Developing a Framework for Assessing Environmental Literacy

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PREFACE

This document presents a new, comprehensive, research-based description of environmental literacy and applies that work to the creation of a framework for an assessment of environmental literacy. The developers, who worked under the aegis of the North American Association for Environmental Education (NAAEE), sought to create materials that are broadly representative of, and build on, the environmental education literature, as well as insights derived from a broad range of disciplines. Their work was informed by:

- previous environmental education frameworks (e.g., Hungerford & Volk, 1990; Roth, 1992; Simmons, 1995; Wilke, 1995);
- recent national assessments of environmental literacy in the United States (e.g. Phases One and Two of the *National Environmental Literacy Assessment Proje*ct (NELA); McBeth et al., 2008, 2011) and in other nations (e.g., South Korea: 2002-2003; Israel: 2004-2006: and Turkey: 2007-2009); and
- the Organisation for Economic Co-operation and Development's (OECD's) international assessments (e.g., the OECD report *Green at Fifteen? How 15-Year-Olds Perform in Environmental Science and Geoscience in PISA 2006* [OECD, 2009]).

In addition, the project brought together, for the first time, experts in research, assessment, and evaluation in the fields of social studies education, science education, environmental education, and related science and social science fields. These experts contributed to the work by critiquing early drafts, providing additional references, and suggesting revisions.

This work is timely; it began as the United Nations (UN) Decade of Education for Sustainable Development (2005-2014) was coming to an end. In the United States, government agencies, professional organizations, educational institutions, and private corporations have demonstrated their interest in the enhancement of environmental literacy by investing hundreds of millions of dollars toward achieving that goal. Assessments for gauging our progress are needed; this material will provide guidance for the design of such assessments.

Who is this work for and in what ways could it be used?

This product is built on internationally accepted definitions of, and research pertaining to, environmental literacy. It is intended for use by those who work on the development of environmental literacy assessments at international (e.g., Programme for International Student Assessment [PISA]) and national (e.g. NELA) levels. By focusing on the competencies of environmentally literate individuals, this document and the analysis on which it rests guide specialists in developing assessments to answer the question: To what degree do these individuals have the knowledge, skills, dispositions, and behaviors for competently making decisions about, and acting on, local, regional, national, and global environmental issues? The document could also be useful to those designing such assessments at the state, provincial, or district level to determine the degree to which students have acquired these competencies (are becoming environmentally literate) by certain ages or grade levels.

Another intended audience includes researchers and policy makers; they may use data from broad environmental literacy assessments based on this work to identify questions for investigation, or implications for education policies and funding, respectively. They could also use the material herein and the results of such assessments to help identify gaps in existing research, educational frameworks, and educational practice.

These materials are not intended for use in developing tests to evaluate achievement of an intended or an implemented curriculum, that is, to answer the question posed by state tests and Trends in International Mathematics and Science Study (TIMSS) assessments: "Did the students learn what was taught?"

Who developed this document?

The United States' National Science Foundation (NSF) awarded the NAAEE a grant (Grant No. 1033934) to coordinate the development of this product. The following team led the development effort:

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As researchers and specialists pursue the assessment of environmental literacy, we believe it is imperative that there be sufficient consistency within and across assessments so that cross-comparisons can be made. With this document, we hope to promote such consistency enabling professionals working in our fields to accumulate evidence and develop understandings regarding the extent to which environmental literacy exists across countries and is influenced by cultural, educational, and political policies and institutions, and begin to compare the degree of environmental literacy among individuals of different ages within a country.

INTRODUCTION

The importance of environmental literacy

At no other time in Earth's history have humans had as great an impact on Earth's natural systems. Globally we face a number of social, economic, and environmental issues resulting from interactions of human activities with the global ecosystem. With the human population at 7 billion people as of October 2011, and projected to be 9 billion by 2050 (Population Reference Bureau, 2011), the pressures caused by these interactions are unlikely to abate. The need for food, clean water, fuel, and space will increase. Changes to the natural and built environments will continue to have significant economic and other social impacts. Just one example – the impact of declines in fish stocks on the economies and cultures of many coastal and island communities – hints at the range and complexity of these changes.

Disagreements about how best to approach these issues will continue to challenge social and political systems. The purpose of improving environmental literacy is to prepare people to understand and address such issues. Only an environmentally literate public will be able to find workable, evidence-based solutions for these challenges.

This document focuses on the types of knowledge, affective components, competencies, and behaviors that are associated with environmental literacy. However, it is worth noting that many of the general skills and strategies that make up environmental literacy are broadly applicable. They can be applied to other social issues – access to education or health care, for example, or reduction of poverty or crime. This is important because it highlights the point that in cases where environmental and social problems are inextricably linked (e.g., access to water, food, or energy resources; proper methods of disposing of/treating sewage or solid waste), the development of environmental literacy may support a more comprehensive understanding of – and a more balanced, sustainable approach to – addressing these complex issues.

History of environmental literacy

Current conceptualizations of environmental education have their roots in the educational movements of the late 19th and early 20th centuries related to nature, conservation, and outdoor education. Beginning in the 1970s, the UN Educational, Scientific and Cultural Organization (UNESCO) took the lead in establishing and refining a definition of environmental education (UNESCO, 1977; UNESCO, 1978; UNESCO, 1987; UN, 1992). That definition states: "The goal of environmental education is: to develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones." In addition, UNESCO-UNEP set forth objectives of awareness, knowledge, skills, attitudes, evaluation ability, and participation (UNESCO-UNEP, 1976, p. 2; UNESCO, 1978).

From the 1980s to the present, theory and practice in environmental education have been advanced by a growing body of research and evaluation studies (e.g., Coyle, 2005; Hines et al., 1986/87; Iozzi, 1984; Rickinson, 2001; Volk & McBeth, 1997; Zelezny, 1999). Status studies

and needs assessments continued to indicate that substantial, well-conceived efforts are needed to help translate definitional features and research findings into sound and widespread practices (e.g., Disinger, 1989; Fleming, 2009; McBeth et al., 2011; McKeown-Ice, 2000; Ruskey & Wilke, 2005; Simmons, 1991; Volk et al., 1984).

Since 1990, a number of environmental literacy frameworks have been published, each of which has reflected the UNESCO's 1978 objectives by addressing knowledge (awareness and knowledge), cognitive skill (skills), affective disposition (attitudes), and behavior (participation) (e.g., Hungerford & Volk, 1990; Roth, 1992; Simmons, 1995; Wilke, 1995). The authors of these frameworks have attempted to provide coherent direction to environmental literacy by synthesizing and including definitional features, national and state program frameworks, and findings from reviews of research. Since 1995 these frameworks have guided reviews of research (e.g., Volk & McBeth, 1997), development of assessment instruments (e.g., Wilke, 1995), and several different national assessments of environmental literacy (e.g., Erdogan, 2009; McBeth et al., 2008; Negev et al., 2008; Shin et al., 2005).

Building on one of these frameworks (Simmons, 1995), the North American Association for Environmental Education (NAAEE) published the *Guidelines for Excellence in Environmental Education Project* (e.g., NAAEE, 2004a, 2004b, 2004c, 2004d). The NAAEE has actively supported initiatives to put these guidelines into practice in the United States (Marcinkowski, 2010; NAAEE, 2007, 2010) and in other countries, including Taiwan and Mexico.

The NAAEE guidelines and contributions from an increasingly diverse array of disciplines have highlighted the growing complexity and interdisciplinary nature of environmental literacy; for instance, in the energy management and use sector alone, economic, sociopolitical, and scientific issues come into play. Resolving such issues calls for multi- and interdisciplinary knowledge, and also for an array of skills – for example, in locating information and gauging the credibility of sources; thinking in integrative, systemic ways; communicating clearly; and working collaboratively to seek solutions. Ecologists, economists, social scientists, and other experts have joined environmental education researchers in calling for ecological literacy, environmental citizenship, and other cross-disciplinary approaches to develop the knowledge, abilities, and dispositions of learners capable of, for example, understanding the value of the world's ecosystem services on which all life depends, and participating in the deliberative and decision-making processes needed today (Aagaard-Hansen & Svedin, 2009; Jakobsen et al., 2004; Berkowitz, et al, 2005; Houser 2009; Costanza et al., 1997; Covitt et al., 2009).

Environmental education for youth and in schools

The importance of both formal and non-formal environmental education has been recognized since the early 1970s (e.g., Hart, 1981; UNESCO, 1977, 1978). Reports from the UN Children's Fund (UNICEF) and others (e.g., Hart, 1992; Hart et al., 1996), have noted that, as of 1992, youth make up 30% of the world's population, and their involvement in environmental decision making was viewed as critical. Since 1992, this need has become even more critical. "Preventing a global climate catastrophe, ensuring safe supplies of food and water, transforming our energy supply and reducing demand, managing ecosystems to minimize irreversible losses of biodiversity and protecting human health…requires an educated populace and a diverse and

competent workforce prepared for the rapidly changing world of the 21st century" (National Council for Science and the Environment, 2008).

Recent reviews of research indicate that various combinations of formal, non-formal, and other environmental experiences for youth have contributed in different ways to the development of environmental literacy. Studies of *significant life experiences* of adult environmental professionals in different nations have consistently found environmentally related formal, non-formal, familial, and social experiences during their youth to be influential (Chawla, 1998; Sward & Marcinkowski, 2001). Various types of formal and non-formal environmental education programs have contributed to gains in *knowledge* and shifts in *attitude* (e.g., Iozzi, 1984; Rickinson, 2001; Volk & McBeth, 1997). However, relatively few environmental education programs have contributed significantly to the development, application, and transfer of *cognitive skills* – though there are several notable exceptions in formal environmental education (e.g., Iozzi, 1984; McBeth et al., 2011; Rickinson, 2001; Volk & McBeth, 1997). Finally, several prominent instructional approaches – notably environmental action research, environmental issue-and-action instruction, and environmental service-learning – have been shown to contribute to the development, application, and transfer of strategies for youth *participation in environmental decision making and problem solving* (e.g., Coyle, 2005; Marcinkowski, 2004; Rickinson, 2001; Volk & McBeth, 1997; Zelezny, 1999).

The need for data about the environmental literacy of youth

Education leaders, policy makers, researchers, and educators in many countries have called attention to the need for data on the status of environmental literacy. An early example was a call for research within all UN Member States on selected components of environmental literacy (i.e., knowledge, attitudes, values, and behavior), approved in 1978 (*Intergovernmental Conference on Environmental Education*, UNESCO, 1978, p. 38).[1]

In the United States, the call for research on the status of environmental literacy among K-12 students, post-secondary students, pre- and in-service teachers, and the general public was first articulated as part of a larger set of research needs developed by a working group of environmental educators in 1990 (Wilke, 1990). Subsequent studies reiterated these goals, identified specific research priorities, and served as the basis for assessment projects (Saunders et al., 1992; McBeth, 1997; Wilke, 1995).

Other bodies that have called for such research include a working group convened by the Environmental Protection Agency's (EPA's) Office of Environmental Education to draft a *National EE Research Agenda* (EPA, 1998, p. 1); the National EE Advisory Council in its 2005 report to Congress (NEEAC, 2005, pp. 25, 34-35); and the National Council for Science and the Environment (2008).

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[1]This recommendation was advanced in subsequent papers on the development of a national strategy for environmental education (Stapp., 1978, pp. 42, 49-50; Stapp et al., 1979b, pp. 94, 102-104).

The status of environmental literacy assessments

Assessments of environmental literacy are a principal source of information, but such assessments are relatively new. As one researcher noted, "Relatively little work has been done along these lines. That should not be surprising, since, until very recently, there has been little clear definition about what [environmental] literacy is" (Roth, 1992, p. 33).

The first wave of national assessments in environmental education was conducted during the 1970s (e.g., Bohl, 1977; Eyers, 1976; Richmond, 1977; Perkes, 1974). Early assessments tended to focus on students' environmental knowledge and attitudes, but some later ones also examined other learning outcomes (e.g., Makki, Abd-El-Khalick, & Boujaoude, 2003; Ndayitwayeko, 1995; Cortes, 1987; Kuhlmeier, Van Den Bergh, & Lagerweij, 2005; Marcinkowski et al., 2011). These assessments paved the way for a second wave of national assessments plus one international assessment that began to test an even wider range of environmental literacy components.

In the United States, two assessments were developed to evaluate knowledge, skill, affective, and behavioral components of environmental literacy: the Middle School Environmental Literacy Instrument (MSELI) and the Secondary School Environmental Literacy Instrument (SSELI) (McBeth, 1997; Wilke, 1995). The MSELI was revised for use in the *National Environmental Literacy Assessment Project* (NELA). Phase One of this project was a baseline study of environmental literacy in a national random (probability proportional) sample of sixth and eighth graders (McBeth et al., 2008; McBeth & Volk, 2010). Phase Two was a study of the effects of established, school-based environmental education programs on environmental literacy of sixth-through eighth-grade students in 64 schools (McBeth et al., 2011). The NELA research team has planned for several additional phases in this national research project.

Researchers in Korea (Shin et al., 2005), Israel (Negev et al., 2008), and Turkey (Erdogan, 2009) have developed national assessments that reflect the same broad conception of environmental literacy that has anchored the recent U.S. assessments, and these have been compared with the U.S. assessments (Marcinkowski et al., 2011).

To date, there has been only one international assessment that has included multiple components of environmental literacy. It was administered as part of the PISA 2006 Science Assessment, and the results were summarized in the OECD report, *Green at Fifteen? How 15-Year-Olds Perform in Environmental Science and Geoscience in PISA 2006* (OECD, 2009).

There is a clear need for national and international assessment data to better understand the status of environmental literacy, with data broken down by the components and by age/developmental levels (i.e., childhood, early adolescents, adolescents, and adults). However, in a broader context, this alone is likely to be insufficient. Evaluation studies are needed to determine the extent to which different environmental education programs and approaches have an appreciable effect on any of the various components of environmental literacy (e.g., McBeth et al., 2011; Stapp et al., 1978, 1979; UNESCO, 1978). In addition, well-designed research studies are needed to further our understanding of how to maximize the potential of those environmental education programs and approaches that do advance environmental literacy (i.e., their promise and their limitations

for different populations of learners) (e.g., McBeth et al., 2011; Stapp et al., 1978, 1979; UNESCO, 1978). Results from curriculum-based assessments, often as part of evaluation and research studies, can provide guidance on which educational programs and approaches are more likely to be fruitful for learners with different characteristics (e.g., different ages, backgrounds, abilities, learning styles). While we acknowledge the importance of such studies, they are not our focus. Our intent is to provide guidance in the development of assessment frameworks for large-scale assessments like NELA and PISA. The results of such large-scale assessments will help us identify where improvement in environmental literacy is (and is not) being achieved and where educational advances appear to be needed.

In summary, the development of this document is a logical step toward reaching a multi-disciplinary consensus on what constitutes environmental literacy and addressing the need for assessment data and, ultimately, in building the environmental literacy of the coming generations.

Challenges in developing this document

There were a number of challenges in doing this work. It was important to build on prior efforts and incorporate applicable work from many disciplines. It was also necessary to grapple with the definition of environmental literacy and craft a definition appropriate for large-scale assessments which includes the best current thinking. Approaches to the assessment of environmental literacy are still being developed, so tension exists between proven measures and advances in educational testing and assessment. These and other challenges are discussed in greater detail in Appendix B.

DEFINING THE DOMAIN OF ENVIRONMENTAL LITERACY

To design an assessment of environmental literacy it is necessary to begin with a working description of what "environmental literacy" is. International definitions of literacy, historical definitions of environmental education, national and state descriptions of environmental education programs, and pertinent research all provide useful constructs, but the differences among them suggest that defining environmental literacy is a dynamic undertaking. As environmental and educational conditions shift, environmental education programs and practices improve, and new research emerges, the domain to be assessed will evolve and definitions – and this document – will need to be reviewed and updated.

An international definition of literacy

PISA has involved over 70 countries in literacy assessments in the last decade and has honed the following definition. *Literacy* is the capacity of students to apply knowledge and skills in key subject areas and to analyze, reason, and communicate effectively as they pose, solve, and interpret problems in a variety of situations (OECD, 2010). The PISA orientation looks to the future by emphasizing 15-year-olds' current ability to use their knowledge and skills to meet life situations, rather than focusing on the extent to which students have learned the content and developed the skills emphasized in school curricular programs (OECD, 2010).

Historical definitions of environmental education

In 1972, the UN Conference on the Human Environment in Stockholm called for UNESCO to work with all appropriate UN agencies, international non-governmental organizations, and the 148 UN member nations to develop a program for promoting environmental education around the world (Stapp, 1979a, p. 33). That led to the preparation of numerous working papers, the creation of UNESCO's International Environmental Education Programme, and to the 1975 International Workshop on Environmental Education in Belgrade (UNESCO, 1977). At that Workshop, 96 participants and observers from 60 countries, equally distributed among five UNESCO regions, unanimously adopted *The Belgrade Charter*. The *Charter* includes the following goal statement, which also serves as a definition of environmental education.

"The goal of environmental education is: to develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones." (UNESCO-UNEP, 1976, p.2)

The 1976 UNESCO statement was further refined during a 1977 UNESCO-UN Environment Programme (UNEP) Intergovernmental Conference at Tbilisi, then in the former U.S.S.R., at which it was concluded that the general public should be expected to achieve the following objectives:

    1. **Awareness:** To help social groups and individuals acquire an awareness of, and sensitivity to, the total environment and its allied problems.
    2. **Knowledge:** To help social groups and individuals gain a variety of experience

in, and acquire basic understanding of, the environment and its associate problems.
3. **Attitudes:** To help social groups and individuals acquire a set of values and feelings of concern for the environment, and the motivation for actively participating in environmental improvement and protection.
4. **Skills**: To help social groups and individuals acquire the skills for solving environmental problems.
5. **Participation:** To provide social groups and individuals with an opportunity to be actively involved at all levels in working toward resolution of environmental problems (UNESCO, 1978, pages 26-27).

These objectives have been reaffirmed at numerous subsequent international meetings.[2]

The Belgrade and Tbilisi statements, taken together, have become the most widely recognized definition of environmental education. It describes the end goal as well as experiences, strategies, and processes important for developing environmental literacy (e.g., UNESCO, 1978; Hart, 1981). Other influences that began moving forward during this same time period were also important for this framework.

Research and program frameworks

The body of research and evaluation studies related to environmental education has continued to grow (see, e.g., Iozzi, 1984; Rickinson, 2001; Roth, 1976; Roth & Helgeson, 1972; Volk & McBeth, 1997). Researchers have also explored active participation in environmental problem solving (see, e.g., Bamberg & Moser, 2007; Hines, 1985; Hines et al., 1986/87; Obsaldiston, 2004; Zelezny, 1999). Collectively, this body of work has shown that additional learning outcomes (beyond those defined at the UNESCO conference in Tbilisi) – including environmental problem solving, additional affective outcomes (e.g., environmental sensitivity, self-efficacy), and a variety of skills for collaboration – should be integrated into views of environmental literacy, and a number of frameworks reflect this.

The earliest effort to develop a framework based on the available environmental education literature came in the late 1970s (Harvey, 1977a, 1977b). This framework included cognitive, affective, and psychomotor domains, and was the first to reflect the fact that environmental literacy develops over time. The framework identified three levels of environmental literacy: literate, competent, and dedicated citizens (Harvey, 1977a, pp. 67-71). Another framework, developed in 1990, defined knowledge, skill, affective, and behavioral components, organized into three developmental clusters: entry-level variables, ownership variables, and empowerment variables (Hungerford and Volk, 1990, pp. 11-13).

A framework developed by Roth and others as part of a standard-setting process undertaken by NAAEE and the American Society for Testing and Materials (ASTM) also included three levels of environmental literacy: nominal, functional, and operational (Roth, 1992; Disinger & Roth, 1992). This framework also defined four broad components of environmental literacy similar the

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[2]These meetings took place in Moscow (1987), Thessaloniki (1997), and Ahmedabad (2007), as well as UNESCO conferences on sustainable development in Rio (1992) and Johannesburg (2002) (UNESCO, 1987, 1992, 2007; UN, 1992).

categories identified in the Tbilisi framework: knowledge, affect (attitudes), skill, and behavior (participation) (Roth, 1992, pp. 17-26).

Analysis of environmental education frameworks used in national and state programs provided the basis for another framework, developed in 1995, which served as the basis for the NAAEE's *National Project for Excellence in Environmental Education* (Simmons, 1995, pp. 54-58; NAAEE, 2004a). NAAEE's guidelines drew on program frameworks from such national-level programs as Project Learning Tree and Project WILD; from states, including Arizona, California, Minnesota, Missouri, New Jersey, and Wyoming; and from the National Science Teachers Association, Earth Education, and other organizations. From this analysis, Simmons identified seven elements of environmental literacy (Simmons, 1995, pp. 55-58) [3]:

> 1. Affect (e.g., environmental sensitivity, attitudes, and moral reasoning).
> 2. Ecological knowledge.
> 3. Socio-political knowledge (e.g., the relationship of cultural, political, economic, and other social factors to ecology and environment).
> 4. Knowledge of environmental issues.
> 5. Skills pertaining to environmental problems/issues and action strategies, systemic thinking, and forecasting.
> 6. Determinants of environmentally responsible behavior (i.e., locus of control and assumption of personal responsibility).
> 7. Behavior (i.e., various forms of active participation aimed at solving problems and resolving issues).

Another framework was created to support the development of several environmental literacy assessment instruments (Wilke, 1995). This framework was reviewed and validated by professionals within and outside the field of environmental education, and defined four clusters of environmental literacy components: cognitive dimensions (knowledge and skill), affective dimensions, additional determinants of environmentally responsible behavior, and personal and/or group involvement in environmentally responsible behavior (Wilke, 1995, pp. 5-6).

Defining the domain for this project

This framework builds on prior work and defines an environmentally literate person as 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. Those who are environmentally literate possess, to varying degrees:

- the knowledge and understanding of a wide range of environmental concepts, problems, and issues;
- a set of cognitive and affective dispositions;
- a set of cognitive skills and abilities; and

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[3] A review of research in environmental education was guided by Simmons' work (Volk & McBeth, 1997).

- the appropriate behavioral strategies to apply such knowledge and understanding in order to make sound and effective decisions in a range of environmental contexts.

This definition treats cognitive (knowledge, skills, and abilities), affective, and behavioral components as both interactive and developmental in nature; that is, individuals develop along a continuum of literacy over time – they are not either environmentally literate or illiterate (Harvey, 1977a, 1977b; Roth, 1992).

In the following paragraphs, parts of this definition of environmental literacy are considered in order to clarify their meaning in relation to assessment.

Knowledge and understanding of a wide range of environmental concepts, problems, and issues

Neither young people nor adults can be expected to have a full range of scientific knowledge and understanding of all of the complexities of the natural and built environment, and associated environmental problems and issues. To be environmentally literate, however, requires some knowledge of the Earth's systems, as well as of physical and ecological systems. Also important are social, political, economic, and cultural influences, as well as technical considerations; the roles they may play in causing or ameliorating environmental issues; and the connections and relationships between and among these complex interacting systems. Fundamental knowledge and understanding of such problems and issues as population growth, use of natural and energy resources, land use, loss of biodiversity, and ecosystem deterioration at local, regional, and global levels are also needed.

Cognitive and affective dispositions

A disposition is "the state or quality of being inclined to or to do something; a frame of mind or feeling" (Oxford English Dictionary, 1989) and the inclination to take action has an evident significance for environmental literacy. Some prominent environmental dispositions tend to focus on the natural world, such as environmental sensitivity (e.g., Chawla, 1998; Sward & Marcinkowski, 2001), others focus on environmental problems, such as environmental attitudes (e.g., Dunlap, 1992, 2002; Hines et al., 1986/87) and environmental concern (e.g., Van Liere & Dunlap, 1980), while others are more immediately associated with problem-solving behavior, such as assumption of personal responsibility, locus of control/self-efficacy, and intention to act (e.g., Hines et al., 1986/87; Bandura, 1977). Although different sorts of experiences appear to foster the development of these dispositions, they have been found to predispose individuals to actively engage in decision making and problem solving.

