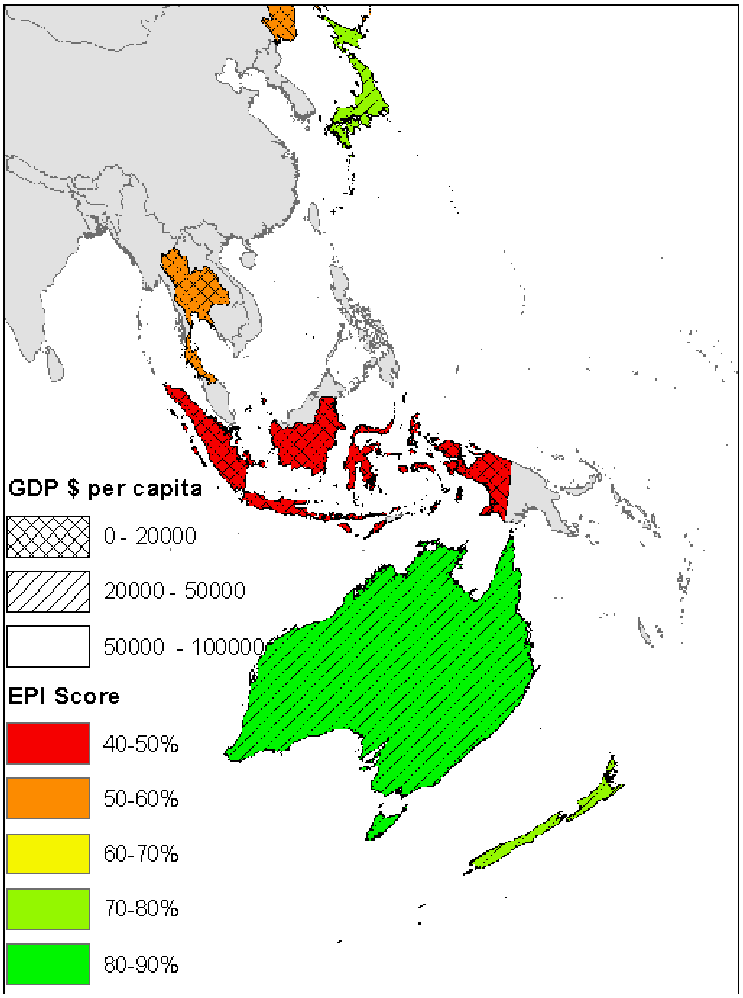

Figure 4.11 Relationship between GDP and environmental performance in Southeast Asia and Australia

4.5 Curriculum Analysis

4.5.1 Overview. Of the top twenty performers, four countries performed within the top ten of both PISA and EPI 2006: Finland, the United Kingdom, Switzerland, and Australia. Fourteen total countries were examined for common curriculum topics within this analysis, Luxembourg and the Netherlands curriculum was not publicly accessible. Of the curriculums, common components included: responsibility to the environment, experiential education, and sustainability education. The top ten countries of PISA and EPI 2006 are listed below (Table 4.1).

Table 4.1 Top ten countries in PISA and EPI 2006

PISA	EPI
1. Finland	1. Switzerland
2. New Zealand	2. Luxembourg
3. Australia	3. Australia
4. Netherlands	4. Czech Republic
5. Canada	5. Spain
6. Slovenia	6. Norway
7. Ireland	7. Sweden
8. Estonia	8. Austria
9. Switzerland	9. United Kingdom
. 10. United Kingdom	10. Finland

4.5.2 Responsibility to the environment. Of the top countries, nine of the fourteen countries include specific terminology requiring students to understand our relationship to the environment. These consist of Finland, Canada, Slovenia, Ireland, the United Kingdom, Spain, the Czech Republic, Norway, and Austria.

The Finnish system includes the objective for pupils to learn how to protect nature and save the natural resources at the end of grade 4. In grades 6 and 7 students are expected to develop environmental literacy, act in an environmentally friendly way, care for their local environment, and protect nature. In grades 7-9 students learn to recognize environmental changes in the pupil's home region, to consider reasons for them, and to present possible solutions to problems (The Finnish National Board of Education 2004).

One of the required courses in primary school (age's six through fourteen) in Slovenia is titled getting to know the environment. Adopted in 1998, this class entails students learning the relationship between humans and the environment. Some of the objectives of the course include understanding the environment, developing an attitude of respect for nature, culture, family, developing a responsible attitude towards the environment, and promoting interest in protecting nature (Krnel et al. 2005).

The United Kingdom has included Education for Sustainable Development as a main cross curricular element since 2005 (The Children, Schools and Families Committee 2009). This includes "social progress that recognizes the needs of everyone, effective protection of the environment, prudent use of natural resources, and the maintenance of high and stable levels of economic growth and employment" (The Learning and Skills Council 2005, pg. 4).

Starting in 2006 Spanish students in secondary compulsory school were expected to "critically evaluate the social habits related to health, consumption, care of living things and environment, contributing to their conservation and improvement" (Government of Spain 2006 pg. 24).

According to the Czech Republic's 2005 national curriculum, students were taught environmental education as a cross curricular concept. Objectives included ecosystems, man's relationship to nature, fundamental conditions for life, and human activities and the environment (Jerabek and Tupy 2005).

Beginning in 1998, Norway included a responsibility to the environment within their curriculum stating the "students shall learn to think critically and act ethically and with environmental awareness" (UNESCO-IBE 2010, pg. 2). The 1990s Core Curriculum includes underlying common goals for all students throughout compulsory school. These goals include moral outlook, creative abilities, work, general education, cooperation, and the natural environment. One of the Core Curriculums objectives states “education should promote an integrated development of the skills and qualities that allow one to behave morally, to create, act, and work together and in harmony with nature” (UNESCO-IBE 2010, pg. 15).

Starting in 2001 Austrian primary students were expected to engage in sound environmental behavior and understanding. During that year many teachers also started to include courses specifically on environmental protection (UNESCO-IBE 2007).

Each of these countries all include teaching their students about the importance and relevance of what the environment not only globally provides for each individual, but also the significance for students to take care of it. When students are taught to appreciate and respect the environment, it adds to the students’ value of it, and therefore could enhance the want to nurture it.

4.5.3 Experiential Learning. Of the fourteen countries in the top twenty performers of PISA and EPI, only two were able to be identified to engage in experiential learning: the top performing country of PISA 2006, Finland, and the seventh performer in PISA 2006, Ireland.

The Finnish system includes an objective for students between grades 5-6 to learn “to move about in the natural environment and observe and investigate nature outdoors” (The Finnish National Board of Education 2004, pg. 55).

Ireland includes experiential learning within many different concepts of their curriculum including: learning about lights, plants, animals, and the environment. Part of the curriculum states “many opportunities should be provided for the children to observe and interact with their environment” (The Curriculum Committee for Social, and Environmental and Scientific Education 1999, pg. 39).

Both of these countries perform in the top ten within PISA 2006. However, Ireland does not perform highly within EPI which suggests using experiential learning is not an indicator alone on a country's high environmental performance.

4.5.4 Sustainability. Of the fourteen countries examined, eight countries included some form of education on sustainability and/or sustainable development. These include Finland, New Zealand, Canada, Australia, Estonia, Switzerland, the United Kingdom, Spain, and Ireland.

The Finnish curriculum includes education for sustainable development, expecting students to be able to explain global environmental and development problems including the greenhouse effect, ozone depletion, pollution of living environments, and population growth. These expectations occur at the end of grade 8. They also are expected to describe personal opportunities to contribute to the improvement of the environment (The Finnish National Board of Education 2004). The Finnish curriculum is being reformed to include education which acknowledges globalization, technology, and sustainable living. Finnish schools will be introduced to this curriculum in the 2016-2017 school year (The Finnish National Board of Education 2015).

In 2002 New Zealand included sustainability as a cross curriculum topic that is essential to learning. This is declared as "education for a sustainable future, including sustainable development and environmental sustainability" (Department of Education 2002).

Canada's 1997 curriculum includes sustainability with a general learning outcome of 9th grade students to "analyze social issues related to the applications and limitations of science and technology, and explain decisions in terms of advantages and disadvantages of sustainability" (The Council of Ministers of Education, Canada 1997, pg. 69).