Cognitive skills and abilities

General cognitive skills and abilities are as important to environmental literacy as they are to other educational domains, such as mathematics, reading, science, and social studies (National Council of Teachers of Mathematics, 2000; International Reading Association & National Council of Teachers of English, 1996; National Research Council, 1996; and National Council for the Social Studies, 2010). These abilities include seeking and accessing information;

comparing, contrasting, and evaluating information; applying thinking to systems; and reasoning about the application of knowledge and action in environmental contexts, and range from ways of identifying issues to thinking critically about possible solutions. More specific problem-solving skills include the capacity to analyze and evaluate an issue; consider costs, risks, and benefits of alternative actions; assess the short- and long-term consequences of actions; communicate clearly; and plan, implement, and evaluate actions. The capacity to use information and communication technologies is another important skill-set.

Appropriate behavioral strategies

Since the late 1970s, environmental literacy has been perceived to include opportunities to participate in service and action that help improve the environment, such as direct conservation and restoration of natural environments, consumer behaviors, and public and interpersonal deliberations and debates. Research in education and psychology suggests that active, real-world experience fosters learning and development (see for example the work of John Dewey and Jean Piaget). Students are interested in applying what they have learned, and a growing body of theory and research suggests that active participation may promote other components of environmental literacy and cultivate life-long environmentally responsible behaviors.

Applying knowledge and understanding in order to make sound and effective decisions

An essential quality of environmental literacy is the ability to apply knowledge and understanding in situations involving environmental issues. Informed and evidence-based decisions are more likely to lead to effective actions.

A range of environmental contexts

Environmental problems and issues range from local to regional to national or global in scale. They may involve such relatively simple decisions as how to reduce the amount of energy used at school as well as such larger decisions as those that affect the status of species and their habitats. Experiences with smaller scale situations set the stage for the larger and more complex situations with long-term consequences that today's young people and future generations are likely to continue to encounter.

Willingness to act on decisions to improve the well-being of other individuals, societies, and the global environment

The expression of environmental literacy includes both personal decisions and those that may involve and affect others, and thereby have broader consequences for the environment and society.

Participation in civic life

Implicit in the definition of environmental literacy is the idea that a thoughtful and engaged citizen, as an individual and in collaboration with others, makes decisions and takes actions in varied contexts that benefit him or herself, the community, and society, both now and in the future.

ORGANIZING THE DOMAIN OF ENVIRONMENTAL LITERACY

An assessment must be based on a clear picture of the domain to be covered. The structure should reflect current thinking in the field and be explicit enough to guide both the design of the assessment as a whole and the development of the test items and survey questions to be used. The organization will also influence the evidence collected through the assessment. There are many dimensions of environmental literacy, but not all can be included in any single assessment. Thus, it is critical to identify the essential elements so that each assessment will include items and tasks that cover the domain and also reflect an appropriate range of difficulty.

As discussed earlier, environmental literacy is not a binary condition that people either do or do not have. Several observers have elaborated on its developmental nature, noting that as literacy develops, an individual's knowledge base expands, dispositions became stronger, competencies became more refined, and his or her behaviors become more sophisticated and, potentially, more effective. However, although environmental literacy develops over time, the process is not linear, but rather tends to involve regular or intermittent interactions among the main components of the domain.

For the purpose of this document, environmental literacy consists of knowledge and understanding of a wide range of environmental concepts, problems, and issues, a set of cognitive and affective dispositions, a set of cognitive skills and abilities, and the appropriate behavioral strategies to apply such knowledge and understanding in order to make sound and effective decisions in a range of environmental contexts. This corresponds with the literature on environmental education, which suggests that it consists of four interrelated components: knowledge, dispositions, competencies, and environmentally responsible behavior (Hungerford & Volk, 1990; Cook & Berrenberg, 1981; Stern, 2000). The interactive structure of this domain is shown in Figure 1. This illustration makes explicit both the variety of contexts in which environmentally responsible behavior may be undertaken and the feedback loops among its components.

Behavior is the ultimate expression of environmental literacy. It may not be possible to directly measure the ongoing development of environmental literacy, as represented by these feedback loops, but it is nevertheless important to recognize that it occurs on a continuum, and that literacy is facilitated by reflection, further learning, and additional experiences. Further study of this developmental continuum will improve efforts to promote the development of environmental literacy.

**Feedback/reflection loop
continued literacy development**

Knowledge

What you know about:
• Physical and ecological systems
• Social, cultural and political systems
• Environmental issues
• Multiple solutions to environmental issues
• Citizen participation and action strategies

Competencies

Skills and abilities that you know how and when to apply:

• Identify environmental issues
• Ask relevant questions about environmental conditions and issues
• Analyze environmental issues
• Investigate environmental issues (scientific and social aspects of issues using primary and secondary sources)
• Evaluate and make personal judgments about environmental issues (the interaction between environmental conditions and sociopolitical systems)
• Use evidence and knowledge to select and defend one's own position(s) to resolve issues
• Create and evaluate plans at various scales/levels to resolve environmental issues

Environmentally Responsible Behavior

Involvement in intentional and habitual behaviors, individually or as a member of a group, that work towards solving current problems and preventing new ones.

Contexts

Personal, Social, and Physical

Dispositions

How you respond to environmental issues:
• Sensitivity
• Attitudes and concern toward the environment
• Assumption of personal responsibility
• Locus of control/ Self-efficacy
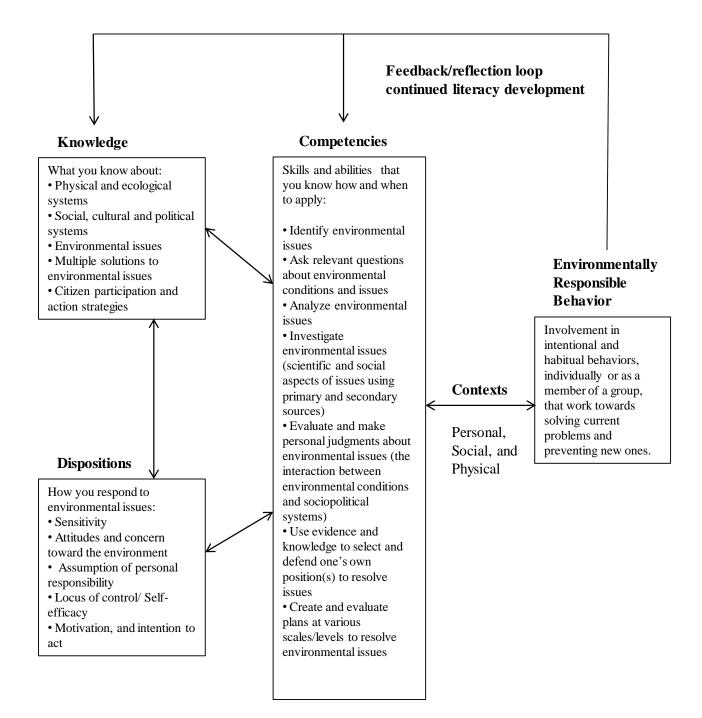• Motivation, and intention to act

Figure 1: The domain of environmental literacy

Knowledge

Environmental literacy is comprised of five types of knowledge that must be drawn on to respond competently to an environmental situation or issue. These are knowledge of: physical and ecological systems; social, cultural, and political systems; environmental issues; multiple solutions to environmental issues; and citizen participation and action strategies. These areas of knowledge have been identified in the environmental education literature since the late 1960s and 1970s (e.g., Disinger, 1983; Hart, 1981; Harvey, 1977b; Roth, 1970; Schmeider, 1977; Schoenfeld, 1969; Stapp et al., 1969). They have also been included among the objectives for environmental education in a number of key documents, albeit some more explicitly than others (e.g., Hungerford et al., 1980; NAAEE, 2004a; UNESCO, 1977, 1978). At least the first three of these knowledge components have been included in program and state environmental education frameworks (Simmons, 1995), although national surveys in the U.S. indicate that uneven attention has been given to each knowledge component in K-12 practice (e.g., Childress, 1976, 1978; Disinger, 1981, 1989). They have also been included in earlier environmental literacy frameworks (e.g., Hungerford & Volk, 1990; Roth, 1992; Simmons, 1995; Wilke, 1995).

Knowledge of physical and ecological systems

The fields of ecology and, more recently, Earth systems science (e.g., Earth Systems Science Committee, 1988; NRC, 2011) have grown and developed in recent decades, and both ecological and physical systems (e.g., geological, oceanic, and atmospheric systems) are important to environmental literacy. Relevant ecological and Earth systems concepts include: interdependent relationships in ecosystems; cycles of matter and energy transfer in ecosystems; interaction among Earth's major systems; the roles of water in Earth's surface processes; climate change and how the effects of human activities on Earth's climate are modeled; and conservation of energy and energy transfer (e.g., Charrett, 1989; Kormondy, 1984; Munson, 1994). This area of knowledge also includes humans as variables in ecosystems and Earth systems, which includes concepts associated with: the ecosystem services and natural capital on which humans (and all life) depend; adverse human impacts to these systems; and humans as agents in the protection and restoration of these systems (e.g., Berkowtiz et al., 2005; Costanza, et al., 1997; see also Marcinkowski, 1984; Volk & McBeth, 1997; Coyle, 2005; Rickinson, 2001; Roth, 1976; Roth & Helgeson, 1972). Hines et al. (1986/87) and Zelezny (1999) have analyzed evidence on the relationship of this knowledge component to behavior.

Knowledge of social, cultural, and political systems

Competent responses to potential or actual environmental issues require an understanding of the various social, cultural, and political systems (e.g., kinship, agricultural, transportation, economic, and legal systems), as well as the historical (temporal) and geographic (spatial) contexts in which they have developed and now function. In one of the few systematic studies of this type of knowledge, McKeown-Ice and Dendinger (2000) identified the "socio-political-cultural foundations of environmental education as the ideas or concepts from the social sciences that are prerequisite to understanding or analyzing environmental issues" (McKeown-Ice & Dendinger, 2000, p. 38). Their list of 63 concepts reflected major fields in the social sciences and the themes in the *Curriculum Standards for the Social Studies* (NCSS, 1994), as each informed

an understanding of human-environmental interactions, environmental issues, and civic participation. For example, one basic concept is the understanding that ecological scarcity – approaching or exceeding the limits of the environment to receive and degrade waste or provide resources – is expressed in, can be influenced by, and can affect cultural, political, and social systems. An understanding of these systems enables students to better understand the relationships among beliefs and practices and the influence of those beliefs/practices on the environment (see also Volk & McBeth, 1997, and Rickinson, 2001).

Knowledge of environmental issues

Two sorts of knowledge fall into this category: (1) knowledge of a variety of environmental problems that arise from biophysical impacts apparent in the natural world, and the causes and effects of those impacts; and (2) knowledge of environmental issues that arise from human conflicts about environmental problems and solutions, including the causes and effects of those conflicts (e.g., differences in access to resources, beliefs and values, and voice and power). Recognizing both biophysical and human causes and consequences of factors that adversely affect natural systems and exceed limits (e.g., overuse of resources, pollution) is an essential aspect of environmental literacy. Based on historical trends since the late 1800s, environmental issues have been apparent in such areas as natural resources; environmental quality and environmental health; human population growth, migration, and settlement; land use; biodiversity; climate change; and sustainability (e.g., Disinger, 1983; Millennium Ecosystem Assessment, 2003, 2005; Miller, 2004; Stapp, 1974; Swan, 1984; UN, 1992; World Commission on Environment and Development, 1987; annual reports of the Worldwatch Institute; biennial reports of the World Resources Institute; see also Wiesenmeyer et al., 1984; Volk & McBeth, 1997; Coyle, 2005; Rickinson, 2001; Roth, 1976; Roth & Helgeson, 1972). Bamberg and Moser (2007), Hines et al. (1986/87), and Zelezny (1999) analyzed evidence on the relationship of this knowledge component to behavior.

Knowledge of multiple solutions to environmental issues

The inclusion of knowledge of multiple solutions to environmental issues reflects a longstanding emphasis on problem solving in environmental education. Knowledge in this domain includes knowledge of past, ongoing, and current efforts, as well as of proposed and future alternatives, aimed at helping to solve environmental problems. It tends to be included in the research literature as an element of educational programs and assessed as part of related competencies. This category of knowledge includes the legacy of efforts – both success stories and failures – aimed at solving environmental problems.

Information about such efforts is often presented in the form of case studies of environmental protection and restoration efforts on the part of governmental agencies and various sectors of society (e.g., Caldwell et al., 1976; Tanner, 1976; Monroe and Kaplan, 1988; Bardwell, 1991). Familiarity with such case studies develops awareness that efforts to solve environmental problems may take a number of forms and include many dimensions (e.g., including scientific and technical, economic, policy and regulatory, information and education). University-level environmental studies texts and courses discuss problem-solving efforts to provide students with historical perspective, stimulate analysis of the effects of different problem-solving strategies,

and to keep students from becoming pessimistic (see Donoho, 1978; Foerstel, 1976; Melton, 1976; Williams, 1998; Hines & Hungerford, 1984; Rickinson, 2001; Roth, 1976; Roth & Helgeson, 1972; Volk & McBeth, 1997; Zelezny, 1999).

Knowledge of citizen participation and action strategies

The inclusion of knowledge of citizen participation and action strategies also reflects the historical emphasis on problem solving in environmental education, although in this case, the focus is on what students and older citizens, alone and in groups, can do to help solve problems and resolve issues. Individuals and groups of individuals may interact with the environment in different ways: (1) positively, by taking action to help improve or maintain the environment; (2) negatively, by acting in ways that decrease the quality of the environment; (3) passively, by neither harming nor helping the environment; and (4) in a mixed manner (i.e., some combination of these).

Positive interactions include many forms of citizen participation, action, and community service intended to preserve or improve the environment, and five categories of action strategies or modes of action have been identified (Hungerford et al., 1996; Hungerford & Peyton, 1980): eco-management (physical action); consumer and economic action; persuasion; political action; and legal action (these are discussed further below). Hungerford and Peyton (1980) recognized that, in many instances, real-world actions draw on a combination of strategies. For example, a letter writing or petitioning campaign uses *persuasion* to lobby for *political action*, in the form of votes on environmental legislation. The collection of funds to purchase and protect environmentally sensitive areas uses *economic* tools for *eco-management*. These categories can be used descriptively (to identify and describe a wide range of possible actions), analytically (as a framework to analyze the various forms of participation, action, and service in which citizens have engaged), and instructionally (as a way of introducing students to the range and variety of possibilities available to them; see Hungerford et al., 2003; see also Peyton, 1978; Marcinkowski, 2004, p. 51; Hines & Hungerford, 1984; Roth, 1976; Roth & Helgeson, 1972; Volk & McBeth, 1997). Hines et al. (1986/87) and Zelezny (1999) analyzed evidence on the relationship of this knowledge component to behavior.

Dispositions

Dispositions are important determinants of behaviors, both positive and negative, toward the environment. Students' dispositions toward the environment are thought to influence their willingness to recognize and choose among value perspectives, as well as their motivation to participate in public deliberations about environmental issues. Dispositions have been included among the objectives for environmental education in major documents (e.g., Hungerford et al., 1980; NAAEE, 2004a; UNESCO, 1977, 1978); in program and state environmental education frameworks (Simmons, 1995); and in other environmental literacy frameworks (i.e., Hungerford & Volk, 1990; Roth, 1992; Simmons, 1995; Wilke, 1995).

Sensitivity

Sensitivity is the expression of caring and positive feelings toward the environment, and has been described as a "set of positive affective characteristics that result in an individual viewing the environment from an empathetic perspective" (Peterson, 1982). Reviews of research have identified the various kinds of formative life experience that appear to contribute to sensitivity (Chawla, 1998; Sward & Marcinkowski, 2001). Studies have found sensitivity and associated life experiences to be significantly correlated with, and predictive of, behavior (e.g., Marcinkowski, 1989, 2001; Sia et al., 1985/86; Sivek & Hungerford, 1989/1990).

Attitudes, concern, and worldview

Attitudes are learned predispositions to respond in a favorable or unfavorable manner toward objects, events, and other referents (e.g., Fishbein & Ajzen, 1975), and therefore reflect students' interests and disinterest (e.g., Krathwohl et al., 1964). However, students' attitudes toward the environment extend well beyond their interests; they encompass dispositions toward selected aspects of the environment and environment-related matters such as nature, energy, pollution, technology, and economics (e.g., Borden, 1984/85; Hines et al., 1986/87; Marcinkowski, 1989; Sia et al., 1985/86). Some have subsumed the dimensions of environmental attitude that pertain to environmental conditions and problems under the general heading of environmental concern (e.g., Finger, 1993; Van Liere & Dunlap, 1976, 1980). Others speak of a more general environmental outlook (disposition) or worldview (e.g., Dunlap, 2008; Dunlap & Van Liere, 1978; Dunlap et al., 2000; Hawcroft & Milfont, 2010). Reviews of research in environmental education have given substantial attention to environmental attitudes and concern, although less to worldview (e.g., Iozzi, 1984; Roth, 1976; Roth & Helgeson, 1972; Rickinson, 2001; Volk & McBeth, 1997). However, additional reviews of research have indicated that the relationship between environmental attitudes and behavior is moderate (e.g., Bamberg & Moser, 2007; Hines et al., 1986/87).

Personal responsibility

The assumption of personal responsibility refers to an individual's "personal commitment to environmentally corrective behaviors" (Borden, 1984/85, p. 14). Research indicates that this includes dispositions associated with meta-cognitive processes that lead individuals to avoid or reduce behaviors that contribute significantly to negative environmental impacts, as well as undertake behaviors that contribute significantly to positive environmental impacts (e.g., Bamberg & Moser, 2007; Hines et al., 1986/87). Students can and do begin to assume responsibility for personal and collective contributions to the reduction and solution of current problems in developmentally appropriate ways, as they grow.

Locus of control/self-efficacy

Locus of control (perception of efficacy) refers to the extent to which people expect to be positively reinforced by the outcomes of their actions (e.g., Peyton & Miller, 1980). Self-efficacy is "the conviction that one can successfully execute the behavior required to produce outcomes" (Bandura, 1977, p.193). Theory and research have refined an early conception that distinguished

between an internal and external locus of control (e.g., Levenson, 1972) by differentiating between *powerful others* and *chance* (luck, fate) as dimensions of an external locus of control, and between individuals *acting alone* and *acting as member of a group* as dimensions of an internal locus of control (e.g., Hines et al., 1986/87; Marcinkowski, 2001; Sia et al., 1985/86; Smith-Sebasto, 1992b). This disposition contributes, along with skills and incentives, to the type and level of effort people make to achieve a goal. It is also predictive – a person is less likely to perform a task they do not think they can perform well or in situations where they do not think they can make a difference (e.g., Bandura, 1997; Hines et al., 1986/87; Marcinkowski, 2001; Peyton & Miller, 1980).

Motivation and intentions

Students may develop the motivation to act and express this disposition in the form of a willingness or intention to act and make decisions. These motivations and intentions are probably influenced by the beliefs and values an individual holds related to a specific issue (Hungerford, et al., 1996). Within the environmental education literature, motivation is the earlier and more general term for this predisposition to act (e.g., Stapp et al., 1969; UNESCO, 1977, 1978). With the popularization of Fishbein and Ajzen's work (1975), including their Theory of Reasoned Action and Theory of Planned Behavior, intention tended to replace motivation as a more common and technical term for one's predisposition to act (e.g., Bamberg & Moser, 2007; Hines et al., 1986/87; Kollmuss & Agyeman, 2002). Reviews of research indicate that intention serves as the strongest correlate with, and predictor of, behavior (e.g., Bamberg & Moser, 2007; Hines et al., 1986/87).

Competencies

Competencies are defined as clusters of skills and abilities that may be called upon and expressed in real-world and assessment settings for a specific purpose. In general, a person is considered to be competent when he or she can do something repeatedly and at a certain level of quality or precision. For example, the identification of environmental issues requires the ability to receive sensory input and interpret that input on the basis of prior knowledge and experience. This competency also may require the identification and use of appropriate media sources; the ability to discriminate between features of environmental problems and issues in those sources; the ability to judge the validity of information and recognize value perspectives apparent in those sources; and the ability to determine the status and relevance of that issue.

The expression of a particular competency is likely both to be influenced by and to influence an individual's *knowledge* and *dispositions*, in the real world and in assessment settings. In this way, both the development and the expression of competencies contribute to the development of environmental literacy. Competencies also can be viewed as a means to an end (e.g., responsible environmental behavior) or an end unto themselves (e.g., an educational objective). However, in the context of environmental literacy, *knowledge*, *dispositions*, and *competencies* enable and are expressed as *behaviors*.

Though these components of environmental literacy are interactive – and are all important – the *competencies* listed in Figure 1 are of primary importance in an assessment context. Those

competencies include the ability to: identify environmental issues; analyze those issues; evaluate environmental phenomena and interactions within socio-political systems; use evidence and knowledge to describe and support a position; and create and evaluate plans to resolve environmental issues. Each is described separately below. These competencies have been included in major sets of goals and objectives for environmental education (e.g., Hungerford et al., 1980; NAAEE, 2004a; UNESCO, 1977, 1978), and in program and state environmental education frameworks (Simmons, 1995). Reviews of research in environmental education have included studies of the development and application of many of the skills and abilities that comprise these competencies (e.g., Bastardo et al., 1984; Coyle, 2005; Hines et al., 1986/87; Marcinkowski, 2004; Rickinson, 2001; Volk & McBeth, 1997). These competencies have also been included in environmental literacy frameworks discussed above (i.e., Hungerford & Volk, 1990; NAAEE, 2004a; Roth, 1992; Simmons, 1995; Wilke, 1995).

Identify environmental issues

It is important to be able to recognize issues that are primarily environmental as well as issues with important environmental dimensions and implications, and to distinguish environmental issues from other types of issues. However, the ability to identify issues involves more than simply naming them. Students and others should be able to describe and provide evidence for the environmental conditions, risk, and impacts (the problem dimension), and for the human disagreements and conflicts (the human dimension) that are central to the environmental issues they identify. They should also be able to describe historical and geographic aspects of these issues, and to recognize and describe factors that cause or contribute to them, along with their implications or likely consequences (e.g., ecological, economic, social, and political). Finally, they should be able to do so for different kinds of environmental issues (e.g., issues pertaining to biodiversity, human population growth and migration, natural resources, pollution and waste, environmental health, land use planning and development, climate change, sustainability).

Ask relevant questions

The ability to ask relevant questions follows from the ability to identify issues. Relevant questions may pertain to problem or human dimensions, to historical or geographic features, or to other aspects of an issue. These questions may point to the need for factual, conceptual, or procedural information, as well as reflect different levels of Bloom's Taxonomy (e.g., Anderson & Krathwohl, 2001; Bloom et al., 1956). Most important is that individuals and groups develop the ability to ask higher-order questions aimed at discovering conditions that may have caused or contributed to an environmental problem, why that problem has become an environmental issue, and the implications of that problem and issue. Some of these questions can set the stage for analyzing an issue (e.g., interview questions for stakeholders and vested interest groups) or for investigating an issue (e.g., research questions). Developing this competency will allow individuals to ask questions of increasing sophistication to help determine what to believe and what is important about an issue, and how to respond to or act on it.

Analyze environmental issues

The ability to analyze an environmental problem involves the interpretation and use of scientific knowledge and new information to determine, with regard to an environmental problem, its historical causes, geographic scope, manifestations, and probable consequences. The ability to analyze the human dimensions of an environmental issue involves the interpretation and use of socio-political knowledge and new information to determine the stakeholders and others with a vested interests in an issue, the positions they take on that issue, the reasons they give for taking those positions, and the degree and type of importance they attach to their positions and reasons (e.g., Ramsey et al., 1989). The analysis of issues also requires the ability to determine which factors appear to cause or contribute to that issue, to determine interactions between features of the problem and the issue, and to generate estimations or predictions about likely consequences of the issue.

Investigate environmental issues

Investigating environmental issues builds on the competencies described above. Investigations can include the ability to locate relevant sources of information about a problem and issue (e.g., using libraries, the internet, or interviews with knowledgeable sources and stakeholders); to gather relevant information from those sources; to review it (e.g., for factual inaccuracies or for bias); and eventually to synthesize and report that information (e.g., as part of a written and/or oral report). The mining of information from existing sources (secondary investigation) often precedes and informs the design and conduct of basic research, which involves gathering new information or data (primary investigation), and requires a new set of abilities associated with the use of processes commonly used in science or social science research (i.e., the ability to pose questions, both quantitative and qualitative; create methods to collect data; interact with the public or the environment to gather data; organize and interpret data; and communicate the outcomes of the investigation).

Evaluate and make personal judgments about environmental issues

This competency involves critical thinking abilities commonly associated with the highest levels of Bloom's Taxonomy (Bloom et al., 1956). It includes the abilities to (1) set criteria and use those criteria to critique or judge (e.g., asking whether there is there sufficient data to warrant action on an issue), and to (2) judge on the basis of internal consistency (e.g., determine the extent to which the available information or data provides a reasonably clear, comprehensive, and coherent portrait of the issue). The ability to summarize information and data gathered from primary and secondary sources, and use it to construct explanations or draw conclusions is essential to this competency. Further, this competency requires the ability to attempt a dispassionate evaluation of the issue (e.g., weighing available data, the beliefs and values of other stakeholders, and the probable consequences of their action or inaction), but also requires the ability to engage in personal judgments and decisions (e.g., to determine when information and data appear to be sufficient to warrant action; which course of action might be most appropriate; which would be most consistent with my personal values; whether I have sufficient capacity to undertake each possible course of action; whether I have the time and resources

needed to resolve the issue; and whether I am willing to do it) (e.g., Hungerford & Peyton, 1980; Newmann, 1975).

Use evidence and knowledge to defend positions and resolve issues

Another important set of competencies includes taking and defending a position, and marshaling evidence in support of an argument. Instructional strategies commonly used in social studies education (e.g., debates and mock trials) demonstrate that there are ways of encouraging students to develop and exercise these competencies. However, in real-world settings, this competence requires the ability (and willingness) to make decisions regarding the resolution of an environmental issue (e.g., deciding whether or not to become involved and committing to a course of action). This competency also requires the ability to support individual or group decisions regarding an appropriate and adequate course of action on the basis of available information or data and understanding of the capacities of those involved (not on the basis of emotion alone). The essential quality of this competency is constructing and defending an argument about what it will take to resolve, or to help resolve, an environmental issue.

Create and evaluate plans to resolve environmental issues

This competency requires a clear assumption of responsibility for acting in ways designed to resolve, or to help resolve, an issue. More specifically, this requires the ability to engage in sound planning based on the environmental conditions, available resources, and the socio-political context. This competency also requires the ability to evaluate a specific course of action before undertaking it, assessing its adequacy and implementation as it is underway, and evaluating its outcomes once it is completed.

Additional competencies

The competencies included above were selected based on three criteria: (1) whether each was addressed in environmental education research and practice; (2) whether there was a sufficient evidence base to support its inclusion; and (3) whether it could reasonably be measured in a large-scale assessment.

There are relevant competencies that are addressed in literature and practice, but did not appear to meet the second or the third criteria. These include the ability to communicate effectively in written, graphic, and oral forms; the ability to think critically (e.g., Athman, 2004; Cheak, 2001); the ability to engage in quantitative, scientific, ethical, and other forms of reasoning (e.g., Berkowitz et al., 2005; Iozzi, 1977, 1978); the ability to think across disciplines/fields and in terms of systems (e.g., Roth, 1992); and the ability to work collaboratively, constructively, and effectively as a member of a group (e.g., Chawla & Cushing, 2007; Muro & Jeffrey, 2008).

Many of these environmental competencies would be fruitful topics for further study, to:

- further define relevant features of each competency;
- develop sound and appropriate methods to assess each;
- determine the relative effectiveness of different curricular and instructional strategies on

the development of each;
- investigate the extent to which each is transferred and applied beyond formal and non-formal programs to real-world settings;
- investigate the relationship of each to environmentally responsible behavior; and
- review research pertaining to each as it becomes available.

Context

Environmental *problems* occur when events, either natural or human-caused, dramatically disrupt the dynamic equilibrium that exists in nature (e.g., carbon dioxide from human combustion of fossil fuels is released into the atmosphere, movement of plate tectonics causes a tsunami, an oil tanker runs aground and releases oil into a waterway). An environmental *issue* occurs when there is disagreement on the nature of, and what to do about, an environmental problem. Should we approve a carbon tax? Should we invest in the development of renewable sources of energy? Should we place more regulations on the building and movement of oil tankers? The nature of environmental issues makes them contextual.

Ultimately, environmental literacy is expressed as the taking of responsible action toward the resolution of environmental issues. Environmental literacy requires understanding the science and systems interactions that affect environmental issues, and possessing the cognitive abilities and affective dispositions to think critically about and act on them, but attention must also be paid to the contextual factors within which literacy is expressed.

The *personal context* – such as cognitive developmental level, level of education, personal situation, and life experience – may help determine or explain how and why an individual takes an action. The *social context* – the influence of social systems – and the *physical context* – the influence of time and place – may also influence responsible environmental action.

Personal context

Expectations for a 10-year-old's behavior are very different from expectations for that of a 20-year-old. It is more likely that the 10-year-old's environmental literacy would be expressed concretely through responsible action on a local issue rather than a more abstract or global one. It may be more important for a younger person to directly witness or experience the results of the action. In contrast, a 20-year-old could be expected to have a deeper knowledge base and express concerns that are beyond his or her immediate experiences. Education, whether formal, informal, or gained through life experiences, is represented by the feedback loops and two-way arrows illustrated in Figure 1.[4] These continued opportunities to express environmental literacy provide the foundation for reflection on actions and outcomes. With more opportunities, more learning may occur, yielding more effective actions. Personal situations also affect behavior. Psychological and physical needs (for food, water, clean air) and the need for safety outweigh the ability to become a self-actualizing learner (Maslow, 1943). Personal finances may also restrict actions an individual may undertake.

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[4] See discussion of assimilation and accommodation in Piaget (1977).

Societal context

Social influences and pressures may affect the way environmental literacy is expressed. Was literacy expressed individually or in the context of a group? Was there pressure to act in a specific manner? What are the personal, familial, and social impacts of an action? What, if any, compromises were made? Further, behaviors that are appropriate within one culture may not be appropriate for other cultures.

Physical context

There are a number of physical environments in which an individual may express his or her environmental literacy (i.e. local, regional, global, urban or rural). The physical environment encompasses a variety of thematic areas as shown in Table 1, p. 4-4. While not all environmental issues are of equal concern to everyone, taking responsible actions on a localized issue or on an issue that is limited in its scope is no less an expression of environmental literacy than is taking action at the global level.

Environmental issues do not operate in a vacuum, but in a variety of physical, personal, social, and political contexts. In different contexts, people may have different disagreements about, and solutions for, similar issues. Environmental literacy is also not stagnant over time, but should be thought of as dynamic, changing as personal beliefs, experience, behavioral sophistication, social influences, and environmental issues develop and evolve.

Environmentally responsible behavior

Environmentally responsible behavior is the expression of knowledge, dispositions, and competencies within a context. It is also a source of experience that supports further learning and new behaviors. Within the environmental education field and in a variety of associated fields, a number of terms have been used for environmentally responsible behavior (e.g. environmental behavior, pro-environmental behavior, ecological behavior; see Bamberg & Moser, 2007, p. 17). Each of these refers to behaviors intended to have a positive impact on the environment by targeting problems and issues, as well as those that actually have a positive environmental consequence (Cook & Berrenberg, 1981; Lipsey, 1977; Marcinkowski, 1989; Stern, 2000).

Environmentally responsible behaviors have been conceptualized in a variety of ways, several of which are not unique to the environmental field. One approach focuses on the nature of individual and collective responses to conditions in ways that are: proactive (e.g., citizen action); interactive (e.g., citizen participation and community service); or reactive (e.g., coping and compliance behavior).

A second approach focuses on a developmental continuum from intentionality to habit (Smith & DeCoster, 2000). In the early stages of literacy development, behaviors could be considered intentional, meaning those that require purposeful thought and are used to generate schemes. Smith and DeCoster describe the processing that could result in intentional behavior as rule-based. In rule-based processing, experiences are the foundation for further processing. New situations are processed within the context of prior experiences. Processing is purposeful,

relatively slow, and analytical (relying on specific associations to make connections). These researchers view habitual behavior as the result of associative processing in familiar situations that may follow from intentional behavior. When encountering a situation that is familiar (i.e., a situation that has been experienced many times and in multiple ways), an individual draws on pre-existing schemas, and the resultant behavior may be similar to that which was previously expressed. Smith and DeCoster cite Bargh (1994) in suggesting that "processing operates preconsciously" (Smith & DeCoster, 2000, p. 111) and that there is an awareness of the outcome but not the act of processing. Associative processing usually occurs automatically and relies on global connections to prior learning. Examples of environmentally responsible behaviors that could be considered habitual include turning out the lights when leaving a room, composting, or walking instead of driving. With enough experience, intentional behaviors can become habitual, so it is important to remember that habitual behaviors are the result of multiple expressions of intentional behaviors.

A third approach, which reflects elements of the first two, was developed for use within the field of social studies education, as a means of citizenship education (e.g., Langton, 1990). The social studies education community has discussed and critiqued numerous curricular and instructional approaches that reflect one or another type of behavior in Langton's framework (e.g., Newmann, 1975; Reische, 1987). Others have explored the implications of this work for environmental education (e.g., Houser, 2009).

Some conceptions of environmental behavior mix other kinds of environmentally related activities that do not meet this intention-and-consequence criterion into their frameworks or measures (such as nature recreation, environmental reading, investigation of problems and issues). Others include behavior-related variables, such as efficacy or intention to act (e.g., Kaiser, 1998).

All of these approaches of environmentally responsible behavior have insights to contribute, but there are measurement problems associated with each, which limits their value in the design of large-scale assessments.

One conceptualization that meets the intention-and-consequence criterion and has been used in large-scale assessments is an itemization of categories (or modes) of citizen action developed by Peyton and Hungerford (Hungerford & Peyton, 1980; Peyton, 1978). These categories are:

1. **Eco-management**: The ways in which individuals can work directly in and with the physical world to help prevent or resolve environmental problems or issues. Examples include picking up litter and other types of waste, creating habitat for native plants and animals, installing erosion and pollution control measures, and participating in larger-scale ecological and environmental restoration projects.
2. **Persuasion**: Approaches that can be used when individuals or groups appeal to others in an effort to convince them to take an action that they believe to be the necessary or correct response to an environmental problem or issue. Three approaches can be taken when making a persuasive argument: logical, emotional, and coercive. A logical argument presents a series of facts that lead to one of the other action types or modes. An emotional approach may or may not present factual information, but its goal is to appeal

to another person's emotions to encourage action. Coercion is forced persuasion: someone is forced into acting by the threat of some type of retribution. Appeals can be either interpersonal (i.e., encouraging family members and friends to recycle) or public (i.e., writing a letter to the paper, speaking at a forum, or the use of social media).

3. **Consumer/economic action**: The use of monetary support or financial pressure to help prevent or resolve an environmental problem or issue. Consumer action can have a direct impact, as in the act of buying or selling, or not doing so; or an indirect impact, as in choosing to ride a bike rather than driving a car.

4. **Political action**: Hungerford et al. (1996) refer to political action as "…any mode of action that brings pressure on political or governmental agencies and/or individuals in order to persuade them to take a positive environmental action" (Hungerford et al., 1996, p. 168). Examples of political action include voting, campaigning for candidates, and lobbying for legislation or funding.

5. **Legal action**: Use of the legal system to support or enforce existing laws that are designed to lead to an improved or maintained environment. Examples include reporting violations of existing laws to authorities, and providing testimony.

Use of these five categories to assess environmentally responsible behavior and report estimates of validity and reliability have been conducted by several researchers (Sia, 1985; Sia et al., 1985/86; Sivek, 1989; Sivek & Hungerford, 1989/90; Marcinkowski, 1989, 2001).These categories also served as the basis for measures in other studies (Champeau, 1983; Champeau & Peyton, 1984; Newhouse, 1986) and have also been used to develop measures and use them in assessments of environmental literacy among high-school students (Marcinkowski & Rehrig, 1995; Plankis, 2009; Willis, 1999) and fourth and fifth graders (Erdogan, 2009). Thus, these categories appear to be robust enough to serve as the basis for measures of environmentally responsible behavior at the elementary, secondary, and adult level.

A second conceptualization of environmentally responsible behavior that reflects the intention-and-consequence criterion was presented by Stern (2000), who distinguished environmental activism, non-activist behaviors in the public sphere, private sphere environmentalism, and other environmentally significant behavior. He cites the results of a factor analysis of the 1993 General Social Survey (Dietz et al., 1998), indicating the utility of this conceptualization for assessment purposes.

Hungerford and Peyton's and Stern's approaches are not the only ways to conceptualize and assess environmentally responsible behavior. Other approaches include the Children's Environmental Knowledge and Attitude Scale (CHEAK) instrument developed by Leeming and his colleagues (Leeming et al., 1995), which was validated for use with middle grades students. For this reason, it was included in the MSELS and used to gather student data in the NELA Phase One and Phase Two studies (McBeth et al., 2008, 2011).

A third conceptualization emphasizes action competence, as exhibited, for example, through civic engagement and collaborative solution seeking. This action competence approach – as described by Jensen & Schnack (1997), Scott & Gough (2003), and Wals (2007), among others – has not yet been used in large-scale assessments. It focuses on critical, integrative thinking as it relates to contextual decisions through citizen participation and, more broadly, the development

of personal competence and agency, as well as collective competence and capacity. Grounded in social learning theory (Bandura, 1997) and Lave and Wenger's notions of situated learning (Lave & Wenger, 1991), this approach has attracted growing interest in natural resources and environmental education research and practice (see, for example, Chawla & Cushing, 2007; Clark, 2010; Keen et al., 2005; and Krasny et al., 2009.)[5]

As the complexity of environmental problems and issues increases in the 21st century, developing and honing skills for productive dialogue, coalition-building, and conflict resolution, will become increasingly critical. Systemic and integrative thinking, collaborative deliberation, and decision making described in this approach will be called to the fore as individuals strive to create healthy built environments and vibrant and resilient social systems, and further the sustainability of Earth's systems. As this approach and the research that undergirds it grow, conceptions of any number of knowledge, disposition, competency, and behavior components included in Figure 1 may change, and possibilities for assessing them may be developed.

Conceptions of environmentally responsible behavior, and its interaction with the knowledge, competencies, and dispositions that make up environmental literacy, are likely to evolve and present new measurement challenges. Further research and deliberation will be needed. The field is likely to grow increasingly interdisciplinary as society seeks effective ways to sustain the ecosystems on which all life depends. Whatever happens, the engagement of, and decision making by, an environmentally literate citizenry will be essential.

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[5] Two forthcoming research compilations of environmentally related research, the *International Handbook on Environmental Education Research* (American Educational Research Association) and the *Oxford Handbook of Environmental and Conservation Psychology* (Oxford University Press), also address this approach.

ASSESSING THE DOMAIN OF ENVIRONMENTAL LITERACY

In reflecting on material presented in the sections entitled "Defining the Domain of Environmental Literacy" and "Organizing the Domain of Environmental Literacy", two general messages emerge. First, over the past 35 years, the progress that has been made in defining environmental literacy and describing the components of it provides a basis for this project and a critical support for the development of assessments. Future international and national assessments of this domain, as well as related studies, will continue to make contributions to our evolving understanding of environmental literacy.

The second message is that, at this point in time, it is clear that this is a very complex domain, and it is virtually impossible to assess all of its components and features in any single assessment. Indeed, some features – such as feedback loops between, and interactions among, the various components – may not be measurable at all. Moreover, the art and science of assessing several of the environmental literacy components shown in Figure 1 are still in an early stage of development.

Perhaps most importantly, for those environmental literacy components that can be assessed, there is simply too much to be assessed in any depth within a single large-scale international or national assessment. Figure 1 depicts the five knowledge components, five dispositions, seven competencies, and different modes of environmental behavior, as well as the varied contexts that make up the defined domain (as discussed earlier). The time that would be required to gather assessment data on all of these components and contexts would be prohibitive. Thus, the developers of every international and national assessment of environmental literacy must select which components to include early in the process of developing an assessment framework. Figure 2 shows the components selected for the NELA project (McBeth et al., 2008, 2011), and the figure on p. 5-18 shows the components proposed for a 2015 PISA assessment of environmental literacy.

The sections that follow describe the major elements of an assessment framework (see Appendix C for a more detailed list). These elements are presented as sets of decisions to be made by assessment designers; the resulting decisions – made to suit the needs of a particular assessment – would be the basis of specifications for that assessment. It should be noted that in practice these decisions would likely not be made in a linear fashion, and might need to be revisited and revised as the framework development process proceeds. A variety of practical considerations – such as design and development timetable, time available to conduct the assessment, finances, and political considerations – would also likely influence these decisions.

Feedback/reflection loop
continued literacy development

Knowledge

What you know about:
• **Physical and ecological systems**
• Social, cultural and political systems
• **Environmental issues**
• Multiple solutions to environmental issues
• Citizen participation and action strategies

Competencies

Skills and abilities that you know how and when to apply:

• **Identify environmental issues**
• Ask relevant questions about environmental conditions and issues
• **Analyze environmental issues**
• Investigate environmental issues (scientific and social aspects of issues using primary and secondary sources)
• Evaluate and make personal judgments about environmental issues (the interaction between environmental conditions and sociopolitical systems)
• Use evidence and knowledge to select and defend one's own position(s) to resolve issues
• **Create and evaluate plans at various scales/levels to resolve environmental issues**

Environmentally Responsible Behavior

Involvement in intentional and habitual behaviors, individually or as a member of a group, that work towards solving current problems and preventing new ones
• **Ecomanagement**
• **Persuasion**
• **Consumer/Economic**

Contexts

Personal, Social, and Physical

Dispositions

How you respond to environmental issues:
• **Sensitivity**
• **Attitudes and concern toward the environment**
• Assumption of personal responsibility
• Locus of control/ Self-efficacy
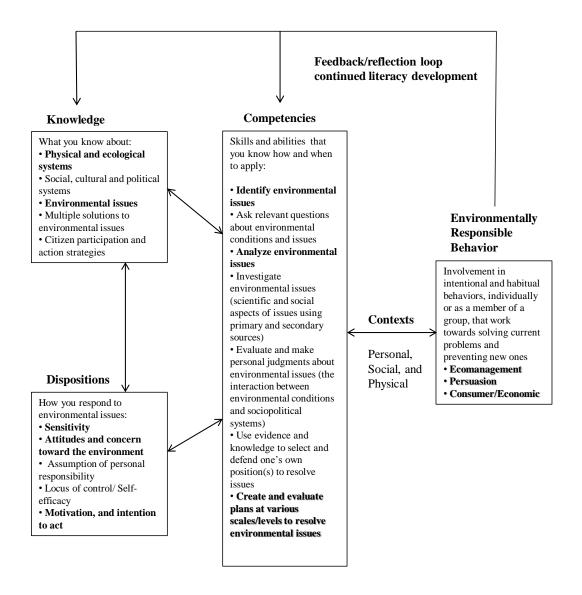• **Motivation, and intention to act**

Figure 2: Components of the domain of environmental literacy assessed in the National Environmental Literacy Assessment Project (McBeth et al., 2008, 2011). The selected components are shown in bold.

Assessment decisions

Scale of the assessment

Assessments of environmental literacy have been limited in number and are needed at all levels, but this document emphasizes large-scale international and national assessments of environmental literacy, because of both a unique opportunity and a compelling need. The

opportunity is for PISA and NELA leaders to collaborate on a project of mutual interest, drawing on what these groups have learned from their respective experiences. This collaboration could help to advance interest in future assessments, and also to build the knowledge base regarding assessment in this area. The compelling need has been for greater consistency in assessments of environmental literacy, to provide a broader and more complete picture of such literacy worldwide. Consistency would particularly benefit the federal agencies, corporations, institutions, and organizations that have been investing in programs and projects to advance environmental literacy, thereby enabling them to gauge progress in achieving that goal.

This approach could also be used to guide smaller-scale assessments, although some of the issues may be different.

Whom to assess

The design of an assessment must take into account the population to be assessed. Decisions about the ages and grade levels to be tested might be based on such factors as the availability of prior research or assessments pertinent to each population, an institution's interest in literacy at a certain point in learners' educational careers, and the social and cultural, developmental, and educational characteristics of each population. For example, NELA assesses middle grades students and PISA assesses 15-year-olds who are at or near the end of their formal schooling. The characteristics of the population to be tested should guide decisions about the developmental appropriateness of content to be assessed, the format of items and tasks, and the manner in which the assessment will be administered.

Determining the scope

Without a doubt, selecting the components of this complex domain to assess is a challenge, and one may ask whether there are any particular components of the framework that must be included in an assessment if it is to adequately assess environmental literacy. While this project considers knowledge, dispositions, competencies, and behavior as important components of environmental literacy, we identify *competencies* as the priority for assessment. However, because competencies are influenced by (and influence) *knowledge* and *dispositions*, those components must also be assessed. Behavior describes the point at which competencies, knowledge, and dispositions are brought to bear within a particular context. However, treating behavior as a component of large-scale environmental literacy assessments is controversial, in part because it is more difficult to assess than the other components. First, *behavior* may be more readily assessed in a national scale assessment than in a large international assessment, because of cultural and political differences that may influence expectations regarding behavior. Second, measures of behavior in large-scale assessments tend, for obvious reasons, to rely heavily on self-reports. Many researchers view self-reports as less valid and/or reliable than other types of measures, although several strategies have been developed and used to address these concerns, at least in part. As a whole, this orientation clearly contrasts with assessments designed to only report students' acquisition of knowledge and skills, and with early assessments of environmental knowledge and attitudes (Kollmuss & Agyeman, 2002; Marcinkowski, et al., in press).

Beyond these basic objectives, assessment developers will also consider the questions that a particular assessment is expected to answer, the developmental levels of those to be assessed, and practical constraints. They will also identify the components most useful for their purpose. These decisions would serve as a first set of specifications to guide the development of the assessment and scoring scales.

Determining the thematic areas

There are a range of thematic areas in which environmental literacy is expressed, as, for example, shown in Table 1. An assessment that reflects this variety offers the greatest possibility of engaging the interest of test-takers and providing an opportunity for them to demonstrate their potential for confronting environmental issues.