A report from the Australian Education Committee in 2005 stated that the nine values in their education system reflect their commitment to a multicultural and environmentally sustainable society where all are entitled to justice (Curriculum Corporation (Australia), Australia, and Department of Education 2005).

Since 1992 Estonia has included the teaching of sustainable development within their primary curriculum. The country states sustainable development is one of the most important issues in contemporary society along with permanent change, lifelong education, and competitiveness in the global market (UNESCO-IBE 2007).

2006 data from Switzerland's curriculum was not accessible but, Switzerland's current curriculum includes sustainability as a topic of education with it being an interdisciplinary topic taught within the system (Swiss media Institute for Education and Culture Cooperative 2010).

Education for sustainable development has been a cross-curricular concept taught to students since 1999 in the United Kingdom. Education "should develop their awareness and understanding of, and respect for, the environments in which they live, and secure their commitment to sustainable development at a personal, local, national and global level" (State for Education and Employment, Qualifications and Employment and Curriculum Authority, and Employment 1999, pg. 12). By age 12, "pupils should be taught to: recognize how people can improve the environment, and how decisions about places and environments affect the future quality of people's lives. Students also recognize how and why people may seek to manage environments sustainably, and to identify opportunities for their own involvement" (State for Education and Employment and Qualifications and Employment and Curriculum Authority 1999 pg. 114).

In 2006 Spain included sustainable development in their basic competencies in school which incorporates the acquisition of “values that encourage respect for living beings and the environment, in particular the value of forest areas and sustainable development” (Government of Spain 2006 pg. 13).

Within the Ireland science curriculum one of the aims includes fostering a commitment to promote the sustainable use of the Earth’s resources through personal lifestyle and participation in collective environmental decision-making (The Curriculum Committee for Social, and Environmental and Scientific Education 1999a).

Out of the nine countries that teach sustainability within their curriculum 7 of them are located within Europe. Of the countries assessed within this research this shows that some European countries are conducting a more progressive education system. This does not indicate only countries within Europe are teaching these progressive techniques, but other countries are likely also including progressive techniques in their curriculum. Countries which make a deliberate action to include sustainability within their government policies can be seen to host higher environmental performance, the European Union made this decision in 2001 (Gothenburg European Council 2001). Included below is a table indicating all countries within the top 10 performers of each PISA 2006 and EPI and their common curriculum topics (Table 4.2).

Table 4.2 Common curriculum topics in top ten PISA and EPI 2006 performers

Responsibility to the Environment	Experiential Education	Sustainability
• Finland • Ireland • Canada • The United Kingdom • Spain • Slovenia • The Czech Republic	• Finland • Ireland	• Finland • New Zealand • Canada • The United Kingdom • Spain • Austria • Switzerland

CHAPTER 5
DISCUSSION AND CONCLUSION

5.1 Science Education and Environmental Performance

The data shown above indicate there is a positive relationship between science test scores and environmental performance.

5.1.1 Mean score on identifying scientific issues scale. Students who perform well on identifying scientific issues can identify the need for a rigorous test, what needs to be measured, and recognize comparisons between two tests. (Adams 2009).

Students who can identify these matters understand the basic concepts of scientific issues and how to tell the difference between variables within different scales. Students have knowledge of cause and effect within a scientific test when they are moderately proficient within this scale. This can have an effect on knowledge regarding the environment due to the interrelationships within nature, specifically students understanding how human action has an effect on the environment. The regression analysis showed a 68% relationship with students being proficient within this scale, this suggests students that perform well in this scale are more likely to understand the relationship between humans and nature. This also indicates 32% of the variance is not explained within the analysis. This could be due to many other factors which have an effect on environmental performance of a country including quality and implementation of policies, dedication within the private sector, relationships with international environmental bodies, a country's institutional foundations, and/or population density (Gallego-Alvarez et al. 2014).

5.1.2 Maps displaying relationship between identifying scientific issues and environmental performance. Countries that perform well in identifying scientific issues perform well environmentally. The only high environmental performing country within North and South America is Canada, which also performed high within identifying scientific issues in PISA 2006. Other countries like Brazil and Mexico performed lower than average within PISA, and on environmental performance, with both countries within the range of 50-60%.