Table 1. Suggested thematic areas for item development*

	Local	**State and National**	**Multinational and Global**
Biodiversity	Local flora and fauna	Endangered species, habitat loss, exotic invasive species	Conservation of biodiversity, sustainable use of species
Human Population	Local growth, birth/ death, emigration, and immigration patterns	Maintenance of human population, population distribution, over population	Population growth and its social, economic and environmental consequences
Natural Resources	Local consumption of living and non-living resources	Production and distributions of food, water, energy	Sustainable use of renewable and non-renewable resources
Environmental Quality and Health	Impacts from local use and disposal of materials on air and water quality	Disposal of sewage and solid waste, environmental impacts	Environmental quality and sustainability
Natural Hazards and Extreme Weather	Local decisions about construction in areas vulnerable to flooding, tidal and wind damage	Rapid changes (e.g., earthquakes), slow changes (e.g., coastal erosion), risks and benefits	Climate change, extreme weather events
Uses of Lands and Exclusive Economic Zones	Local conservation of agricultural lands, greenways, and wetlands	Impact of development on watersheds, flood plains, and the coastal zones	Production and loss of topsoil, loss of arable land, dead zones in coastal and ocean waters

*Note: Each thematic area is intended to include terrestrial, aquatic, and marine conditions.

However, not all environmental situations will be equally familiar to all test-takers, so items and tasks should reflect the circumstances of the population being assessed. For example, as young people grow, their perspectives widen – from home and school situations for elementary students, to neighborhood and community situations for middle level students, to state and national situations for secondary students, to international and global situations for college students and adults. As Table 1 shows, different kinds of environmental problems and issues are associated with different thematic areas, and the table identifies the levels at which problems and issues may express themselves (i.e., local, state/national, and multinational/global).

The thematic areas in the table are intended to be illustrative, not exhaustive, and they are not mutually exclusive; that is, topics associated with the themes often intersect, and conditions associated with them often interact in dynamic ways. Table 1 is therefore intended to serve only as a general guide. Assessment designers must modify this table to reflect the thematic areas, levels, and problems/issues that are appropriate for the population being assessed and that the designers wish to assess. That modified table would serve as their second set of specifications.

Distribution and weighting

The specifications resulting from the decisions about what is to be assessed and the thematic areas to be covered will guide the design of a particular assessment's structure, and of the items and tasks that will yield the desired evidence. Test designers must consider:

- The degree of emphasis, or distribution of items and tasks, across the thematic areas and selected components (competencies, knowledge, dispositions, behaviors) – how many items there will be to cover each of these areas and what proportion of the assessment will address each.
- The relative weight to be assigned to each area, in terms of scoring.
- The nature and format of the items and tasks.

The first structuring decisions pertain to the relative degree of emphasis and intended distribution of score points for the elements in the assessment. The term "degree of emphasis" is used to identify the relative number of items and tasks associated with each element. The term "score points" is used in preference to "items," as it is possible that some partial credit items, which yield more than one score point, would be included. Score distributions for each might be expressed in ranges that reflect the expected weighting. Tables 2a and 2b are given as examples to illustrate the weighting of the knowledge and disposition components of the NELA assessment (McBeth et al., 2008, 2011). A complete set of tables that can be used to facilitate discussions and decisions about the expected weighting of these elements has been included in Appendix C. Decisions about weighting for a new assessment would be recorded in such tables and would serve as a third set of specifications for assessment developers.

Table 2a. Degree of emphasis and distribution of score points for environmental knowledge in the NELA assessment*

	Physical and Ecological Systems	Socio-Political Systems	Environ-mental Issues	Multiple Solutions to Environmental Issues	Citizen Participation/ Action Strategies	Total
Emphasis	88 %	0 %	12 %	0 %	0 %	100%
Score Pts.	88 %	0 %	12 %	0 %	0 %	100%

*Note: Percentages reflect the number of items or points to be earned in each area.

Table 2b. Degree of emphasis and distribution of score points for dispositions toward the environment in NELA*

	Environmental Sensitivity	Environmental Attitudes and Concern	Assumption of Personal Responsibility	Locus of Control/ Efficacy	Motivation and Intention to Act	Total
Emphasis	44 %	8 %	0 %	0 %	46 %	100%
Score Pts.	44 %	8 %	0 %	0 %	46 %	100%

*Note: Percentages reflect the number of items or points to be earned in each area.

Length, difficulty, and order of test sections

Decisions also need to be made about the length, difficulty, and ordering of the items and sections in an assessment instrument, based on the population to be assessed and the nature of evidence to be collected. A lengthy test section – say more than 45-60 minutes for younger students – may tire test-takers, and adversely affect their performance. Similarly, the relative difficulty of sections and items can influence participants' responses. Adverse effects can be reduced by careful attention to the length of each section and of the overall instrument, as well as the relative difficulty and placement of sections. For example, it might be most effective to avoid placing the longest, most complex sections at the beginning or end of an assessment. Research has indicated that the order in which sections are placed can influence responses and scores. For example, Armstrong and Impara (1990) found that completion of knowledge sections before attitudinal sections can contribute to elevated attitude scores. These decisions have implications for data preparation as well (e.g., how to handle participant records with a sizable number of blank responses).

Decisions about the relative length, difficulty, and ordering of sections within an assessment would serve as a fourth set of specifications for an assessment.

Item design

Decisions about the types of items, tasks, and response formats to be used are also important, and are based both on the kinds of evidence that are needed for each component and on technical and practical considerations. In general, the options are selected-response items, constructed-

response items, or some combination of the two. In NELA, only selected-response formats were employed because Scantron forms were used to collect responses. In PISA, both selected- and constructed- response formats have been used.

Selected-response formats require students to choose one or more responses from a given set of response options. For assessments of knowledge and competencies, standard multiple-choice items, which require the selection of one option from a set (usually of four), are often used. Teachers, teacher educators, test developers, and others have developed a number of variations on this standard multiple-choice item format in an effort to overcome common limitations and criticisms (see for e.g., Chase, 1999; Mertler, 2003; Musial et al., 2009; Oosterhof, 2001; Worthen et al., 1999). Other types of selected-response items for assessing knowledge and skill include variations on true/false and matching item formats; these can be used effectively in large-scale assessments. Thus, while selected-response items are typically regarded as most suitable for identifying and recognizing information (e.g., Levels 1 and 2 in Bloom's Taxonomy; Bloom, 1956), they can also be an efficient way of measuring students' understanding of higher-order concepts.

Constructed-response items require students to generate their own answers. The expected answers may be, for example, a single word or figure, a few sentences, or a worked calculation. Constructed-response items that require a more extended answer are used to collect information about more complex constructs, such as students' capacity to explain how to design an investigation, a position on an issue, or decisions about a proposed solution or action, or to demonstrate a process that involves analysis or evaluation (i.e., Levels 3 through 6 in Bloom's Taxonomy; Bloom, 1956).

Selected-response item formats also can be used to assess dispositions and behavior. For most, if not all, of these components, ordinal scales can be used, such as: Likert-type scales; semantic differential scales; ratings scale based on extent, degree, relative frequency, or relative importance; and rank ordering scales (e.g., Iozzi et al., 1990; Marcinkowski, 1993). In addition, interval or ratio scales can be used to measure the frequency of activities within a specified period of time (e.g., within the past six months, twelve months, or two years). For example, this was done in studies of activities associated with environment sensitivity (e.g., Chawla, 1998; McBeth et al., 2008, 2011) and with environmental behavior (e.g., Sia et al., 1985/86; Erdogan et al., in press). Constructed-response formats also can be used to assess these components, but as discussed below, procedures for scoring those responses in a fair, reliable, and efficient manner may limit their usefulness in large-scale assessments.

Research suggests that different groups (e.g., boys and girls, students in different countries) respond differentially to item formats. Several studies on response format effect based on PISA data suggest that there are strong arguments for retaining a mix of multiple-choice and constructed-response items. In their study of PISA reading literacy results compared with those from the Progress in International Reading Literacy Study (PIRLS), Lafontaine and Monseur (2006) found that response format had a significant differential impact on performance by gender. Routitsky and Turner (2003) showed that in PISA mathematics, students at different ability levels from different countries performed differentially according to the format of the items used. In another study, countries were found to show differential equivalence of item

difficulties in PISA reading on items in different formats (Grisay & Monseur, 2007). These findings may reflect the fact that students in different countries are more or less familiar with particular item formats. Thus, including items in a variety of formats is likely to provide a better balance and fairer and more valid assessment for students around the world.

More generally, some item formats have been found to be more effective than others for assessing environmental literacy (see for e.g., Iozzi et al., 1990; Marcinkowski, 1993). Assessment designers and test developers need to be careful to ensure that the item format does not confound the interpretation of the results, as it might if responses reflect some test-takers' unfamiliarity with some formats.

A final consideration pertains to the resources required to score these various types of item formats. Selected-response and very short constructed-response items (i.e., those requiring specific responses) do not require expert scoring. However, all but the simplest constructed-response items generally require expert judges who have been trained and who are monitored. While most selected- and short constructed-response items can be scored dichotomously (full credit or no credit), the scoring scheme for longer constructed-response items and tasks can allow for partial credit, which makes possible more nuanced scoring of items and a more complex scoring scheme.

Decisions about the types of items to be used, in what proportion, and with what weights assigned to each, should take into account all of these considerations. These decisions can be recorded in tables, such as Table 1, above, and Tables 2a through 2f (see Appendix C), and will serve as a fifth set of specifications.

Research literature on instrument development

For many readers, the prospect of assessing environmental literacy remains relatively new and therefore presents numerous challenges, some of which have already been discussed. Assessment designers and test developers will need to work with multiple sets of specifications, as indicated above, and these are grounded in a body of research. This literature offers some guidance about *what* to assess – the selection and description of components of the domain – and *how* to assess – how to guide the development of items and tasks and assemble test instruments – and we summarize key findings relevant to environmental education here.

This literature includes instrument development and validation studies (hereafter, *instrumentation studies*) conducted and reported over the past four decades. This review does not include information about instruments used to assess environmental literacy (e.g., MSELI and MSELS: Bluhm et al., 1995; McBeth, 1997; McBeth et al., 2008; SSELI: Marcinkowski & Rehrig, 1995; and FELS: Bogan 1993; Bogan & Kromrey, 1996), or instruments that include scales for assessing a sizable number of environmental literacy components (e.g., Dyar, 1976; Passineau, 1976). Rather, this review will include information about instrumentation studies that pertain to measures of one or a small number of environmental literacy components. The studies discussed here (and listed in Table 3) may be of use to assessment designers and developers, and may guide them to relevant research. However, their inclusion here does not constitute an endorsement of any particular research or approach. The responsibility for analyzing these

instruments, their specifications, the procedures used to develop them, the estimates of validity and reliability, the populations and settings to which those estimates apply, and other relevant features lies solely with those responsible for designing each assessment and developing the instrument(s) for use in it.

The listed instrumentation studies can provide insight into: (1) dimensions of the environmental literacy components to be assessed; (2) item and task formats that have been developed and used to assess one or more of these components; (3) the relative length and format of instruments that have been developed for this purpose; and (4) the validity and reliability of those measures for particular purposes and populations. These studies can provide useful information, but assessment designers should consider findings from this body of work together with the specifications for their assessment. Many of the studies address a particular assessment and may not have findings that are widely applicable. They may also have used a variety of means of estimating validity and reliability so the procedures used to generate those estimates, and the populations and settings to which those estimates apply, must also be considered.

Instrumentation studies pertaining to environmental knowledge

Figure 1 identified five components of environmental *knowledge*. A total of 13 studies were located that pertained to the development and validation of scales to assess knowledge components. One or two of these pertained to the development and validation of measures of four of the five areas of knowledge (Table 3). A number of instrumentation studies were found that focused on general environmental knowledge (i.e., knowledge in more than one of these areas), or that focused on knowledge in several closely related areas, such as marine science and environmental health.

Instrumentation studies pertaining to environmental dispositions

Figure 1 identified five environmental *dispositions*. A total of 18 studies pertained to the development and validation of scales to assess these five dispositions, although the greatest emphasis was given to assessment of environmental attitudes and/or concern (Table 3). The least attention seems to have been given to measures of environmental responsibility, in part because this has often been inferred from other assessed variables (e.g., attitudes and concern, intention, behavior). A number of studies were found that focused on several related dispositions, including values and value orientations, and worldview.

Instrumentation studies pertaining to environmental competencies

There were a limited number of studies that addressed the development and validation of measures of *competencies,* particularly compared with the number of studies of the other major components. A total of seven instrumentation studies addressed competencies, and at least one addressed each of five defined competencies. Three of these pertained to selected aspects of evaluating and making personal judgments about issues, with one focusing on perceived risk and two focusing on ethical/moral reasoning. Cheak (2001) is listed several times because that study used multiple populations to field test and validate the measures, and included broader measurement of critical thinking skills.

Table 3. Citations for instrument development and validation studies pertaining to components of environmental literacy, by age level

Component	Elementary	Middle	Secondary	College/Teacher/Adult
Age Levels				

A. Knowledge

Component	Elementary	Middle	Secondary	College/Teacher/Adult
* General Environment	Leeming et al., 1995		Fleetwood, 1973	Rentsch, 1974 Riblet, 1972
* Physical and Ecological Systems	Zosel, 1978			Morrone et al., 2001
* Social, Cultural, and Political Systems			Dunkerly-Kolb, 1999	
* Environmental Issues				Maloney & Ward, 1973 Maloney et al., 1975
* Multiple Solutions				
* Citizen Partic./Action Strategies				Peyton, 1978
Other Related Areas of Knowledge				
* Marine Science			Fortner, 1978	Hedlund, 1982
* Environmental Health				Brennan, 1975

B. Dispositions

Component	Elementary	Middle	Secondary	College/Teacher/Adult
* Sensitivity			Fortner, 1978	Sia , 1985
* Attitudes and Concern	Brown-Allen, 1992 Eastman, 1974 Leeming et al., 1995 Muser & Diamond, 1999 Muser & Malkus, 1994	Moyer, 1975	Asche, 1973 Fleetwood, 1973 Marlett, 1972	Berberoglu & Tosunoglu, 1995 Borden, 1984/85 Bowman, 1974 Ebenbach, 1999 Maloney & Ward, 1973 Maloney et al., 1975 Schindler, 1999 Van Liere & Dunlap, 1981 Weigel & Weigel, 1978

Table 3. (continued)

Component	Elementary	Middle	Secondary	College/Teacher/Adult
		Age Levels		

B. Dispositions (cont.)

Component	Elementary	Middle	Secondary	College/Teacher/Adult
* Personal Responsibility		Horvat & Voelker, 1976		
* Locus of Control				Champeau, 1983
				Levenson, 1972
				Sia, 1985
				Smith-Sebasto, 1992a
				Smith-Sebasto & Fortner, 1994
* Motivation and Intent	Leeming et al., 1995			Maloney & Ward, 1973
				Maloney et al., 1975

Other Related Dispositions

Component	Elementary	Middle	Secondary	College/Teacher/Adult
* Value Orientations	Bunting & Cousins, 1983		Baker et al., 1978	McKechnie, 1974, 1977
			Sarnowski, 1975	Silvernail, 1978
				Zimmerman, 1996
* Worldview	Manoli et al., 2007			Dunlap & Van Liere, 1978
				Dunlap et al., 2000
				LaTrobe & Acon, 2000

C. Competencies

Component	Elementary	Middle	Secondary	College/Teacher/Adult
* Identify Issues		Volk, 1980		
* Ask Questions about Conditions and Issues				
* Analyze Issues		Cheak, 2001	Cheak, 2001	Cheak, 2001
		Volk, 1980		
* Investigate Issues				
* Evaluate and Make Personal Judgments About Issues			Iozzi, 1977, 1978	Swearingen, 1990
				Weber et al., 2002

Table 3. (continued)

		Age Levels		
Component	**Elementary**	**Middle**	**Secondary**	**College/Teacher/Adult**

C. Competencies (cont.)

Component	Elementary	Middle	Secondary	College/Teacher/Adult
* Use Evidence & Experience to Defend Positions on Issues				Kinsey, 1979; Kinsey & Wheatley, 1980
* Create and Evaluate Plans to Resolve Issues				Peyton, 1978

Other Related Competencies

Component	Elementary	Middle	Secondary	College/Teacher/Adult
* Critical Thinking Skills		Cheak, 2001	Cheak, 2001	Cheak, 2001
D. Behavior	Erdogan et al., in press Leeming et al., 1995	Horvat & Voelker, 1976		Antil & Bennett, 1979 Kaiser, 1998 Leonard-Barton, 1981 Maloney & Ward, 1973 Maloney et al., 1975 Newhouse, 1986 Sia, 1985 Smith-Sebasto & D'Costa, 1995

Instrumentation studies pertaining to environmental behavior

In the "Organizing the Domain of Environmental Literacy" section, this document identifies ways of conceptualizing environmental *behavior*, but this aspect of environmental literacy has been conceptualized and structured in numerous other ways, so studies that address it in any way are included here. A total of 11 studies pertained to the development and validation of behavior measures, three of which reflected the five categories discussed earlier (Erdogan et al., in press; Newhouse, 1986; Sia, 1985). Of the 11 studies, eight focused on behaviors expected of adults, including college students and teachers.

A detailed analysis of measures of behavior scales was beyond the scope of this project, but it is worth noting that most such assessments are based on self-reports by participants of their attitudes and actions. Research has documented that self-reports of behavior can be influenced by social desirability factors, which can significantly limit the validity of inferences based on such data. There are at least three strategies for addressing this concern. One is to use blind observers to check and corroborate self-reported behavior (e.g., Zelezny, 1999). While this has been done in smaller studies (e.g., Horsely, 1977; Ramsey, 1979; Ramsey et al., 1981), it is more difficult, and therefore uncommon, in large-scale assessments. A second is to use several negatively worded items, or *wake-up items*, in a behavior assessment. This strategy was used in the NELA studies (McBeth et al., 2008, 2011). A third strategy is to use *foil items*, that is, items that measure unrelated behaviors, the results of which can be compared to those for environmental behavior measures. This strategy was not used in any of the national environmental literacy assessments discussed above.

Overview

Even a cursory review of the studies listed in Table 3 reveals two general trends. First, of the components illustrated in Figure 1, attention has been given, in descending order, to measures of dispositions (notably attitudes), then knowledge, and then behavior. Significantly less research attention has been paid to the assessment of competencies or the skills and abilities they subsume. Second, the greatest research attention has been given to assessment of environmental literacy among adults. Nine studies pertained to elementary students and another nine pertained to secondary students; only four studies addressed the assessment of middle grades students. While these studies can serve as a source of information for assessment designers and instrument developers, this review suggests that there are noticeable gaps in this portion of the research literature, and a need for substantial additional research.

Summary

This section has discussed a number of the major decisions that must be made in the course of designing and developing an environmental literacy assessment framework. These included the scale of the assessment, the populations to be assessed, the scope of the domain (i.e., the components) to be assessed, and the thematic areas in which to assess those components. These decisions have been structured as steps that assessment designers and instrument developers can use to develop the framework for a viable assessment instrument.

Since the 1970s, researchers in environmental education have conducted a considerable number of large-scale assessments of varying combinations of the knowledge, attitudes, and behaviors that comprise environmental literacy. None of these, however, included *competencies* or reflect the wider range of environmental literacy components presented in this document, although recent national environmental literacy assessments in Korea, Israel, the United States, and Turkey mark a departure from that historical trend (Marcinkowski et al., in press), and a shift to the approach envisioned in this document. Nonetheless, much remains to be learned about the design and conduct of these kinds of assessments at national and international levels. On the other hand, as discussed above, there is a growing research base of instrumentation studies regarding components of environmental literacy, in which assessment designers and instrument developers can find practical ideas related to assessment design, development, conduct, and reporting. (See Appendix C. *Guiding Questions for Developing an Environmental Literacy Assessment Framework* for more details.)

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This document was designed to guide and support the development of frameworks for assessing environmental literacy for specific purposes and populations. In the next section, this work has been applied to the development of a framework for an international assessment of environmental literacy among 15-year-olds. That framework has been proposed as part of PISA in 2015 and was submitted to the Organisation for Economic Co-operation and Development (OECD) on August 28, 2011 as a stand-alone document. It is included here as *one* example of how the competencies and other components of this work can be used to design a large-scale assessment framework that is tailored for a particular context. We hope this entire document, including the PISA example, will be of use in the development of other frameworks for large-scale assessments of environmental literacy in the future.

Assessing Environmental Literacy

**A Proposed Framework
for the
Programme for International Student Assessment
(PISA) 2015**

**Submitted
to the
Organisation for Economic Co-operation and Development
(OECD)**

August 28, 2011

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PREAMBLE

1. This document presents a framework for the assessment of environmental literacy as an optional component in the Programme for International Student Assessment (PISA) 2015. The introduction of this optional assessment has been motivated by the Organisation for Economic Co-operation and Development's (OECD's) report, *Green at Fifteen? How 15-Year-Olds Perform in Environmental Science and Geoscience in PISA 2006* (OECD, 2009b), the end of the United Nations' Decade of Education for Sustainable Development in 2014, and the initiation of national assessments of environmental literacy in several nations. The United States' National Science Foundation (NSF) awarded the North American Association for Environmental Education a grant to coordinate the development of this draft framework.

2. The framework has been developed by the following team:

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3. The framework also was discussed at the April 2011 PISA Governing Board meeting in Santiago, Chile.

4. The first draft of the Environmental Literacy Framework built on works published by the UN, governmental agencies, and professional journals. The draft framework was critiqued at a meeting, held in Baltimore, Maryland, USA, from 14-15 July 2011, and via electronic input. A list of the meeting participants and reviewers is attached as Appendix A.

INTRODUCTION

The importance of environmental literacy

The nature, scale, and complexity of environmental issues

Globally, the natural environment continues to face increased pressure. As the world's population increases, the demand for food, goods, and space increases. These demands are manifested in the reduction of forests, decrease in potable water, depletion of the world's fisheries, air that is unhealthy to breathe, increases in the production of greenhouse gases resulting in atmospheric global warming trends, and a worldwide disparity in financial resources and, thus power. How long can we, as a global society, continue the practices of unchecked consumerism and the production to meet these demands? How long can global communities be exploited for corporate profit? Is the demand on the planet's biological diversity sustainable under the current and future economic and social activities of our global society? These are questions that need to be addressed throughout our society if we are to move into a sustainable future.

Population growth, consumption, and the need to address continuing conflicts over limited natural resources

In the past 24 years, the global population has grown by two billion people (from five to seven billion), an average population growth of about one billion every twelve years. This population, that reached the seven billion mark in 2011, is predicted to grow to nine billion by 2045 (http://www.prb.org/Publications/Datasheets/2010/2010wpds.aspx#). With this ever increasing population come increased demands on the finite natural resources of the world. Also, increased populations mean an increase in waste production, which pollutes the water we depend on for drinking and food. Air pollution is increasing as transportation and production of goods increase to meet the demands of consumers. Land is being lost to the expansion of urban areas by at least 16 million hectares per year (http://geojoedr.tripod.com/id3.html), resulting in the elimination of farmland, forests, and wetlands. To compensate for the removal of farmland from production, intensive farming techniques usually accompanied by the application of synthetic chemicals are on the rise. Due to the increased demand for food, overfishing has caused the world's fisheries to be in a state of decline.

Energy efficiencies and the need for adequate responses in a carbon-constrained world

Between 1951 to 2007, global per capita carbon emissions due to fossil-fuel burning, cement manufacturing, and gas flaring increased from 0.64 to 1.25 metric tons (http://cdiac.ornl.gov/trends/emis/glo.html). As demands on the world's non-renewable energy resources increases, not only do we need to improve and continue to develop the technology that will allow for the use of renewable energy resources, we also need to make energy accessible to all. Mr. Koïchiro Matsuura, Director-General of the United Nations Educational, Scientific and Cultural Organization (UNESCO, June 2008), indicated that the world's energy demands can no longer be met through the exploitation of traditional energy resources. We must increase our efforts to develop, distribute, and use "environmentally friendly renewable sources of energy"

that will "complement" contemporary sources of energy production. Further, Mr. Matsuura identified the need to provide energy access to the more than two billion (nearly one-third of the world population) people without access as the "most urgent concern." These "environmentally friendly energy resources" tend to be non-carbon producing. An increase in energy production via these resources (e.g., wind, solar, geothermal, and anaerobic digesters) will effectively decrease the amount of greenhouse gases released into the atmosphere.

Decline in species diversity

Biological diversity (biodiversity), the maintenance in diversity of genetics, species, ecosystems, and landscapes, is important in maintaining the dynamic equilibrium (homeostasis) on which all life depends. Human activity continues to negatively impact diversity through the clearing of forests, development of land to accommodate ever increasing populations, and increased production of greenhouse gases to satisfy consumer demands. The decrease in biodiversity creates a tenuous equilibrium on a global level; an equilibrium that may be permanently disrupted by the continuation of these activities. Not only will the loss of biodiversity slow or make impossible the process of recovery from natural and human caused disasters, we are also eliminating potential sources of study and medical breakthroughs that may aid in the solutions to some of the world's social, health, and economic problems. The loss of biodiversity itself should be looked upon as a human created disaster.

Natural hazards and extreme weather events

When plotting observed global temperatures due to natural forces and those due to human activity, climate change models show a direct relationship between the observed increases in temperatures and in human activity. Direct temperature observations indicate that the global surface temperature has risen by 1.4 degrees F or 0.8 degrees C since the early 20th Century. This increase has resulted in a decrease in snow cover in the Northern Hemisphere, a decrease in the total volume of Earth's glaciers, as well as a rise and increased temperature of the world's oceans (National Oceanic and Atmospheric Administration [NOAA], http://www.ncdc.noaa.gov/indicators/). It is estimated that at least 80 percent of this heat has been absorbed by the Earth's oceans, raising sea levels by an average of 3 mm per year since 1993. This rise is due to thermal expansion of the oceans and melting of continental ice (NOAA, http://www.noaanews.noaa.gov/stories2010/20100920_oceanwarming.html). The increased ocean temperatures and thus energy may be causing a shift of El Niño occurrence from the eastern to the central Pacific, as well as an increase in its strength. This can impact global weather patterns and may be responsible for global increases in droughts, floods, and hurricanes (NOAA, http://www.noaanews.noaa.gov/stories2010/20100825_elnino.html).

Environmental changes and impacts on the lives and livelihoods of people

It can be successfully argued that population growth has had a substantial negative impact on the natural environment. However, it also can be argued that the desire to increase power and economic advantage in the world has had this same impact; the world's wealthiest countries consume most of the world's resources and produce the majority of the world's greenhouse-gas emissions. An example reveals the complexity of these issues: corporations look for cheaper

labor in poorer countries. For these countries' workers and their nations there are advantages, including increased wages, the potential to decrease poverty, and the growth of personal wealth. For the corporations, the advantages include cheaper wages, lower costs for workers' benefits, and fewer regulations regarding both worker health and safety and the environment (e.g., Maquiladoras in Mexico). So while the desire of corporations to seek cheap labor may help lift individuals out of poverty while increasing corporate wealth, the global price of continued use of already stressed natural resources and increased outputs of greenhouse gases may be too high a cost that outweighs the benefits. Thus, these corporate interests and economic forces have often adversely affected both local peoples and local environments. Does this mean that poorer countries need to follow this trend to increase their wealth and power while sacrificing these protections? Or are there other paths to development that advance social and economic goals while maintaining human and environmental protections? Over the past decade, this question has spawned numerous "experiments" at all levels that fall under the general heading of sustainable development.

Returning to the current state of affairs, in some countries wealthy or poor, the social wealth inequality is growing. These inequalities in wealth, both locally and globally, affect many of the world's economic, social, and environmental justice issues (http://www.globalissues.org/article/4/poverty-around-the-world#Inequalityincreasessocialtensions).

Potential benefits of environmental literacy: The need to find appropriate evidence-based responses

There are parts of the world where the need for basic human rights (i.e., food, shelter, water, freedom of expression, and freedom from oppression) outweigh environmental concerns. However, it is possible that the development of, and research into, environmental literacy may help in understanding the conditions that need to be met to alleviate some of these concerns, both directly and indirectly The understanding of environmental issues and the acquisition of the requisite knowledge to do so, the development of environmental affect (caring, concern, responsibility, motivation), the ability to use critical thinking to analyze environmental issues as a prerequisite to making decisions about appropriate individual and collective action strategies, as well as the participation in the resolution of local, regional, national, and global environmental problems may help the world's citizens address some of these issues. Further, many of the general skills and strategies inherent in environmental literacy can be transferred and applied to social problems and issues (e.g., access to education or health care; reduction of poverty or crime), thereby enabling people to better understand and address them. Finally, in cases where environmental and social issues are inextricably linked (e.g., access to water, food, or energy resources; proper methods of disposing or treating sewage), the development of environmental literacy may support a more comprehensive understanding of, and a more balanced, sustainable approach to, addressing these complex issues.

Education for environmental literacy

Historical context

Although its intellectual roots are ancient, environmental education as referred to at Stockholm [1972] is a relatively new concept, having come into prominence during the late 1960s (Schmieder, 1977, p. 23).

In the United States of America (USA), several prominent educational movements preceded the rise of environmental education in the 1960s. Those most often cited include the Nature Study movement (ca. 1890s), the Outdoor Education movement (ca. 1920s), and the Conservation Education movement (ca. 1930s). These movements grew out of two early waves of conservation and environmental activities within the USA and reflect different and sometimes competing environmental philosophies (i.e., the Preservation and Resource Management waves). In addition, the Progressive Education Movement was a prominent influence on the educational philosophy of environmental education. In Europe, writers such as Comenius, Rousseau, Pestalozzi, and Froebel influenced environmental education, while in the USA, Dewey and his contemporaries were influential. There are few analyses of the extent to which these movements influenced the nature and development of environmental education beyond the USA, although there are some studies of the historical and/or contemporary influence of these movements in other nations (e.g., Erdogan et al., 2009).

Significant milestones

In 1972 the United Nations (UN) held a Conference on the Human Environment in Stockholm, which called for UN member countries to work with all appropriate UN Agencies, international non-governmental organizations, and the 148 member nations to develop a framework and direction for furthering environmental education internationally. This was followed by a 1975 International Workshop on Environmental Education in Belgrade. The core document to come out of this, The Belgrade Charter, stated that the goal of environmental education is "to develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations, and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones" (UNESCO, 1976, p. 2). This definition was built upon at a 1978 Intergovernmental Conference on Environmental Education in Tbilisi. Delegates from 66 UNESCO Member States approved categories of objectives for environmental education as a refinement of the draft objectives prepared in Belgrade: Awareness, Knowledge, Attitudes, Skills, and Participation (UNESCO, 1978). The Tbilisi Objectives have been reaffirmed at UNESCO Meetings in Moscow (1987), Thessaloniki (1997), and Ahmedabad (2007), as well as UNESCO conferences on sustainable development in Rio (1992) and Johannesburg (2002) (UNESCO, 1978, 1987, 2007; United Nations, 1992). As a result, this set of objectives has served as the most widely recognized definition of environmental education in nations around the world.

Contemporary situation

To inform and advance theory and practice in the field, efforts were made in the 1980s, 1990s, and early 2000s to review the growing body of research and evaluation studies in environmental education. Of these, status studies and needs assessments continue to indicate that substantial, well-conceived efforts are needed to help translate definitional features of, and research findings in, the field of environmental education into sound and widespread practices (e.g., Disinger, 1989; Fleming, 2009, McBeth et al., 2011).

Since 1990, a number of environmental literacy frameworks have been published, each of which has included knowledge, cognitive skill, affective disposition, and behavior components (e.g., Hungerford & Volk, 1990; Roth, 1992; Simmons, 1995; Wilke, 1995). In an attempt to provide coherent direction to environmental literacy, these have attempted to synthesize and include definitional features, national and state program frameworks, and findings from reviews of research. Since 1995, these frameworks have guided reviews of research (e.g., Volk & McBeth, 1997), development of assessment instruments (e.g., Wilke, 1995), and several national assessments of environmental literacy (e.g., Erdogan, 2009; McBeth et al., 2008; Negev et al., 2008; Shin et al., 2005).

Building on one of these frameworks (Simmons, 1995), the North American Association for Environmental Education (NAAEE) initiated the Guidelines for Excellence in Environmental Education Project, a set of recommendations for designing programs and developing and selecting environmental education materials. Since publishing these guidelines, NAAEE has actively supported initiatives to put these guidelines into practice in the USA and abroad (e.g., Taiwan and Mexico).

Environmental education for youth and in schools

The education of youth through formal and non-formal education has been a guiding principle and key characteristic of environmental education since the early 1970s (e.g., Hart, 1981; UNESCO, 1977, 1978). In a paper on environmental education in secondary schools prepared for the UN Belgrade Workshop, Eichler noted that "two solutions are available: first, to get students involved in out-of-school activities including problem solving and community action; and second, to concentrate on…school teaching: ecology, resource depletion and distribution, population dynamics, hunger and starvation, etc. Students are citizens with rights and responsibilities. They must be positively encouraged to exercise these rights" (Eichler, 1977, p.102). More recently, Agenda 21 stressed the importance of achieving universal access to basic education, as well as to environmental and development education, from primary school age through adulthood (United Nations, 1992). This report, as well as reports from UNICEF and others (e.g., Hart, 1992; Hart et al., 1996), noted that, as of 1992, youth made up 30% of the world's population, and that their involvement in environment and development decision making was critical.

Evidence from reviews of research pertaining to formal and non-formal environmental education for school-aged youth indicate that progress has been made toward the goal of developing a more environmentally literate citizenry. Studies of significant life experiences of groups of adult

environmental professionals in different nations have consistently found environmentally related formal, non-formal, familial, and social experiences during their youth to be very influential (Chawla, 1998; Sward & Marcinkowski, 2001). Various types of formal and non-formal environmental education programs have contributed to gains in knowledge and shifts in attitude (e.g., Iozzi, 1984; Rickinson, 2001; Volk & McBeth, 1997). However, relatively few environmental education programs have contributed significantly to the development, application, and transfer of cognitive skills, with the notable exceptions being formal environmental education programs (e.g., Iozzi, 1984; McBeth et al., 2011; Rickinson, 2001; Volk & McBeth, 1997). Finally, several prominent environmental education instructional approaches, notably action research, issue-and-action instruction, and service-learning, have contributed to the development, application, and transfer of strategies for youth participation in environmental decision making and problem solving (e.g., Coyle, 2005; Volk & McBeth, 1997).

The need for data about the environmental literacy of youth

In nations around the world, educational leaders, policy makers, researchers, and educators have expressed the need for data on the status of environmental literacy, particularly as past environmental problems have worsened and new ones have arisen. One of the earliest recommendations pertaining to the need for research within all UN Member States relevant to environmental literacy (i.e., knowledge, attitudes, values, and behavior) was approved during the Intergovernmental Conference on Environmental Education held in Tbilisi in 1977 (UNESCO, 1978, p.38).

In the USA, the call for research into the status of environmental literacy among K-12 students, post-secondary students, pre- and in-service teachers, and the general public was first articulated as part of a larger set of research needs developed by a working group of environmental educators, with support from the National Science Foundation (Wilke, 1990). These research needs were included in a national Delphi study of research priorities in environmental education (Saunders et al., 1992). Three of the top five research needs from that study focused on the status of environmental literacy (i.e., among K-12 and post-secondary students, and the general public). These research priorities served as the basis for projects aimed at developing environmental literacy assessments (McBeth, 1997; Wilke, 1995)

Since then, the need for research on the status of environmental literacy within different populations has been articulated by several noteworthy bodies within the USA, including: the working group convened by the Environmental Protection Agency (EPA) Office of Environmental Education, which drafted a *National EE Research Agenda* (EPA, 1998, p. 1); the National Environmental Education Advisory Council (NEEAC) in its 2005 report to Congress (NEEAC, 2005, pp. 25, 34-35), t, and the National Council for Science and the Environment (NCSE, 2008). Furthermore, the conduct and reporting of national assessments of environmental literacy beyond the USA indicates that similar discussion of need have taken place in a growing number of nations around the world.

The status of environmental literacy assessments

The National Environmental Literacy Assessment (NELA) and the need for an international perspective

During the 1970s, the first wave of national assessments in environmental education appeared. These tended to focus solely on students' environmental knowledge and attitudes. Of the national assessments that followed, some focused on similar learning outcomes, while others began to expand this range of learning outcomes (Marcinkowski et al., 2011). As a whole, these assessments foreshadowed and paved the way for a second wave of national and international assessments that focused on the wider range of environmental literacy components.

Within the USA, efforts to develop instruments for assessing environmental literacy have tended to focus on the middle level (i.e., the Middle School Environmental Literacy Instrument, or MSELI) and the secondary level (i.e., the Secondary School Environmental Literacy Instrument, or SSELI) (McBeth, 1997; Wilke, 1995). Through 2010, few, if any, efforts beyond these have been made within the USA to design, develop, pilot, refine and validate instruments to assess knowledge, skill, affective, and behavioral components of environmental literacy.

The MSELI was further refined, renamed (i.e., the MSELS), and used in the only national assessment of environmental literacy in the USA (i.e., in the National Environmental Literacy Assessment project, or NELA). Phase One of this project was a baseline study of environmental literacy in a national random (probability proportional) sample of sixth and eighth graders (McBeth et al., 2008; McBeth & Volk, 2010). Phase Two was a study of the effects of established, school-based environmental education programs on environmental literacy of sixth through eighth grade students in 64 schools (McBeth et al., 2011). The NELA research team has planned for several additional phases in this national research project.

Efforts have been made in Korea, Israel, and Turkey to review the literature pertaining to environmental literacy, and then to design, conduct, and report national assessments that reflect this broad conception of environmental literacy. Recent efforts have been made to summarize and compare features of these along with the USA assessment (Marcinkowski et al., 2011). To date, the only international effort to assess multiple components of environmental literacy was embedded in, and carried out as, part of the PISA 2006 Science Assessment. The results of this assessment were summarized in the OECD report, *Green at Fifteen?* (OECD, 2009b).

In summary, there is a need for assessment evidence to better understand the status of environmental literacy, component by component, among school-aged youth. However, this alone is likely to be insufficient. Evaluation studies are needed to determine the extent to which different environmental education programs and approaches have an appreciable effect on any of the various components of environmental literacy (e.g., McBeth et al., 2011; Stapp et al., 1978, 1979; UNESCO, 1978). Finally, well-designed research studies are needed to further our understanding of how to maximize the potential of those environmental education programs and approaches that advance environmental literacy (i.e., both their promise and limitations for different populations of learners). Results from assessments such as PISA can provide guidance

on where environmental literacy is (and is not) being achieved and where educational advances appear to be needed, while results from curriculum-based assessments, often as part of evaluation and research studies, can provide guidance on which educational programs and approaches are more likely to be fruitful with different kinds of learners.

The development of this framework complements development of PISA frameworks and includes a sequence of four steps:
- Development of a working definition for the domain and description of the assumptions that underlie that definition;
- Identification of a set of key characteristics that should be taken into account when constructing assessment tasks for international use;
- Operationalization of the set of key characteristics that will be used in test construction, with definitions based on existing literature and experience in conducting other large-scale assessments; and
- Evaluation of how to organize the set of tasks constructed in order to report to policy makers and researchers on achievement in each assessment domain among 15-year-old students in participating countries.

DEFINING THE DOMAIN OF ENVIRONMENTAL LITERACY

In developing a working definition of environmental literacy that can be used as the basis for designing an assessment, this project looked to extant international definitions of literacy, historical definitions of environmental education, several national frameworks for environmental education, and pertinent research.

PISA, an international example, conceives of literacy as the capacity of students to apply knowledge and skills in key subject areas and to analyze, reason, and communicate effectively as they pose, solve, and interpret problems in a variety of situations (OECD, 2010).

The PISA orientation looks to the future by emphasizing 15-year-olds' competencies for meeting life situations, rather than focusing on the extent to which students have attained the content of school curricular programs. OECD defines *competence* as "the ability to successfully meet complex demands in a particular context. Competent performance of effective action implies the mobilization of knowledge, cognitive and practical skills, as well as social and behavior components such as attitudes, emotions, and values and motivations. A competence – a holistic notion – is therefore not reducible to its cognitive dimension, and thus the terms "competence" and "skill" are not synonymous" (OECD, 2003, p. 2).

The report *Green at Fifteen? How 15-Year-Olds Perform in Environmental Science and Geoscience in PISA 2006* (OECD, 2009b) presented a definition of performance in environmental science and geoscience based on the PISA 2006 science framework (OECD, 2006). That report defined environmental science performance as:
- Scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain biological and geoscience phenomena related to the environment, and to draw evidence-based conclusions about the environment;

- Understanding of the characteristic features of environmental science as a form of human knowledge and inquiry;
- Awareness of how the application of environmental science can shape our use of earth's resources, policies about environmental sustainability, and future responsibility towards environmental quality;
- Willingness to engage with environmental science and with the ideas of environmental science, as a reflective citizen and consumer of geological and biological resources (OECD, 2009b, pages 24-25).

From both international and historical perspectives of environmental education, *The Belgrade Charter: A Global Framework for Environmental Education* must be considered. In 1975, 96 participants and observers from 60 countries, equally distributed among five UNESCO regions, gathered in Belgrade for an International Environmental Education Workshop. The participants unanimously adopted *The Belgrade Charter*, which included this goal statement that provides a definition of environmental education.

The goal of environmental education is:

To develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones (UNESCO-UNEP, 1976).

The 1976 UNESCO statement was further clarified and refined during the 1977 UNESCO-UNEP Intergovernmental Conference, notably in the form of categories of objectives for environmental education and, by inference, elements of environmental literacy. The general public would be expected to achieve the following objectives.

1. **Awareness:** to help social groups and individuals acquire an awareness of, and sensitivity to, the total environment and its allied problems.
2. **Knowledge:** to help social groups and individuals gain a variety of experience in, and acquire basic understanding of the environment and its associate problems.
3. **Attitudes:** to help social groups and individuals acquire a set of values and feelings of concern for the environment, and the motivation for actively participating in environmental improvement and protection.
4. **Skills:** to help social groups and individuals acquire the skills for solving environmental problems.
5. **Participation:** to provide social groups and individuals with an opportunity to be actively involved at all levels in working toward resolution of environmental problems (UNESCO, 1978, pp. 26-27).

The definitions of environmental education describe experiences, strategies, and processes important for developing environmental literacy. An assessment framework requires a contemporary definition of environmental literacy, one that encapsulates the essential elements of these historical discussions. The working definition of environmental literacy for this project is as follows:

Environmental literacy is knowledge of environmental concepts and issues; the attitudinal dispositions, motivation, cognitive abilities, and skills, and the

confidence and appropriate behaviors to apply such knowledge in order to make effective decisions in a range of environmental contexts. Individuals demonstrating degrees of environmental literacy are willing to act on goals that improve the well-being of other individuals, societies, and the global environment, and are able to participate in civic life.

This definition has two parts. The first refers to the kinds of knowledge, attitudes, and behaviors that characterize the domain. The second part refers to the purposes for attaining higher levels of environmental literacy.

In the following paragraphs, each part of the definition of environmental literacy is considered in turn to clarify its meaning in relation to the assessment.

Environmental literacy…

Using the term "environmental literacy" underscores the importance of assessing the knowledge, abilities, dispositions, and behaviors of students that enable students to make decisions and act to address environmental issues. This orientation contrasts with assessments designed to only report students' acquisition of knowledge and skills. The metaphor "literacy" is viewed as a constellation of knowledge, attitudes, abilities, and behaviors – i.e., competencies – that individuals develop throughout life. That is, one's literacy represents a continuum rather than a simple classification scheme. Individuals present degrees of literacy (Harvey, 1977; Roth, 1992). They are not either environmentally literate or environmentally illiterate.

…knowledge of environmental concepts and issues…

Most 15-year-old students cannot be expected to have a full range of scientific knowledge and understanding of all of the complexities of the natural environment and associated environmental issues. However, it can be assumed that they have some knowledge of the Earth systems as well as physical, life, social, and technical systems. In addition, they should have some knowledge and understanding of environmental issues at local, regional, and global levels. Students should recognize issues at the interface of the environment and society, many of which include, for example, population growth, use of natural resources, land use, loss of biodiversity, and ecosystem deterioration. Understanding environmental issues also includes the role and function of social, political, economic, and cultural influences on the causes, consequences, and amelioration of environmental problems and issues.

…the attitudinal dispositions, motivation, cognitive abilities, and skills…

Environmental literacy involves more than knowledge about a variety of problems. It includes the disposition to engage in activities, the cognitive abilities – such as accessing information, comparing, contrasting, and evaluating information – and reasoning about the applications of knowledge and actions in environmental contexts. Skills include consideration of cost, risk, and benefits of alternative actions, and the capacity to review the short and long-term consequences of actions. Other literacies, such as mathematics, reading, and using information and

communication technologies (ICT), are recognized as including and fostering skills that are part of environmental literacy.

…and the confidence…

Students demonstrating significant levels of environmental literacy have confidence in their understanding of and actions that will influence decisions that are intended to and actually do help improve the environment.

…and appropriate behaviors…

Environmental literacy is not limited to the knowledge, abilities, and disposition that might be seen as prerequisites to informed decision making and to responsible and effective actions. Since the late 1970s, environmental literacy has included opportunities to participate in various forms of service and action that help improve the environment at various levels, such as direct conservation and restoration of natural environments, consumer behavior and action, and environmentally related public and interpersonal persuasion. The rationales for this include: the need for active, real-world experience to foster both learning and development in educational philosophy and psychology; student interest in applying what they have been learning; and a growing body of theory and research regarding the effects of "participation" on other environmental literacy components and on the cultivation of life-long, environment-friendly habits.

…to apply such knowledge in order to make effective decisions…

An essential quality of environmental literacy is the ability to apply knowledge and understanding in situations involving environmental issues. This translates to the decisions that underlie effective actions.

…in a range of environmental contexts.

Effective decisions and actions apply to a variety of life situations – contexts – that range from local to global. The environmental contexts for young peoples' daily life will mostly be local and, to some extent, regional or global. Contexts can involve relatively simple decisions, such as use of energy in their home, to larger situations about impacted species and polluted habitats. These experiences set a stage for more complex situations with long-term consequences individuals may encounter as citizens.

Individuals demonstrating degrees of environmental literacy are willing to act on goals that improve the well-being of other individuals, societies, and the global environment…

Environmental literacy includes both personal decisions and those decisions and actions that have broader consequences in time and space for the environment and societies.
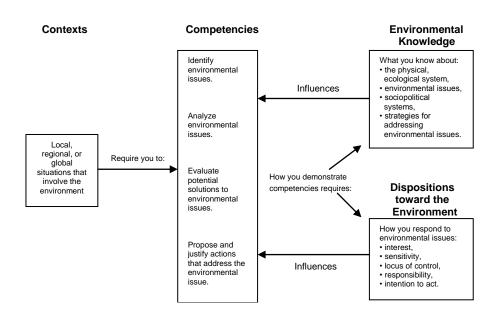
...and are able to participate in civic life.

Environmental literacy implies the importance of an individual's role as a thoughtful and engaged citizen. Individuals that demonstrate high levels of environmental literacy are better able to make decisions and take actions in varied contexts that benefit themselves and their communities for longer times and for the wider environment on which future generations will depend.