Many European countries perform well on both PISA and EPI 2006. Countries which scored between 60% and 80% on the environmental performance index scored over 400 in PISA 2006. This indicates students within those countries are adequately proficient in identifying science issues, performing at “level two” within PISA 2006. When students perform at Level 2, they have adequate scientific knowledge to provide possible explanations to draw conclusions based on simple investigations. They are capable of direct reasoning and interpretations of the results of scientific inquiry or technological problem solving (Adams 2009).

As one can detect from the map, Romania performs within this range with a mean score of 409. This weak environmental performance may be due to a communist ran country until a large change in Romania’s government during 2005/06, with the beginning of a four party elected system. Romania also joined the European Union in 2004, where Romania was expected to expand its environmental protection. In 2006 the European Commission listed Romania’s two main remaining environmental issues as increased transparency of decisions and improved waste management (Library of Congress – Federal Research Division 2006). In 2005 many teachers went on strike because of low funding (Library of Congress – Federal Research Division 2006), this could also explain poor performance in PISA 2006.

All five countries listed within Southeast Asia and Australia align with their PISA scores and EPI scores accordingly, each country that performed well environmentally also performed well in PISA. This shows countries that are proficient in the identifying scientific issues scale also have a high environmental performance.

5.1.3 Mean score in student performance on the explaining phenomena scientifically scale. Students who perform well in explaining phenomena scientifically can predict outcomes from changes in a scientific system and simply and clearly explain them (Adams 2009).

If a student can properly identify the outcomes in changes in a systematic way, they may be able to view relationships between performance patterns such as the greenhouse effect and its relationship to Carbon Dioxide emissions. It helps them identify the possible relationships in a scientific manner such as being able to read graphs and come to conclusions based on those graphs. This could have an effect on environmental performance with students being able to interpret scientific data regarding environmental knowledge such as graphs relaying information about greenhouse gas emissions and the earth's temperature.

5.1.4 Mean score in student performance on the earth and space systems scale. Students who perform well in the earth, space, and systems scale can identify the structures, energy, and change of earth systems, its history, and earth in space (OECD 2009).

When students perform well in this scale they can apply the knowledge above to how the earth works within the constructs of space, therefore possibly the effects the solar system has on the global environment and the earth's health.

5.1.5 Mean score in student performance on the living systems scale. Students who are proficient in the living systems scale are expected to understand cells, ecosystems, biosphere, populations, and humans (OECD 2009).

Knowledge of this content area could affect students' overall environmental knowledge, as they learn how ecosystems are interdependent with each other within the biosphere. Students therefore understand how the health of an ecosystem (including humans) are affected by external factors such as amount of oil used, use of paper and how it affects an ecosystem.

5.1.6 Mean score in student performance on the physical systems scale. Students who perform well in the physical systems scale are knowledgeable of structure of matter, motions and forces, interactions of energy and matter, and energy and its transformations (OECD 2009).

When students are knowledgeable in this content area they could apply facts of what elements have different effects on the environment. For example, a released PISA question included in the physical systems scale asks why acid rain is more acidic than normal rain. It also asks where the absorbed gasses come from to cause acid rain (OECD 2007).

5.1.7 Implications. Results indicate students who perform higher on any of the science education variables are part of a country with a high environmental performance. The variance was highest within the mean of students identifying scientific issues scales (68%) and students' being knowledgeable of living systems (68%), suggesting students who are more proficient in these topics are from countries that perform better environmentally. These are contrasted with other individual variables identified such as: physical systems, earth and space systems, and explaining phenomena scientifically.

Physical systems still shows a high variance with 65%. This slightly smaller variation with environmental performance could exist because it does not identify facts regarding the relationship between humans and the environment. It largely focuses on how intangibles (energy) have an effect on the environment. Therefore students cannot apply theories and facts learned from physical systems to the environment and how their actions effect it.

Earth and space systems had the lowest variance with 63%. This smaller variance with environmental performance could exist, similar to physical systems, because the content is both vast and theoretical. Students may not feel personally connected to these systems whereas living systems focuses on tangible examples of humans interacting with the environment.

Explaining phenomena scientifically encapsulates earth and space systems, living systems, and physical systems. Therefore, the variation of explaining phenomena scientifically has a lower variance due to the average of all three of these content areas together.