ORGANIZING THE DOMAIN

The way the domain of environmental literacy is organized determines the assessment design, including the test items and survey questions. This organization also influences the evidence collected from the survey (i.e. both test and questionnaire items) about students' proficiencies in environmental literacy. Although there are many dimensions of environmental literacy, not all can be assessed. It is necessary to select the essential elements so tasks and items of appropriate range of difficulty and coverage of environmental issues can be assessed. A review of literature on environmental education indicates the key questions and domains may be characterized as consisting of four interrelated components. The framework in Figure 1 presents those components.

Figure 1.

A proposed framework for assessing environmental literacy – PISA 2015

Elements of the framework can be introduced here and elaborated in the following sections.

Contexts

In life, individuals confront environmental situations in which they must use knowledge as well as cognitive abilities and attitudinal dispositions to respond. Context refers to these situations in which knowledge about the environment, skills, and abilities must be applied, in situations ranging from local to global. Contexts are not assessed; rather, they provide an orientation and meaning for the units within which items are presented.

Competencies

As individuals confront life situations related to the environment, their ability to effectively identify, analyze, and evaluate environmental issues, as well as propose and justify sound actions for addressing them, can be expressed in competencies.

Environmental Knowledge/Content

The content for the assessment involves the areas of knowledge and understanding that are essential for environmental literacy

Dispositions toward the Environment

The disposition of an individual to respond to environmental issues is strongly influenced by ones attitudes, values, and beliefs about the environment and about his/her role in taking action to address environmental issues.

This assessment focuses on the *competencies* that lead individuals – independently or collectively – to act to solve environmental problems or prevent new ones. While such behavioral acts indicate achievement of the highest level of environmental literacy, measurement of them may only be self-reports in this assessment.

Contexts

In building a framework for environmental literacy, and the assessment units and items that will be developed, reviewed, and selected based on the framework, attention is given to the breadth of contexts in which environmental literacy must be exercised. Presenting students with a range of contexts offers the greatest possibility of engaging their interest and attaining their current level of proficiency and potential for confronting issues in future decades.

Certain environmental situations will be more familiar to 15-year-olds. Assessment tasks should be framed in situations that include, but are not limited to, familiar contexts. The variety of contexts must include environmental situations such as: biodiversity, natural resources, hazard and land use. The contexts must range from local to global systems and involve personal to civic responsibilities.

Selected contexts from PISA 2006 Science (OECD, 2006) present an initial set of contexts and dimensions for this framework. Those contexts include natural resources, environmental quality

and health, and hazards. Additional contexts include population growth, biodiversity, and land use. Table 1 displays the contexts from local to regional to global levels. Table 1 provides examples that may be useful in the development of test items or questions on the survey.

Table 1. Contexts for environmental literacy

	Local	Regional	Global
Biodiversity	Flora and fauna	Endangered species, habitat loss, exotic invasive species	Ecological sustainability, sustainable use of species
Population Growth	Growth, birth/death, emigration, immigration	Maintenance of human population, population distribution, over population	Population growth and its social, economic, and environmental consequences
Natural Resources	Personal consumption of materials	Production and distributions of food, water, energy	Sustainable use of renewable and non-renewable resources
Environmental Quality and Health	Impact of use and disposal of materials on air and water quality	Disposal of sewage and solid waste, environmental impact	Sustainability of ecosystem services
Natural Hazards and Extreme Weather	Decisions about housing in areas vulnerable to flooding, tidal and wind damage	Rapid changes (e.g. earthquakes), slow changes (coastal erosion), risks and benefits	Climate change, extreme weather events
Land Use	Conservation of agricultural lands and natural areas	Impact of development and diversion of water, watersheds, and flood plains	Production and loss of topsoil, loss of arable land

Competencies

This framework for assessment of environmental literacy gives priority to the competencies listed in Figure 1, including the ability to: identify environmental issues; analyze those issues; evaluate potential solutions to environmental issues; and propose and justify an action to address specific environmental issue(s). These competencies involve knowledge about a variety of environmental issues, dispositions to respond to the issues, and behaviors that serve to address or ameliorate environmental issues.

Identifying environmental issues

It is important to be able to distinguish environmental issues and content from other forms of important issues. Students and others should be able to differentiate environmental issues and the evidence supporting those issues from other factors that may be associated with the issue; for example, economic consequences or political priorities.

Analyzing environmental issues

Related to the identification of environmental issues is the ability to analyze a given issue and apply scientific knowledge to explain causes for the problem and make predictions about the consequence.

Evaluating potential solutions to environmental issues

Evaluating environmental issues includes abilities to recognize and make decisions about their cause and effect using quantitative and qualitative evidence, as well as recognizing elements of the sociopolitical systems that impinge on them and the need to consider them to adequately respond to the environmental problem.

Proposing and justifying actions to address environmental issues

This competence requires students to make sense of the environmental issue and use evidence and knowledge of scientific and sociopolitical systems to support their claims for an adequate response. The essential quality of their competency is constructing and defending a sound argument about what it will take to resolve the environmental issue and proposing effective strategies for addressing the issue.

The resolution of environmental issues requires responsible behaviors and sound practices relative to resources and environments. While we expect the assessment of students' sense of responsibility and intention for acting in ways designed to resolve environmental issues or conserve resources, for example, it is beyond the scope of this assessment to measure environmentally responsible behaviors except through self-reports on, for instance, the student questionnaires.

Environmental Knowledge

The content of environmental literacy consists of knowledge that must be drawn upon in order to respond competently to an environmental situation or issue. A review of the content from existing standards and frameworks for environmental literacy provided the basis for this framework. There are four primary content domains for the framework: knowledge of physical and ecological systems, knowledge of environmental issues, sociopolitical knowledge, and knowledge of strategies for addressing environmental issues.

Knowledge of physical and ecological systems

This content area focuses primarily on physical and ecological concepts such as the interaction and interdependencies of individual organisms and populations, biogeochemical cycles, energy production and transfer, adaptation, flow of energy, change and limiting factors, and humans as variables in ecosystems.

Knowledge of environmental issues

Ecosystems function within limits. Exceeding the limits results in changes that are detrimental to the individual species and populations within the ecosystems. Recognizing the causes and consequences of factors that exceed limits (e.g., overuse of resources, pollution) is an essential aspect of environmental literacy.

Knowledge of sociopolitical systems

Competent responses to potential or actual environmental issues require some understanding of sociopolitical systems, including the historical, geographic, cultural, and economic contexts in which they have developed and now function. Here, one of the basic levels of this framework is the idea that ecological scarcity – approaching or exceeding the limits of the environment to receive and degrade waste or provide resources – is expressed in economic, political, and social systems. An understanding of these systems and the connection to limiting factors serve as prerequisites that enable students to understand the relationships among cultural beliefs/practices and the influence of those beliefs/practices on environments and resources.

Knowledge of strategies for addressing environmental issues

Knowledge of alternative means for solving environmental problems provides students with models for addressing environmental issues. Familiarity with successful and unsuccessful efforts using educational, economic, regulatory, and other strategies, as well as direct problem- and project-based experiences, provides students with a repertoire of strategies for achieving change.

Dispositions toward the Environment

Attitudes and values are considered important constituents of environmental literacy. Moreover, individual performance and dispositions about past and future performance are important determinants of behaviors, both positive and negative, toward the environment. Students' attitudes toward the environment influence their willingness to recognize and choose among value perspectives and their motivation to participate in environmental protection and improvement.

Interest

Interest expresses an initial level of students' attitudes toward the environment.

Sensitivity

Beyond interest is a sensitivity about the environment, its associated concerns, problems, and its protection and improvement. Concern can be viewed as an empathy toward the environment and its associated problems.

Locus of control

In formal terms, locus of control or efficacy pertains to the extent to which people expect to be positively reinforced by the outcomes of their actions. In more general terms, this concept refers to the belief and/or feeling that people hold that they individually or collectively will be able to influence or bring about the positive environmental change for which they are working. Acceptance of personal responsibility for negative impacts on the environment and willingness to correct and resolve those impacts may also be a part of one's locus of control.

Responsibility

The assumption of responsibility for positive actions is another dimension of attitudes toward the environment. Students can assume responsibility for personal and collective contributions to the reduction and solution to current problems.

Intentions to act

Just short of actions, students may express intention to act. These are positive attitudes toward the environment and indications of actions to prevent future problems or solve current issues. Assessment of environmental literacy could provide important evidence on the relationship between knowledge, competencies and intention to actively participate in protection and improvement of the environment, sound consumerism, and conservation of resources.

ASSESSING ENVIRONMENTAL LITERACY

Previous sections have outlined the conceptual framework for environmental literacy. The concepts in the framework must in turn be represented in tasks and questions in order to collect evidence of students' competency in environmental literacy. This section discusses the structure of the assessment, the distribution of tasks across the framework variables, and the choice of response formats. There also is a short discussion of the likely impact of knowledge and skills from other domains on environmental literacy and the implications for the assessment.

The conceptual framework is concerned with presenting a comprehensive view of the domain. It lays out the definition and the major variables that will be addressed in the assessment instrument. The key ideas are elaborated through lists of sub-topics and examples. These elaborations should not be construed as a checklist of tasks to be included in the assessment. As a proposed international option in 2015, only one hour of assessment material will be administered in PISA 2015 – not enough to cover every detail of each variable as described in the preceding

sections. At a minimum, PISA 2015 science should include an adequate number of items for a report such as *Green at Fifteen?* (OECD, 2009b).

Released tasks from 2006 are included in Appendix B. Later versions of the 2015 Framework will include a fuller discussion of the factors affecting item difficulty that will contribute to the building of an interpretive scheme for describing development of proficiency in the domain.

The structure of the proposed assessment

This discussion is based on the acceptance of environmental literacy as a country optional survey. In countries participating in the environmental literacy international option, two additional student booklets will be included with the core domain paper and pencil rotation of 13 booklets in the main survey. These two booklets will comprise two 30-minute clusters of environmental literacy, and two 30-minute clusters of science literacy. The latter will include some environmental items. (As the major domain for PISA, every sampled student in PISA will be assessed in science.) The same two clusters of environmental literacy items will appear in both booklets, but their positions will be rotated. Thus, there will be a total of 60 minutes of environment literacy material, with each student selected for the environmental literacy sample being administered all 60 minutes. It is anticipated that 30 to 40 items will be included in the main survey. Twice this amount of material will be included in the field trial. Analysis of completion rates in the field trial will be used to determine the actual number of items that will be included in the main survey.

As is normal for PISA assessments, items will be grouped in units (typically comprising 1, 2, or 3 items) based on a common stimulus that will describe the environmental issue. To minimize the level of reading literacy required, stimulus material (and task statements) will be as clear, simple, and brief as possible. The selection will aim to include diverse stimulus material, such as prose, diagrams, tables, charts, and illustrations.

The assessment will comprise a broad sample of items covering a range of difficulty that will enable the strengths and weaknesses of populations and key sub-groups to be determined.

In 2015, the main assessment likely will be a computer-based test. The assessment for environmental literacy also could be administered via computers. However, it is anticipated that many non-OECD countries will not be able to conduct a computer-based assessment. Therefore, it is recommended that a pencil and paper option be available for the assessment of environmental literacy.

Distribution of score points

This section outlines the intended distribution of score points across the categories of the characteristics discussed in the previous sections: contexts, competencies, knowledge, attitudes, and actions. The term "score points" is used in preference to "items," as it is possible that some partial credit items, which yield more than one score point, will be included. The distributions are expressed in terms of ranges, which at this stage indicate only roughly the expected weighting of the various categories.

The expected distribution of contexts is shown in Table 2. As appropriate for an assessment of environmental literacy, the primary emphasis is on population growth, resources use, and environmental quality and health. Although important, biodiversity and hazards are allocated smaller proportions, but are included to ensure some coverage in the survey.

Table 2. Distribution of contexts

Biodiversity	Population Growth	Resources: Terrestrial and Marine	Environmental Quality and Health	Hazards/ Disasters	Total
15% - 20%	20% - 25%	20% - 25%	20% - 25%	5% - 10%	100%

Table 3 shows the proposed distribution for the four competencies.

Table 3. Distribution of score points for competencies

Identify Issues	Analyze Issues	Evaluate Issues	Propose and justify actions to address an Issue	Total
10%	20%	30%	40%	100%

Table 4 displays the proposed distribution for knowledge about the environment and related issues.

Table 4. Distribution of score points for environmental knowledge

Physical and Ecological Systems	Environmental Issues	Sociopolitical Systems	Strategies for Addressing Issues	Total
10% - 20%	30% - 40%	30% - 40%	10% - 20%	100%

Table 5 presents the distribution for dispositions toward the environment.

Table 5. Distribution of emphasis for dispositions toward the environment

Interest	Sensitivity	Locus of Control	Responsibility	Intention	Total
10% - 20%	10% - 20%	20%	20% - 30%	20% - 30%	100%

Response formats and coding

Decisions about the form in which the data is collected – the response formats of the items – are determined according to what is considered appropriate given the kind of evidence that is being collected, and also according to technical and pragmatic considerations. In the environmental literacy assessment, as in other PISA assessments, two broad types of items will be used: constructed response items and selected response items.

Constructed-response items require students to generate their own answer. The format of the answer may be a single word or figure, or may be longer: a few sentences or a worked calculation. Constructed response items that require a more extended answer are ideal for collecting information about students' capacity to explain decisions or demonstrate a process of analysis.

Selected response items require students to choose one or more alternatives from a given set of options. The most common type in this category is the multiple-choice item, which requires the selection of one option from a set, usually four. A second type of selected response item is complex multiple choice, in which students respond to a series of "Yes/No"-type questions. Selected response items are typically regarded as most suitable for assessing items associated with identifying and recognizing information, but they are also an efficient way of measuring students' understanding of higher-order concepts that they may not easily be able to express themselves.

Research suggests that different groups (e.g., boys and girls, students in different countries) respond differentially to the various item formats. Several research studies on response format effect based on the PISA data suggest that there are strong arguments for retaining a mixture of multiple choice and constructed response items. In their study of PISA reading literacy compared with PIRLS, Lafontaine and Monseur (2006) found that response format had a significant impact on differential gender performance. Routitsky and Turner (2003) showed that in PISA mathematics, students at different ability levels from different countries performed differentially according to the format of the items used. In another study, countries were found to show differential equivalence of item difficulties in PISA reading on items in different formats (Grisay & Monseur, 2007). This finding may relate to the fact that students in different countries are more or less familiar with the particular formats. Including items in a variety of formats is likely to provide a better balance of the types of tasks with which students in classrooms around the world are familiar.

Although particular item formats lend themselves to specific types of questions, care needs to be taken that the artifact of the format in which the item is presented does not confound the interpretation of the results.

A further consideration is one of resources: all except the most simple of constructed-response items are coded by expert judges who must be trained and monitored. Selected response and very short "closed" constructed response items do not require expert coding.

The proportion of constructed- and selected-response items will be decided taking into account all of these considerations. It is anticipated that the majority of the items will not require expert judgment.

Most items will be coded dichotomously (full credit or no credit), but if appropriate the coding scheme for an item will allow for partial credit. Partial credit makes possible more nuanced scoring of items; some answers, even though incomplete, are better than others. If incomplete answers for a particular question indicate a higher level of environmental literacy than inaccurate or incorrect answers, a scoring scheme will be devised that allows partial credit for that question.

The impact of other domain knowledge and skills on environmental literacy

Numeracy skills

A certain level of numeracy is regarded as a necessary condition of environmental literacy, and it is assumed that students taking part in the environmental literacy assessment will have some foundational mathematical proficiency. However, dependence on calculation will be minimized in the assessment; tasks will be framed in such a way as to avoid the need for substantial or repetitive calculation.

The nature of the mathematical literacy expected is basic arithmetic: the four operations (addition, subtraction, multiplication, and division) with whole numbers, decimals, and simple percentages. Such arithmetic, as well as commonly used charts and graphs, will occur naturally within the environmental literacy context and enable environmental knowledge to be applied and demonstrated. Use of formulae (requiring capability with algebra) is not considered appropriate.

The calculators used by students in their classrooms and on the PISA mathematics assessment should also be available for the environmental literacy assessment, but success in the items will not depend on calculator use.

Reading and vocabulary

It is assumed that all students taking part in the environmental literacy assessment will have some basic reading proficiency. This is assumed even though it is known from previous PISA surveys that reading skill varies widely both within and across countries. To minimize the level of reading literacy required, stimulus material (and task statements) will generally be as clear, simple, and brief as possible. If possible, highly technical terminology relating to environmental matters will be avoided.

Collecting data about environmental attitudes and experience

Information about non-cognitive factors related to environmental literacy will be collected in a short student questionnaire at the end of the cognitive assessment. Items will address the key areas identified for inclusion by the environmental literacy group: attitudes toward the

environment and intention to act. The questionnaire will comprise a small set of questions that explore the range and types of students' interest in, and experience with, environmental issues.

The questions for the short questionnaire will be based on existing national surveys of environmental literacy, and will also include some questions adapted from recognized protocols for attitudes and behaviors from behavioral psychology. Additional information that is pertinent to understanding the distribution of environmental literacy will be drawn from the standard PISA background questionnaires. In particular, data about the student's home situation (family socioeconomic status in particular) and school experience may be relevant to understanding the environmental literacy results.

REPORTING ENVIRONMENTAL LITERACY

The data from the environmental literacy assessment will be stored in a database separate from the main PISA database. This database will include, for the sampled students, their environmental literacy and science results; the environmental literacy attitudes and behavior data from the short questionnaire on environmental literacy; and data from the general student questionnaire and school questionnaire.

A report on environmental literacy as an independent result should be possible; and on environmental literacy in relation to science performance, environmental attitudes, and intention to act, and in relation to some background variables, such as socioeconomic status and immigrant status.

The environmental literacy data will be scaled in a similar way to the other PISA data. A description of the modeling technique used for scaling can be found in the PISA 2006 Technical Report (OECD, 2009a). Each item is associated with a particular point on the PISA environmental literacy scale that indicates its difficulty, and each student's performance is associated with a particular point on the same scale that indicates the student's estimated proficiency.

The relative difficulty of tasks in a test is estimated by considering the proportion of test takers getting each question correct. The relative proficiency of students taking a particular test is estimated by considering the proportion of test items that they answer correctly. A single continuous scale showing the relationship between the difficulty of items and the proficiency of students will be constructed. Because the number of items in the environmental literacy instrument is not known, the reporting of only a single scale or sub-scales is not clear. If a single scale is reported, the scale will be divided into levels, based on a set of statistical principles, and then descriptions will be generated, based on the tasks that are located within each level, to encapsulate the kinds of skills and knowledge needed to successfully complete those tasks. The scale and set of descriptions are known as a described proficiency scale (see *Green at Fifteen?* [OECD, 2009b] for an example).

By calibrating the difficulty of each item, it will be possible to locate the degree of environmental literacy that the item represents. By showing the proficiency of each student on

the same scale, it will be possible to describe the degree of environmental literacy that the student possesses. The described proficiency scale will help in interpreting what students' environmental literacy scores mean in substantive terms.

Following PISA practice, a scale will be constructed having a mean of 500 and a standard deviation of 100 (based on OECD countries' participation). The optional assessment of environmental literacy in PISA 2015 will provide essential inputs and data for both the PISA program and countries interested in environmental education.

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APPENDIX A

Workshop Participants and Reviewers

Workshop Participants

Dr. Shorna Broussard Allred – Cornell University
Dr. Susan Clayton – College of Wooster
Dr. Alice C. Fu – Stanford University
Dr. Eric Keeling – Cary Institute of Ecosystem Studies
Dr. Lori Kumler – Youngstown State University
Dr. Augusto (Gus) Medina – Independent Consultant
Ms. Ginger Potter – U.S. Environmental Protection Agency
Ms. Chris Rozunick – Pearson's Assessment and Information Group
Ms. Sarah Schoedinger – National Oceanic and Atmospheric Administration
Dr. Bora Simmons – University of Oregon, Institute for a Sustainable Environment
Dr. Trudi Volk – Center for Instruction, Staff Development and Evaluation

Observers

Dr. David Campbell – Program Director at the National Science Foundation in the Division of
                Research on Learning in Formal and Informal Settings
Dr. Eugene Owen – Senior Advisor to the International Activities Program at the National
                Center for Education Statistics in the U.S. Department of Education

Reviewers

Dr. Charles W. (Andy) Anderson – Michigan State University
Dr. Nicole Ardoin – Stanford University
Dr. Troy Sadler – University of Missouri
Dr. Libby McCann – Antioch University New England
Dr. Paul C. Stern – National Research Council

APPENDIX B

Sample Units from
PISA 2006 Science

Read the texts and answer the questions that follow.

THE GREENHOUSE EFFECT: FACT OR FICTION?

Living things need energy to survive. The energy that sustains life on the Earth comes from the Sun, which radiates energy into space because it is so hot. A tiny proportion of this energy reaches the Earth.

The Earth's atmosphere acts like a protective blanket over the surface of our planet, preventing the variations in temperature that would exist in an airless world.

Most of the radiated energy coming from the Sun passes through the Earth's atmosphere. The Earth absorbs some of this energy, and some is reflected back from the Earth's surface. Part of this reflected energy is absorbed by the atmosphere.

As a result of this the average temperature above the Earth's surface is higher than it would be if there were no atmosphere. The Earth's atmosphere has the same effect as a greenhouse, hence the term greenhouse effect.

The greenhouse effect is said to have become more pronounced during the twentieth century.

It is a fact that the average temperature of the Earth's atmosphere has increased. In newspapers and periodicals the increased carbon dioxide emission is often stated as the main source of the temperature rise in the twentieth century.

A student named André becomes interested in the possible relationship between the average temperature of the Earth's atmosphere and the carbon dioxide emission on the Earth.

In a library he comes across the following two graphs.

André concludes from these two graphs that it is certain that the increase in the average temperature of the Earth's atmosphere is due to the increase in the carbon dioxide emission.

GREENHOUSE – *QUESTION 3 (S114Q)*

Question type: Open-constructed response
Competency: Using scientific evidence
Knowledge category: "Scientific explanations" (knowledge about science)
Application area: "Environment"
Setting: Global
Difficulty (on the environmental science index): 490 •———————————————————————|
Percentage of correct answers (OECD countries): 54.0%

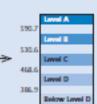| |
|---|
| Level A — 590.7 |
| Level B — 530.6 |
| Level C — 468.6 |
| Level D — 386.9 |
| Below Level D |

What is it about the graphs that supports André's conclusion?

....

....

Scoring

Full Credit:

Refers to the increase of both (average) temperature and carbon dioxide emission. For example:

- As the emissions increased the temperature increased.
- Both graphs are increasing.
- Because in 1910 both the graphs began to increase.
- Temperature is rising as CO_2 is emitted.
- The information lines on the graphs rise together.
- Everything is increasing.
- The more CO_2 emission, the higher the temperature.

Refers (in general terms) to a positive relationship between temperature and carbon dioxide emission. *[Note: This code is intended to capture students' use of terminology such as "positive relationship", "similar shape" or "directly proportional"; although the following sample response is not strictly correct, it shows sufficient understanding to be given credit here.]* For example:

- The amount of CO2 and average temperature of the Earth is directly proportional.
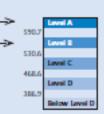- They have a similar shape indicating a relationship.

Comment

For the competency using scientific evidence, the unit GREENHOUSE (Figure A) present good examples for Level C. In GREENHOUSE, question 3, students must interpret evidence, presented in graphical form, and deduce that the combined graphs support a conclusion that both average temperature and carbon dioxide emission are increasing. The student is required to judge the validity of a conclusion correlating the Earth's atmospheric temperature and the quantity of carbon dioxide emissions by comparing evidence from two graphs having a common time scale. The student must first gain an appreciation for the context by reading a number of descriptive lines of text. Credit is given for recognising that both graphs are rising with time or that there is a positive relationship between the two graphs, thus supporting the stated conclusion. The effects of this environmental issue are global which defines the setting. The skill required by students is to interpret the graphical data supplied so the question belongs in the "Scientific explanations" category.

A student gaining credit for this Level C question is able to recognise the simple pattern in two graphical datasets and use this pattern in support of a conclusion.

Question type: *Open-constructed response*
Competency: *Using scientific evidence*
Knowledge category: *"Scientific explanations" (knowledge about science)*
Application area: *"Environment"*
Setting: *Global*
Difficulty (on the environmental science index): *Full credit 662; Partial credit 556* ■——————┘
Percentage of correct answers (OECD countries): *34.5%*

| Level A |
| Level B |
| Level C |
| Level D |
| Below Level D |

590.7
530.6
468.6
386.5

Another student, Jeanne, disagrees with André's conclusion. She compares the two graphs and says that some parts of the graphs do not support his conclusion.

Give an example of a part of the graphs that does not support André's conclusion. Explain your answer.

....
....
....

Scoring

Full Credit:

Refers to one particular part of the graphs in which the curves are not both descending or both climbing and gives the corresponding explanation. For example:

- In 1900–1910 (about) CO_2 was increasing, whilst the temperature was going down.
- In 1980–1983 carbon dioxide went down and the temperature rose.
- The temperature in the 1800s is much the same but the first graph keeps climbing.
- Between 1950 and 1980 the temperature didn't increase but the CO_2 did.
- From 1940 until 1975 the temperature stays about the same but the carbon dioxide emission shows a sharp rise.
- In 1940 the temperature is a lot higher than in 1920 and they have similar carbon dioxide emissions.

Partial Credit:

Mentions a correct period, without any explanation. For example:
- 1930–1933.
- before 1910.

Mentions only one particular year (not a period of time), with an acceptable explanation. For example:
- In 1980 the emissions were down but the temperature still rose.

Gives an example that doesn't support André's conclusion but makes a mistake in mentioning the period. *[Note: There should be evidence of this mistake – e.g. an area clearly illustrating a correct answer is marked on the graph and then a mistake made in transferring this information to the text.]* For example:
- Between 1950 and 1960 the temperature decreased and the carbon dioxide emission increased.

Refers to differences between the two curves, without mentioning a specific period. For example:
- At some places the temperature rises even if the emission decreases.
- Earlier there was little emission but nevertheless high temperature.
- When there is a steady increase in graph 1, there isn't an increase in graph 2, it stays constant. *[Note: It stays constant "overall".]*
- Because at the start the temperature is still high where the carbon dioxide was very low.

Refers to an irregularity in one of the graphs. For example:
- It is about 1910 when the temperature had dropped and went on for a certain period of time.
- In the second graph there is a decrease in temperature of the Earth's atmosphere just before 1910.

Indicates difference in the graphs, but explanation is poor. For example:
- In the 1940s the heat was very high but the carbon dioxide very low. *[Note: The explanation is very poor, but the difference that is indicated is clear.]*

Comment

Another example from GREENHOUSE centres on the competency using scientific evidence and asks students to identify a portion of a graph that does not provide evidence supporting a conclusion. This question requires the student to look for specific differences that vary from positively correlated general trends in these two graphical datasets. Students must locate a portion where curves are not both ascending or descending and provide this finding as part of a justification for a conclusion. As a consequence it involves a greater amount of insight and analytical skill than is required for Q03. Rather than a generalisation about the relation between the graphs, the student is asked to accompany the nominated period of difference with an explanation of that difference in order to gain full credit.

The ability to effectively compare the detail of two datasets and give a critique of a given conclusion locates the full credit question at Level A of the scientific literacy scale. If the student understands what the question requires of them and correctly identifies a difference in the two graphs, but is unable to explain this difference, the student gains partial credit for the question and is identified at Level B of the environmental science and geoscience performance indices.

This environmental issue is global which defines the setting. The skill required by students is to interpret data graphically presented so the question belongs in the "Scientific explanations" category.

GREENHOUSE – QUESTION 5 (S114Q)

Question type: *Open-constructed response*
Competency: *Explaining phenomena scientifically*
Knowledge category: *"Earth and space systems" (knowledge of science)*
Application area: *"Environment"*
Setting: *Global*
Difficulty (on the environmental science index): *626*
Percentage of correct answers (OECD countries): *18.9%*

590.7	Level A
530.6	Level B
468.6	Level C
386.5	Level D
	Below Level D

André persists in his conclusion that the average temperature rise of the Earth's atmosphere is caused by the increase in the carbon dioxide emission. But Jeanne thinks that his conclusion is premature. She says: "Before accepting this conclusion you must be sure that other factors that could influence the greenhouse effect are constant".
Name one of the factors that Jeanne means.

....

....

Scoring

Full Credit:
Gives a factor referring to the energy/radiation coming from the Sun. For example:
- The sun heating and maybe the earth changing position.
- Energy reflected back from Earth. *[Assuming that by "Earth" the student means "the ground".]*

Gives a factor referring to a natural component or a potential pollutant. For example:
- Water vapour in the air.
- Clouds.
- The things such as volcanic eruptions.
- Atmospheric pollution (gas, fuel).
- The amount of exhaust gas.
- CFC's.
- The number of cars.
- Ozone (as a component of air). *[Note: for references to depletion, use Code 03.]*
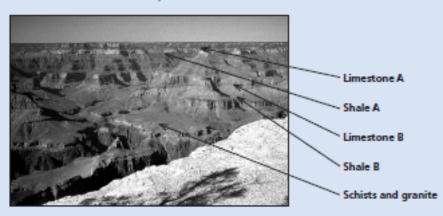
Comment

Question 5 of GREENHOUSE (Figure A) is an example of Level A and of the competency explaining phenomena scientifically. In this question, students must analyse a conclusion to account for other factors that could influence the greenhouse effect. The student needs to understand the necessity of controlling factors outside the change and measured variables and to recognise those variables. The student must possess sufficient knowledge of "Earth systems" to be able to identify at least one of the factors that should be controlled. The latter criterion is considered the critical scientific skill involved so this question is categorised as explaining phenomena scientifically. The effects of this environmental issue are global which defines the setting.

As a first step in gaining credit for this question the student must be able to identify the change and measured variables and have sufficient understanding of methods of investigation to recognise the influence of other factors. However, the student also needs to recognise the scenario in context and identify its major components. This involves a number of abstract concepts and their relationships in determining what "other" factors might affect the relationship between the Earth's temperature and the amount of carbon dioxide emissions into the atmosphere.

The Grand Canyon is located in a desert in the USA. It is a very large and deep canyon containing many layers of rock. Sometime in the past, movements in the Earth's crust lifted these layers up. The Grand Canyon is now 1.6 km deep in parts. The Colorado River runs through the bottom of the canyon.
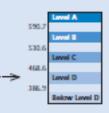
See the picture below of the Grand Canyon taken from its south rim. Several different layers of rock can be seen in the walls of the canyon.

Limestone A

Shale A

Limestone B

Shale B

Schists and granite

GRAND CANYON (Figure B) is a question at Level D on the scale for the competency *Explaining phenomena scientifically.*

GRAND CANYON – *QUESTION 3 (S426Q03)*

Question type: *Multiple choice*
Competency: *Explaining phenomena scientifically*
Knowledge category: *"Earth and space systems" (knowledge of science)*
Application area: *"Environment"*
Setting: *Social*
Difficulty (on the environmental science index): *437*
Percentage of correct answers (OECD countries): *67.6%*

590.7	Level A
530.6	Level B
468.6	Level C
386.9	Level D
	Below Level D

The temperature in the Grand Canyon ranges from below 0 °C to over 40 °C. Although it is a desert area, cracks in the rocks sometimes contain water. How do these temperature changes and the water in rock cracks help to speed up the breakdown of rocks?

A. Freezing water dissolves warm rocks.

B. Water cements rocks together.

C. Ice smoothes the surface of rocks.

D. Freezing water expands in the rock cracks.

Scoring

Full Credit: D. Freezing water expands in the rock cracks.

Comment

This is a multiple-choice question. Choosing the correct explanation for the weathering of rocks involves the student knowing that water freezes when the temperature falls below 0 °C and that water expands when becoming solid ice. The wording of this question does give some cues to the student as to what to eliminate, so its difficulty is lower.

The student needs to recall two tangible scientific facts and apply them in the context of the described conditions in the desert. This locates the question at Level D.

GRAND CANYON – *QUESTION 5 (S426Q05)*

Question type: *Multiple choice*
Competency: *Explaining phenomena scientifically*
Knowledge category: *"Earth and space systems" (knowledge of science)*
Application area: *"Natural resources"*
Setting: *Social*
Difficulty (on the environmental science index): 405
Percentage of correct answers (OECD countries): 75.8%

Level A	590.7
Level B	530.6
Level C	468.6
Level D	386.5
Below Level D	

There are many fossils of marine animals, such as clams, fish and corals, in the Limestone A layer of the Grand Canyon. What happened millions of years ago that explains why such fossils are found there?

A. In ancient times, people brought seafood to the area from the ocean.

B. Oceans were once much rougher and sea life washed inland on giant waves.

C. An ocean covered this area at that time and then receded later.

D. Some sea animals once lived on land before migrating to the sea.

Scoring

Full Credit: C. An ocean covered this area at that time and then receded later.

Comment

The question requires the student to recall the fact that fossils are formed in water and that when the seas recede they may reveal fossils of organisms deposited at an earlier age and then to choose the correct explanation. Credible distractors means the recalled knowledge has to be applied in the context provided. The question is located at Level D.

Figure C
ACID RAIN

Below is a photo of statues called Caryatids that were built on the Acropolis in Athens more than 2500 years ago. The statues are made of a type of rock called marble. Marble is composed of calcium carbonate.

In 1980, the original statues were transferred inside the museum of the Acropolis and were replaced by replicas. The original statues were being eaten away by acid rain.

ACID RAIN – *QUESTION 2 (S485Q02)*

Question type: *Open-constructed response*
Competency: *Explaining phenomena scientifically*
Knowledge category: *"Physical systems" (knowledge of science)*
Application area: *"Hazards"*
Setting: *Social*
Difficulty (on the environmental science index): 474
Percentage of correct answers (OECD countries): 57.7%

	Level A
590.7	
	Level B
530.6	
	Level C
468.6	
	Level D
386.9	
	Below Level D

Normal rain is slightly acidic because it has absorbed some carbon dioxide from the air. Acid rain is more acidic than normal rain because it has absorbed gases like sulphur oxides and nitrogen oxides as well.

Where do these sulphur oxides and nitrogen oxides in the air come from?

....

....

Scoring

Full Credit:

Any one of car exhausts, factory emissions, burning fossil fuels such as oil and coal, gases from volcanoes or other similar things.

- Burning coal and gas.
- Oxides in the air come from pollution from factories and industries.
- Volcanoes.
- Fumes from power plants. *["Power plants" is taken to include power plants that burn fossil fuels.]*
- They come from the burning of materials that contain sulphur and nitrogen.

Partial Credit:

Responses that include an incorrect as well as a correct source of the pollution. For example:

- Fossil fuel and nuclear power plants. *[Nuclear power plants are not a source of acid rain.]*
- The oxides come from the ozone, atmosphere and meteors coming toward Earth. Also the burning of fossil fuels.

Responses that refer to "pollution" but do not give a source of pollution that is a significant cause of acid rain. For example:

- Pollution.
- The environment in general, the atmosphere we live in – *e.g.* pollution.
- Gasification, pollution, fires, cigarettes. *[It is not clear what is meant by "gasification"; "fires" is not specific enough; cigarette smoke is not a significant cause of acid rain.]*
- Pollution such as from nuclear power plants.

Scoring Comment: *Just mentioning "pollution" is sufficient for Code 1.*

Comment

An example of a question in the middle of the scale is found in ACID RAIN – Question 2 (Figure C). This question requires students to explain the origin of sulphur and nitrogen oxides in the air. Correct responses require students to demonstrate an understanding of the chemicals as originating as car exhaust, factory emission, and burning fossil fuels. Students have to know that sulphur and nitrogen oxides are products of the oxidation of most fossil fuels or arise from volcanic activity.

Students gaining credit display a capacity to recall relevant facts and thus explain that the source of the gases contributing to acid rain was atmospheric pollutants. This locates the question at Level C. The awareness that oxidation results in the production of these gases places the question in the "Physical systems" content area. Since acid rain is a relatively localised hazard, its setting is social.

Attributing the gases to unspecified pollution is also an acceptable response. Analysis of student responses show little difference in the ability levels of students giving this response compared to those giving the more detailed response.

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APPENDIX A. Workshop Participants and Reviewers

Workshop in Baltimore, Maryland, July 14 - 15, 2011

<u>Participants</u>

Dr. Shorna Broussard Allred – Cornell University
Dr. Susan Clayton – College of Wooster
Dr. Alice C. Fu – Stanford University
Dr. Eric Keeling – Cary Institute of Ecosystem Studies
Dr. Lori Kumler – Youngstown State University
Dr. Augusto (Gus) Medina – Independent Consultant
Ms. Ginger Potter – U.S. Environmental Protection Agency
Ms. Chris Rozunick – Pearson's Assessment and Information Group
Ms. Sarah Schoedinger – National Oceanic and Atmospheric Administration
Dr. Bora Simmons – University of Oregon, Institute for a Sustainable Environment
Dr. Trudi Volk – Center for Instruction, Staff Development and Evaluation

<u>Observers</u>

Dr. David Campbell – Program Director at the National Science Foundation in the Division of Research on Learning in Formal and Informal Settings
Dr. Eugene Owen – Senior Advisor to the International Activities Program at the National Center for Education Statistics in the U.S. Department of Education

<u>Post-Workshop Reviewers</u>

Dr. Charles W. (Andy) Anderson – Michigan State University
Dr. Nicole Ardoin – Stanford University
Dr. Troy Sadler – University of Missouri
Dr. Libby McCann – Antioch University New England
Dr. Paul C. Stern – National Research Council

APPENDIX B. Challenges of Developing this Document

The core and extended team that worked to develop this material faced a number of challenges. These include: (a) understanding where the development of this framework could build upon prior efforts, and where it needed to depart from them; (b) challenges associated with the definition of environmental literacy; (c) challenges associated with the development of environmental literacy; (d) challenges associated with the assessment of environmental literacy; and (e) other challenges associated with the development of this framework. Each of these challenges is discussed below.

Understanding commonalities and differences between this and prior efforts

As a team, we were unaware of any prior efforts of this kind in the field of environmental education or pertaining to the domain of environmental literacy. However, there have been a number of efforts to develop environmental literacy frameworks, and those provided much needed guidance in the description or definition of environmental literacy herein. Only one of these environmental literacy frameworks was designed to guide the development of assessments (i.e., Wilke, 1995), even though several have been used for this purpose (e.g., use of the Simmons 1995 framework to guide national assessments in Korea and Turkey). This review made clear that there is a substantial difference between developing an environmental literacy framework that may guide assessment and the development of an actual assessment framework.

In addition there have been at least four national assessments of environmental literacy. These also have been informative to this effort. However, while each was based on one or more of these published environmental literacy frameworks, the extent to which this type of assessment framework was developed by a team in each nation is unclear. Nonetheless, it is true that each of those national assessments was developed for a particular geographic area and one or more target populations (Marcinkowski et al., in press). As a result, the team came to recognize that these national assessments and any accompanying assessment framework differed from this effort because this process for developing assessment frameworks is not being designed for use in a particular nation and with one or more particular target populations.

Further, these national assessments are similar to those developed by PISA and by NAEP in that all were designed for use in a defined geographic area and with one or more particular target populations. However, they differ in that each of the PISA and NAEP assessments involved the development of an assessment framework. As a result, several PISA assessment frameworks (e.g., the PISA 2006 Science Assessment: https://eelinked.naaee. net/n/ael/posts/Science-Literacy-Frameworks; and the PISA 2012 Financial Literacy Assessment Framework: http://www.pisa.oecd.org/dataoecd/8/43/ 46962580.pdf) and several NAEP assessment frameworks (e.g., the 2010 NAEP Civic Framework: http://www.nagb.org/publications/ frameworks/civicsframework.pdf; the 2014 NAEP Technology and Engineering Literacy Framework: http://www.edgateway.net/cs/ naepsci/download/lib/249/prepub_naep_tel_ framework.pdf?x-r=pcfile_d) have provided much-needed and valuable guidance to this effort. However, because these were developed for use in defined geographic areas and with defined target populations, the team came to recognize that these assessment frameworks are somewhat different from what we have developed. The *Frameworks* for which we aimed to provide design

guidance could be adapted for use in a wide range of national and international contexts, and with a variety of target populations. Further, our materials had to be flexible enough so that it could be used in assessments that have some tie to national curriculum guidelines (e.g., the Turkish Ministry of Education's Science and Technology Curriculum in Erdogan's 2009 national assessment of environmental literacy) and those that did not (e.g., PISA and NELA). As a result, one of the largest challenges to team members has been to recognize these differences and to determine what else was needed in this work.

Challenges associated with the definition of environmental literacy

Over the past forty years, a number of challenges associated with the definition of environmental literacy have arisen. One of these challenges pertains to the use of phrases that appear to be synonymous with or related to *environmental literacy* in environmental education and related fields. One of these terms is *ecological literacy*, a term often attributed to Frijof Capra. Today, there are at least two prominent uses of this term. The first refers to the branch of science education that pertains to the teaching and learning of ecology (e.g., Klemow, 1991; Berkowitz et al., 2005). This use of ecological literacy is narrower than environmental literacy (i.e., it is restricted to scientific knowledge). The second use refers to education that begins with ecological understandings of natural systems, and then expands to focus on postmodern applications of systems thinking and biological imperatives inherent in ecological thought to the creation of sustainable human communities (e.g.,; Orr, 1992; Puk & Behm, 2000; Stone & Barlow, 2005). Some, including Capra, use *ecological consciousness* as an analogous phrase for this (e.g., Puk & Makin, 2006). This second use differs somewhat from environmental literacy, although in more subtle ways (e.g., philosophical and social change orientation: progressivism vs. reconstructionism; environmental problem orientation: solve current vs. prevent future problems). The challenge presented by this has been to recognize and articulate both commonalities and differences in the common use of these and other related terms in the literature and wider field.

A second challenge has been to determine the proper scope of environmental literacy and, by association, environmental education. While many have conceptualized environmental literacy as including cognitive (awareness/knowledge and skills/abilities), affective, and behavioral dimensions (e.g., Harvey, 1977a, 1977b; Hungerford & Volk, 1990; Roth, 1992; Simmons, 1995; Wilke, 1995), this has not always been so. Despite critiques by Hendee (1972), Hungerford (1975), and Lucas (1981), some have suggested that environmental education and environmental literacy should be defined primarily, if not solely, in terms of affective dispositions such as attitudes and values. Others have suggested that environmental education and environmental literacy should be defined primarily in cognitive terms (e.g., Independent Commission on Environmental Education, 1997; Salmon, 2000). More recent efforts to infuse environmental education into K-12 education in the current climate of standards-based accountability also focus almost exclusively on cognitive knowledge and skills, primarily due to limited attention to affective and behavioral components of environmental literacy in standards and in testing programs (e.g., California Environmental Protection Agency, available at http://wwwcaleda.ca.gov/Education/EEI/; Environmental Literacy Council and the National Science Teachers Association, 2007; Minnesota Office of Environmental Assistance, 2002). Finally, due to the relatively recent and growing interest in environmental behavior and behavior

change within the social sciences and environmental education (e.g., Darnton, 2008; Monroe, 2003; Zelezny, 1999), some professionals in the field seem to define environmental education and environmental literacy in these terms. The challenges presented by these tendencies in the field of environmental education include recognizing and affirming the value of work in each learning domain as it relates to this broader conception of environmental literacy.

Closely allied with this third challenge has been the tendency to accept and default to what is referred to as the knowledge-attitude-behavior (K-A-B) model due to its prevalent influence on thinking, research, and practice in the field. For example: "*Increased knowledge* leads to *favorable attitudes* … which in turn leads to *action* promoting better environmental quality" (Ramsey & Rickson, 1976. p. 10, emphasis added) and "As previous research indicates … the assumption must be made that *informed attitudes* will lead to subsequent water *conservation behavior*" (Birch & Schwaab, 1983, p. 30, emphasis added). Over time, critiques have pointed out a number of limitations inherent in the K-A-B model (e.g., Hungerford & Volk, 1990; Kolmuss & Agyeman, 2002; Marcinkowski, 2004). These include: (a) research that questions these knowledge-attitude and attitude-behavior assumptions (e.g., Ajzen & Fishbein, 1977; Kraus, 1995; Rogers, 1995); (b) the absence of dispositions other than attitudes (e.g., sensitivity, efficacy, intention), and the tendency to subsume all of these under "attitude", despite theory and research that indicates otherwise (e.g., Ajzen & Fishbein, 1986; Chawla, 1998); (c) research that questions the direction of the A-B relationship by suggesting that behavior influences attitudes and other dispositions (e.g., Bruvold, 1973; DeYoung, 1986); and (d) the absence of cognitive skills and abilities in this model, despite their relevance (e.g., Hungerford et al., 1980; Simmons, 1995; UNESCO, 1977; 1978). Despite these and other flaws, this model was prominent enough to influence the manner in which data were analyzed and reported in the recent national assessment of environmental literacy in Israel (Negev et al., 2008). Given this, the challenges facing the team are to avoid reliance on this model, and recognize how vital it is to define this domain and prepare these materials in a way that will help others interested in environmental literacy assessment to develop frameworks that include competencies as well as other components.

A fourth challenge that also is allied with the second has been the basis or bases on which professionals have attempted to identify critical components of environmental literacy. One of the earliest of these efforts was based on a nearly exhaustive review of literature on theory and practice of environmental education (i.e., Harvey, 1977a, 1977b). In some cases, environmental and ecological literacy have been defined on the basis of a review of the literature and critical analysis of environmental conditions, both postmodern and otherwise (e.g., Orr, 1992; Roth, 1992). As noted earlier, in only one instance has this been done on the basis of a review of the national and state program frameworks, as well as the theoretical and research literature (i.e., Simmons, 1995). As the number of available reviews of research in environmental education has grown, these took on a more prominent role in identifying these components (e.g., Hungerford & Volk, 1990; Wilke, 1995). Finally, to the best of our knowledge, only one environmental literacy framework has been through a validity panel review process (i.e., Wilke, 1995). The challenge to the team has been to articulate these different bases, recognize the potential role and contributions of each and, whenever possible, rely on existing and new research evidence to inform the selection of these components.

A fifth challenge follows from the widespread attention that real-world environmental conditions, impact, protection, and improvement have received in numerous disciplines and fields of study. Many have contributed to modern-day understandings of these real-world conditions, problems, and solutions, including the sciences, history and the social sciences (e.g., geography, psychology, sociology, economics), and the humanities (e.g., philosophy and literature). Due to its grounding in real-world conditions, environmental literacy cannot be limited to any disciplinary perspective. In the tradition of pragmatism, those attempting to understand and define environmental literacy must be open to relevant advances in theory, research and practice in a wide range of disciplines and fields. Thus, a challenge to the team has been to understand the terminology and frames of reference used in a variety of fields, and to determine points of commonality (e.g., skills or dispositions of mutual interest), in an attempt to include the best of current thinking about the components of environmental literacy.