These findings support the relevant research question number 1, is science education correlated to a country's environmental performance. This does not indicate this is the only variable that does effect environmental performance with many other factors including the government style and regulatory actions placed through government (Esty and Porter 2001), but this analysis does show science education does have an effect on a country's environmental performance.

5.2 Gross Domestic Product, Science Education, and Environmental Performance

Data showed GDP, science education, and environmental performance have a positive relationship to each other. This suggests countries with a higher GDP are more likely to have a scientifically literate population versus countries with a low GDP. Countries with a higher GDP may be able to finance better education systems and therefore allocate more for teachers pay and resources. This could increase the amount of science education/scientifically literate students, and environmental performance. Of the ten countries with the highest GDP, seven of them were also in the top ten performers in EPI and PISA 2006. These included Luxembourg, Norway, Switzerland, Ireland, Denmark, Sweden, the Netherlands, and the United Kingdom.

These findings support research question number 2, is there a relationship between Gross Domestic Product (GDP), science education, and environmental performance. This does not indicate this is the only variable that has an effect on environmental performance, but does show there is a high positive relationship. There also is a positive relationship with GDP and EPI signifying that countries which have a higher environmental performance also tend to have a high GDP. This shows countries that are lesser developed may be less likely have a high environmental performance due to the lack of resources available, but, this does not indicate a country cannot be a high environmental performer because of a low GDP. The Czech Republic, for example, performs 3rd in the Environmental Performance Index and has a GDP of $15,159 versus Luxembourg (the highest GDP) at $88,680, but is not in the top ten of PISA 2006.

5.2.1 Maps displaying relationship between Gross Domestic Product (GDP) and environmental performance. Countries which have a higher Gross Domestic Product have a higher environmental performance. Maps visualizing the relationship between GDP and environmental performance show when a country has a high GDP, a high environmental performance tends to follow. All countries in North and South America show this relationship, except the United States. In 2006 the United States had a GDP of $46,432, but did not perform well in environmental performance, unlike its northern neighbor Canada with a GDP of $40,243.

This suggests that because the United States is not a high scientifically literate country, they did not perform well environmentally. This also indicates countries that perform well environmentally do not always have a high GDP, and other factors such as education could play a factor.

Countries within Europe were some of the highest environmental performers in 2006. Within the figure the country of Luxembourg is not visible, but worth briefly discussing. With the highest GDP in 2006 being $88,680, Luxembourg topped the environmental performance list, and also scored adequately in PISA 2006 with a mean score of 483 on the identifying scientific issues scale. This indicates countries that have a low environmental performance is not solely based on a population who is scientifically literate.

All four countries in the results of Southeast Asia and Australia have variations with Gross Domestic Product and environmental performance. Australia, for example, had a GDP of $36,084, but performed third within the environmental performance index. This indicates GDP does not solely influence environmental performance, but a combination of science education and GDP could have a large effect on environmental performance. If a country chooses to make environmental performance a key policy initiative within their country, not only how much they educate their students is important, but what they educate their students holds just as much weight. Starting in 1992 Australia has included sustainability within their government policies with the National Strategy for Ecologically Sustainable Development, then continuing with report every five years starting in 1996 titled the State of the Environment (Australian Government Department of the Environment 2016). Australia has also included sustainability within their curriculum since 2005 stating their nine values reflect their commitment to an environmentally sustainable society (Curriculum Corporation (Australia), Australia, and Department of Education 2005).

5.3 Common curriculum topics within top PISA and Environmental Performers

As mentioned within the results, the common curriculum topics of top PISA and environmental performers are sustainability, experiential education, and responsibility to the environment. These three topics encompass students learning to appreciate nature throughout their primary schooling years. Within this portion of the chapter discussion will take place on the importance of these topics within the national curriculum.

5.3.1 Sustainability. Eight countries included education of sustainability and/or sustainable development. These are: Finland, New Zealand, Canada, Australia, Estonia, Switzerland, the United Kingdom, Spain, and Austria. Of these eight countries four of these countries were both in the top ten in PISA and EPI 2006. Each of these countries included some form of education for sustainability within their curriculum since the 1990s and/or early 2000s. This suggests that countries that educate their students in sustainability will be knowledgeable about sustainability and understand the need to be future-oriented thinking within their actions that affect the planet.

5.3.2 Experiential Learning. Of the fourteen countries examined, only two countries clearly engage in experiential education: Finland and Ireland. Countries seldom make pedagogical techniques public, which served to complicate researching if experiential education was utilized within countries identified within this study. However, the literature shows students who learn experientially form connections within nature the greater their intentions will be to engage with it, and therefore the more likely to have environmental concerns (Müller, Kals, and

Pansa 2009; Hinds and Sparks 2008). This implies countries that use experiential education, could have more students who are not only scientifically literate, but also connected to nature and hold concern towards the environment, this could also lead to a higher environmental performer.

5.3.3 Responsibility to the environment. Nine of the countries examined included specific terminology within their national curriculum requiring students to understand our relationship to the environment. These consist of Finland, Canada, Slovenia, Ireland, the United Kingdom, Spain, the Czech Republic, and Norway.

Students who are aware of the interrelationship between humans and nature prove to be part of countries which perform better environmentally. Of the countries identified, two of them were in the top ten of both PISA and EPI 2006. This indicates students who learn about a human's responsibility to the environment has an effect on how well a country performs environmentally. Students aged 15 who are knowledgeable in these topics will continue to hold this knowledge and become scientifically literate citizens who therefore make a more conscious effort regarding the state of the environment.

5.3.4 Implications. Students who performed well in PISA 2006 were largely located in more developed countries. Eight of these countries were in the European Union in 2001 were in the highest performers of PISA and EPI 2006 (Table 5.1). These countries include: Finland, Luxembourg, Sweden, the Netherlands, Austria, Ireland, the United Kingdom, and Spain. In 2001 the European Union formed a report on sustainability stating “the education system also has a vital role to play in promoting better understanding of the aim of sustainable development, fostering a sense of individual and collective responsibility, and thereby encouraging changes in behavior" (Gothenburg European Council 2001 pg.8), as well as "member states should consider how their education systems can develop wider understand of sustainable development" (Gothenburg European Council 2001, pg. 9). Other countries that hold a high environmental performance tend to include a national focus on sustainability i.e. Australia, Spain, and Czech Republic.

Table 5.1 2001 European Union countries

Finland	Spain
Luxembourg	Portugal
Sweden	Greece
Netherlands	Belgium
Austria	France
Ireland	Italy
United Kingdom	Germany
Denmark	

5.4 Application of research

National education systems that include sustainability, responsibility to the environment, and/or experiential education within science education have a positive relationship with their environmental performance. Students who are taught about these curriculum topics are not only able to apply scientific knowledge to real life situations, but also promote understanding of our duty to the environment and reasoning behind protecting it. However, further investigation is needed to validate if environmental education, which includes sustainability, responsibility to the environment, and experiential education, independently leads to a higher environmental performance. Further research is also needed to assess whether a country's science education for lesser developed countries also has a positive effect on environmental performance.

It was shown there is a lack of tools to identify and/ or gauge the amount of experiential education used within a country. A quantitative assessment is needed to validate benefits of experiential education. Studies show when students are given the opportunity to engage personally with the environment they are be more likely to have a valuable experience which leads to a want to protect nature (Hinds and Sparks 2008; Cox, Calder, and Fien 2010; Mifsud 2012; The Nature Conservancy 2011; Müller, Kals, and Pansa 2009; Kim 2011)**.**

5.6 Conclusion

Students in the current school system may become active citizens in the political process, giving them the power to initiate widespread change to support a sustainable future. Countries that prioritize environmental performance often include higher standards within their science education curriculum, therefore producing more scientifically literate students.

This research indicated that science education, GDP, and curriculum topics are variables which strengthen environmental performance, but they are not the only variables which affect it. A country's environmental performance could also be affected by the government's control over environmental policy, the quality and implementation of policies, dedication within the private sector, relationships with international environmental bodies, and a country's institutional foundations (Gallego-Alvarez et al. 2014; Esty and Porter 2001). More extensive research is needed to investigate other variables that have an effect on environmental performance. It was shown that countries that teach their students responsibility to the environment, sustainability, and/or experiential education will lead to higher science literacy rates and a higher environmental performance. Students are our road to an environmentally sound future. The more we invest in the present, the more we will secure our future.

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