Challenges associated with the development environmental literacy

Over the past forty years, a number of challenges associated with the development of environmental literacy also have arisen. One of these challenges pertains to the relationship between environmental education and environmental literacy. Early definitions of environmental education (e.g., Disinger, 1983; Stapp et al., 1969) and sets of goals and objectives for environmental education (e.g., Hungerford et al., 1980; UNESCO, 1977, 1978) focused on desirable short- and long-term outcomes of environmental education. As a result, these definitions and goals/objectives said as much about environmental literacy as they did about environmental education. Along the way, some have suggested that the primary purpose of environmental education is to foster the development of environmental literacy (e.g., Hungerford & Tomera, 1985; National Environmental Education Advisory Council, 2005). While many recognize and affirm this purpose today, some have suggested other related purposes for environmental education, including fostering school achievement (e.g., Coyle, 2005; Lieberman & Hoody, 1998), improving public health (e.g., Louv, 2005) and, more recently, supporting economic development or competitiveness. There is no doubt that these are worthy purposes, that environmental education can and does contribute to each, and that each has some bearing on and relationship to environmental literacy. Thus, the challenge to the team has been to affirm this primary purpose in a manner that neither compromises the integrity of environmental literacy nor detracts from these other societal purposes for (or benefits of) environmental education.

A second challenge has been the paucity of research designed to trace the development of environmental literacy, whether as single components, as sets of interacting components, or as a whole (i.e., longitudinal research). The primary reasons for this include the lack of recognition of this as a research need and priority within the field, the dedication of time and effort it takes to carry out such research in highly mobile societies, and the financial and other resources required to carry this out. In the absence of such research, recent reviews of research have attempted to piece together an understanding of the development of environmental literacy from available descriptive and intervention studies (e.g., Rickinson, 2001; Volk & McBeth, 1997). Nonetheless, in the light of this glaring research limitation, it is a challenge to the team to present what is known in a clear manner while at the same time attempting to avoid overstating that.

A third challenge follows closely from the second, and pertains to what is known about factors that appear to influence the development of environmental literacy. <u>One</u> of these factors is environmental programming in *formal* K-12 school. For several decades, Disinger conducted national surveys of K-12 environmental education programs (e.g., Disinger, 1981, 1989). The results of these surveys indicated that there was a lot of "it" going on in K-12 schools, but that "it" was spotty geographically and diverse programmatically. The only assessments that may have accompanied these surveys would have been done at the local level, so until recently it has been nearly impossible to link program characteristics to learning outcomes in the schools surveyed on a larger scale. The NELA Phase Two study (McBeth et al., 2011) was designed to begin to explore this (i.e., how different approaches to environmental education emphasize different goals and contribute to different environmental literacy outcomes). However, as useful as those results may be, they are limited to grades 6-8 within the K-12 spectrum. A <u>second</u> of these factors is *non-formal* environmental education. Non-formal environmental education can and does take place in a wide variety of non-school settings, including museums, camps, nature and environmental centers, zoos and aquaria, botanical gardens and herbaria, and the wide range of lands and waters protected by federal, state, and local agencies (e.g., Norland & Somers, 2005; NAAEE, 2004c). Within the U.S., an array or organizations recognize or accredit one or more of these types of non-formal programs (e.g., museums: AAM; camps: ACA; zoos and aquaria: AZA; nature centers: ANCA). However, there is nothing approaching a national list of all types of non-formal programs in environmental education, so the kinds of K-12 surveys undertaken by Disinger have not been possible in the non-formal sector. Further, there have been relatively few comprehensive surveys of non-formal programs of any given type (e.g., Rakow & Lehtonen, 1988; Simmons, 1991). Therefore, as with the K-12 sector, evidence to link program characteristics to learning outcomes within or across the different types of non-formal programs on a larger scale appears to be very limited. A <u>third</u> factor includes immediate *social influences*, primarily in the form of family members and peers (e.g., Rickinson, 2001). The PISA 2006 Science Assessment gathered and reported evidence on this (OECD, 2009), but this is limited to 15-year-olds within the K-12 spectrum. A <u>fourth</u> factor includes print and electronic media, including the Internet, which some in environmental education refer to as *informal* environmental education, as this can take place almost anywhere and anytime. There do not appear to be any broad reviews of research that focus specifically on the contributions of either social influences or informal education to the development of environmental literacy. However, some targeted reviews of research, such as those pertaining to environmental sensitivity and significant life experiences (e.g., Chawla, 1998; Sward & Marcinkowski, 2001), and some broader reviews of research (e.g., Rickinson, 2001; Volk & McBeth, 1997), present findings that underscore the influence of non-formal, social, and informal experiences of youth on the development of environmental literacy. The challenge that these influences and research limitations posed to the team has centered on how to encourage users of this document to gather meaningful evidence about these factors so as to permit analyses of their possible influence on the development of environment literacy.

A fourth challenge pertains to the status of environmental education within the K-12 sector. In countries around the world, K-12 educational systems were in place long before the advent or rise of environmental education. As a result, environmental education is rarely included as a school subject in any country. At all levels, policy makers and practitioners often struggle with how best to include or infuse environmental education into K-12 curricula and programs (e.g., as

an elective in the middle grades in Korea). At the national level, Ministries of Education often attempt to expand attention to environmental education and/or components of environmental literacy in successive national curriculum guidelines (e.g., Bulgaria and Turkey: Erdogan et al., 2009; Korea: Noh & Marcinkowski, 2004; U.S.: NAAEE, 2004a), with or without the benefits of a description of the domain of environmental literacy such as the one presented here. At the local level, this often contributes to the development of more-or-less unique scope-and-sequence plans for environmental education for each school, school system, and/or state/province. It seems reasonably safe to suggest that the status of environmental education in general, and of attention to environmental literacy in specific, often varies widely between and within countries. The challenge that this presented to the team is that in the relative absence of scope-and-sequence plans to serve as guides, team members had to prepare these materials, the workshop, and other review procedures that would help potential users begin to identify what would be more vs. less developmentally appropriate to include in future large-scale assessments of environmental literacy among learners at differing ages and in differing grade levels.

The final challenge regarding the development of environmental literacy pertains to formal and non-formal educators. It is widely recognized and accepted that the preparation and professional development of environmental educators is vital to the nature and effectiveness of environmental education in both formal and non-formal settings. To foster the development of environmental literacy, educators need to: (a) be environmentally literate themselves; (b) understand the nature and scope of environmental literacy; (c) know how to design and facilitate learning experiences appropriate to the age/grade level of their students that foster the development of one or more environmental literacy component; and (d) how to use appropriate formative and summative assessment methods both to improve teaching and learning and to document learning gains. Thankfully, some work has been undertaken within the U.S. to support and implement this conception of preparation and professional development in environmental education (e.g., NAAEE, 2004b, 2007, 2010). However, those who have been involved in these efforts recognize that this vision calls for modifications and improvements to the ways in which we have undertaken the preparation and professional development of environmental educators in the past, as well as for the development of new support systems (e.g., the on-line *Fundamentals of Environmental Education* course; State/Provincial EE Certification Programs). Available evidence is limited to pre-service teacher education, and this indicates that much work remains to address the needs apparent in (a) through (d), above (e.g., Heimlich et al, 2001; McKeown-Ice, 2000; Ruskey & Wilke, 2005). For this reason, the NELA team collected and reported data using several questions related to (a) and (b), above (McBeth et al., 2008, 2011). As noted in the third challenge, the challenge this presented to the team working on this project was how to address this within our work in a manner that would encourage users to gather meaningful evidence about the environmental and educational background of the educators with whom students study in order to permit analyses of their apparent influence on the development of learners' environment literacy.

Challenges associated with the assessment of environmental literacy

Over the past forty years, a number of challenges associated with the assessment of environmental literacy also have arisen. Several of these were mentioned in the earlier section on

"The status of environmental literacy assessments". One of these challenges pertains to the stages of development within the field of environmental education, which are not unlike the stages of development of teacher concerns described by Fuller (1969). Much of the work in the 1970s focused on defining and establishing the field (i.e., akin to Fuller's "self"), and over 1970s through the 1990s on the design, development, and implementation of programs in formal and non-formal settings (i.e., akin to Fuller's "technical"). It is only in the1990s that attention expanded to include assessment (i.e., akin to Fuller's "impact"), in part due to requirements for increased accountability within the federal and formal education sectors that have followed the rise of standards-based assessment. It is noteworthy that this more-or-less imposed increase in attention to assessment happened to coincide with the development of environmental literacy frameworks. Nonetheless, in comparison to other fields in education such as science and social studies education, work on the assessment of environmental literacy is relatively recent (Roth, 1992). The challenge this posed for the team was to recognize where sufficient progress in this area had and had not been made in environmental education, and to determine how to adapt advances in educational assessment in other fields to accommodate the unique features of environmental education and environmental literacy.

A second challenge follows closely from this. Following Thorndike's definition of measurement, for tests or assessments to function as measures, three conditions must be met: "[1] identifying and defining the quality or the attribute that is to be measured, [2] determining the set of operations by which the attribute may be isolated and displayed, and [3] establishing a set of procedures or definitions or translating observations into quantitative statements of degree or amount" (Thorndike et al., 1991, p. 9). Of these, [1] was satisfied with the publication of research-based environmental literacy frameworks that defined the domain of environmental literacy and its components. To satisfy [2], what was needed were test item and alternative assessment formats that could be used to gather meaningful data on each component in this domain. Some of the early efforts to address this drew from measures created by numerous researchers in the field (e.g., Iozzi et al., 1990; Marcinkowski, 1993). To satisfy [3], what was needed were practical and reliable strategies to properly score responses and interpret assessment results. Some progress has been made on [2] and [3], particularly for middle and secondary students (e.g., McBeth, 1997; McBeth et al., 2008; OECD, 2009; Wilke, 1995). However, given the opportunities presented by advances in educational testing and assessment, the need to refine existing and develop new measures of components for use with middle and secondary students, and the need for measures for use with other age ranges, much work lies ahead. The challenge this posed for the team was essentially the same as the one described above for the first challenge: how to encourage the adaptation of advances in educational measurement, testing, and assessment in other fields to the assessment of this domain within this document.

A third challenge pertains to advances in the use of recent and emerging technologies for a variety of assessment purposes. Computers are now used routinely to develop tables of specifications, maintain test item banks, conduct assessments, analyze data, conduct item analyses, maintain data sets, and report reports (e.g., Chase, 1999; Worthen et al., 1999). One of the uses of computers and on-line technologies for conducting assessments is computer-adaptive testing (CAT), although it is unclear if the nature and purposes of CAT will ever be compatible with those inherent in the assessment of environmental literacy. However, a simpler and more widespread use of computers and on-line technologies is to use these to conduct assessments as

an electronic replacement for pencil and paper. This opens up new opportunities, such as the use of dynamic visuals to support the assessment of complex, higher-order cognitive skills and processes (e.g., Clarke-Midura et al., 2011). The advantages of this for large national and international assessments are clear (i.e., standardized administration, reduced time and cost, and use of dynamic rather than static items and associated graphics), as long as disadvantages can be overcome (e.g., formatting of the most appropriate types of selected- and constructed-response assessment items; a sufficient number of computer stations to permit all or most students to complete an assessment simultaneously). Another different use of computers for assessment involves their use in posing and engaging students in demonstrating higher order cognitive skills. While such uses are in the feasibility stage, the work of the Virtual Performance Assessment Project at Harvard indicates promise for the development of virtual assessments for Environmental Literacy that could measure collaborative problem-solving and the complex competencies (e.g. evaluating possible strategies for addressing an environmental issue and then proposing and justifying an action to resolve the issue) that are part of environmental literacy. Given this, those involved in both NELA and PISA assessment have begun to explore arrangements that would allow each to be administered electronically. The challenge this posed for the team was to determine and communicate the conditions under which a computer-based assessment of environmental literacy would be more vs. less advantageous.

The final challenge regarding the assessment of environmental literacy pertains to the development of assessment specialists and coordinators in the field of EE. Part of this responsibility falls to the design and offering of coursework in this area as part of university graduate programs and program options, and part of this falls to on-the-job professional training and development opportunities. Team members are aware of the substantial discrepancy between this emerging need in the field of environmental education and the very limited number of universities and employers associated with the field of environmental education that are prepared to address this need. On the one hand, this challenge led members of the team to share their particular areas of expertise relevant to the development of these Framework-development materials with and for the benefit of other team members. On the other hand, this challenge is one that clearly lies beyond the scope of this project, but is one that is likely to impact or influence future applications of this work. For this reason, team members feel obligated to communicate this challenge and need to those who are in the higher education, agency, and private sectors and are in a position to address it.

Other constraints and challenges associated with the development of this product

As in any funded project, available resources served as a practical constraint. In this project, available funding limited the number of team meetings to one initial planning meeting and the use of periodic conference calls and e-mail messages (e.g., for sharing drafts and comments on them). This also limited the total number of professionals who could be invited to the July Workshop, as well as the duration of this Workshop. Efforts were made to overcome these constraints by involving Workshop participants in a substantive pre-Workshop review of draft documents, and by involving selected professionals in a post-Workshop electronic review process (i.e., particularly for invitees who were unable to attend the Workshop).

APPENDIX C. Guiding Questions for Developing an Environmental Literacy Assessment Framework

The following sets of questions are intended to serve as a general guide to those who are involved in planning and conducting large-scale environmental literacy assessments (e.g., on a national or international scale). These questions have been organized into sets and placed under headings that reflect the relative sequence in which they are likely to arise and require attention by a planning team. However, those who are involved in such a venture will need to review these sets of questions carefully to determine which must be addressed, which are less relevant or irrelevant to that particular assessment, the sequence and relative timetable in which they need to be addressed, and which may need to be revisited and addressed further as the design of a particular assessment unfolds.

A. Framing and organizing the assessment

1. What is the geographic scale and scope of this assessment (e.g., one country, several countries, a large number of countries)?

    * What are the major commonalities and differences within, between, or among participating countries with respect to: (a) natural environments; (b) existing environmental problems and issues; (c) national policies, programs, and practices that pertain to environmental protection and remediation/restoration; (d) national policies and cultural practices that pertain to citizen participation, environmental action, and community service; and (e) national education policies and programs that pertain to attention to (a-d) in formal and non-formal education?

    * What implications do these commonalities and differences hold for the selection and description/definition of environmental literacy components to be assessed?

    * What implications do these commonalities and differences hold for the selection of thematic areas in which environmental literacy components are to be assessed?

2. Is this framework to be used for an assessment directly related, indirectly related, or unrelated to national curriculum guidelines assessment (e.g., policies, frameworks) in the participating country or countries?

    * Will there be any formal or informal review of national curriculum guidelines to inform the selection and/or definition of environmental literacy components to be assessed?

    *What are the major commonalities and differences between the Ministry/Department of Education's National Curriculum Framework(s) and this environmental literacy framework?

    * What implications do these commonalities and differences hold for the selection and description/definition of environmental literacy components to be assessed?

3. Which agencies, organizations, institutions, and firms will assume responsibility for the major functional roles in this assessment, to include: organizing, funding, designing, developing, administering, analyzing data, preparing reports, and using findings?

    * What implications, if any, do these responsibilities hold for the scope and substance of this environmental literacy assessment?

B. *Shaping the scope and substance of the assessment*

4. What are the target audience(s) of this assessment (e.g., one or more age cohorts, such as elementary, middle, and secondary students)?

    * What are the developmental and experiential characteristics of each target audience?
    * What implications do these characteristics hold for the selection of environmental literacy components to be assessed?
    * What implications do these characteristics hold for the selection of thematic areas in which environmental literacy components are to be assessed?

5. Which prior empirical studies have been conducted and reported for each target audience that pertain to these environmental literacy components in this geographic area (i.e., reviews of research, descriptive studies or curricular and instructional practices, assessments, and evaluation studies)?

    * In these studies, which environmental literacy components have and have not been studied?
    * What are the major findings from these studies about these environmental literacy components?
    * What implications do these studies and findings hold for the selection, description/ definition, and measurement of the environmental literacy components to be assessed?
    * What implications do these characteristics hold for the selection of thematic areas in which environmental literacy components are to be assessed?

6. On the basis of responses to previous questions, which components of environmental literacy will be assessed in each of the following sub-domains: environmental *knowledge*; *dispositions* toward the environment; environmental *competencies*; and *environmentally responsible behavior*?

7. On the basis of responses to previous questions, in which thematic areas should greater vs. lesser attention be given to the assessment of these components of environmental literacy?

C. Determining the degree of emphasis/distribution of score points

8. Using the charts presented below or a revised version of them, how much emphasis should be placed on the assessment of selected components in each of the following: (a) *thematic areas*; (b) environmental *knowledge*; (c) *dispositions* toward the environment; (d) *competencies*; and (e) *environmentally responsible behavior*? In other words, what is the approximate distribution of score points for each?

Table a: Degree of emphasis and distribution of score points for thematic areas

	Biodiversity	Human Population	Natural Resources	Env. Quality/ Health	Natural Hazards/ Extreme Weather	Land Use/ Economic Zones	Total
Emphasis	%	%	%	%	%	%	100%
Score Pts.	%	%	%	%	%	%	100%

Table b: Degree of emphasis and distribution of score points for environmental knowledge

	Physical & Ecological Systems	Socio-Political Systems	Env. Issues	Multiple Solutions to Env. Issues	Citizen Participation/ Action Strategies	Total
Emphasis	%	%	%	%	%	100%
Score Pts.	%	%	%	%	%	100%

Table c: Degree of emphasis and distribution of score points for dispositions toward the environment

	Env. Sensitivity	Env. Attitudes & Concern	Assumption of Personal Responsibility	Locus of Control (Efficacy)	Motivation, & Intention to Act	Total
Emphasis	%	%	%	%	%	100%
Score Pts.	%	%	%	%	%	100%

Table d: Degree of emphasis and distribution of score points for competencies

	ID Issues	Ask Relevant Questions About Issues	Analyze Issues	Investigate Issues	Evaluate & Make Judgments About Issues	Use of Evidence/ Experience to Defend Positions on Issues	Create & Evaluate Plans to Resolve Issues	Total
Emphasis	%	%	%	%	%	%	%	100%
Score Pts.	%	%	%	%	%	%	%	100%

Table e: Degree of emphasis and distribution of score points for environmentally responsible behavior

	Ecomanagement (Physical)	Consumer & Economic	Persuasion	Political	Legal	Total
Emphasis	%	%	%	%	%	100%
Score Pts.	%	%	%	%	%	100%

Table f: Overall degree of emphasis and distribution of score points for environmental literacy

	B. Environmental Knowledge	C. Dispositions	D. Competencies	E. Behavior	Total
Emphasis	%	%	%	%	100%
Score Pts.	%	%	%	%	100%

D. Determining item formats and scoring procedures

9. About how much time will be available to administer this assessment?

   * What implications does administration time hold for the relative amount of time available to assess each of the underlined selected components given the emphases/distributions reflected in responses to **Question 8.b - 8.f**?

   * What implications does administration time hold for the relative amount of time available to assess these components in the selected thematic areas given the emphases/distribution reflected in response to **Question 8a**?

10. Which types of selected- and constructed-response items should be used to assess the selected components and in the selected thematic areas identified in response to **Question 6?**

    * To which types of selected- and constructed-response items have subjects in the target population(s) been exposed?

    * Which types of selected- and constructed-response items have been used in prior studies of each of the selected components?

    * Are there any "valid and reliable measures" of these selected components that use these types of selected- and constructed-response items?

Sub-Domain	Components	**Selected- and Constructed-Response Items**			
		Target Population Exposure	Use in Prior Studies: Citations (Author, Date)	V&R? (Y/N)	Use? (Y/N)
Knowledge	Physical & Natural World Socio-Political Systems Environmental Issues Alternative Solutions Action Strategies				
Dispositions	Sensitivity Attitudes/Concern Personal Responsibility Locus of Control/Efficacy Motivation/Intent				
Competencies	Identify Issues Ask Questions Analyze Issues Investigate Issues Evaluate/Judge Issues Defend Positions Create/Evaluate Plans				
Behaviors	Ecomanagement Consumer/Economic Persuasion Political Legal				

11. Approximately how many of these items will be used to assess each of the selected components of environmental literacy?

12. Which component(s) will be assessed in separate scales and sections, and which component(s) will be combined in each section? (*Draft the directions and items for gathering responses in each section of the assessment instrument*.)

13. If this assessment will be administered to subjects in different countries and/or to different cultural groups, how will items be reviewed to ensure their appropriateness?

14. If this assessment is to be administered in different languages, how will items be translated and how will items translations be reviewed to ensure consistency across these languages?

15. To what extent is the level of readability of the developed items consistent with the age(s), grade level(s), developmental abilities, of the target population identified in response to **Question 4**?

16. How will the selected- and constructed-response items used to assess each selected component be scored? (*Develop the answer and scoring key and/or scoring protocols for this assessment*)

> * What implications do the emphases/distributions reflected in charted responses to **Question 9** hold for the scoring of the items to be used to assess each of the selected components of environmental literacy?

E. Determining methods to conduct the assessment

17. How will those who are to participate in the assessment be selected to do so?

> * What is the critical or optimal sample size for this assessment, and how will that be determined?
> * What will be the sampling unit for this assessment (e.g., individual students, selected classes within a school, all students/classes in a particular grade level, selected schools)?
> * Which sampling methods will be used to select these participants (e.g., purposeful, simple random, stratified random, multi stage probability-proportional)?

18. How will the assessment be administered (e.g., as a paper-and-pencil instrument, in an electronic or on-line format)?

> * If this assessment is to be administered in pencil-and-paper form, who will do so? How will they be oriented/prepared to do this? What additional steps will be taken to ensure a high degree of consistency of assessment administration across sites?

> * If this assessment is to be administered using an on-line format, are there a sufficient number of computer stations to support simultaneous assessments? To what extent are subjects in each site familiar with on-line tests and assessments? Once a decision is made to do so, who will oversee the formatting of the on-line assessment? Can the electronic assessment be formatted to allow students to return to previous questions within that section of the assessment?

F. Scoring responses

19. What decision rules and procedures, if any, will be used to remove incomplete and invalid responses?

20. What steps, if any, will be taken to fill in any remaining 'blanks' in a subject record (e.g., which form of imputation will be used)?

21. Which items, if any, will require reverse scoring (i.e., due to the reversal of item wording and meaning, such as the use of "not" as a check on the reliability of responses)?

22. What steps, if any, must be taken to convert responses from alphabetic to numeric form?

23. What procedures will be used to generate raw scores for each section and/or selected component?

24. How, if at all, will raw scores be transformed for further analysis and/or reporting purposes (e.g., into a percentile rank, a weighted score, a standard score, and/or a performance level)?

G. Planning for the collection and analysis of additional, context-relevant data

25. What kinds of additional data, if any, will be collected from students?

    * Will any demographic data be collected (e.g., age, grade, gender, etc.)?

    * Will any experiential data be collected (e.g., for students: curricular and extra-curricular experiences such as environmental courses, projects, and clubs; non-formal experiences such as camps and on-site programs; and informal/free time experiences with family, peers, and on their own)?

26. What kinds of additional data, if any, will be collected from schools?

    * Will any information or data about the schools be collected (e.g., grade levels served, total number of students, student : teacher ratio)?

    * Will any information about the curricular and instructional features of the environmental program to which students are exposed be collected (e.g., curricular materials used, sites and additional resources used for instruction, teaching methods)?

    * Will any information or data about teachers who work with these students be collected (e.g., number of years teaching, years teaching at particular grade levels and in certain subject areas, professional development and personal experiences in the environmental area, professional and personal perceptions)?

27. What kinds of additional data, if any, will be collected from parents of students?

    * Will any additional demographic data be collected (e.g., parental educational levels, socio-economic status, occupation)?

    * Will any additional data on parents' environmental views be collected (e.g., their environmental perceptions, opinions, attitudes, behaviors)?

    * Will any additional information or data be collected from parents that can be used as a validity check on self-reported student data (e.g., on the relative frequency of student participation in different kinds of outdoor experiences as a check on student self-reports

when outdoor experience items are included in a *sensitivity* scale; on the relative frequency of student engagement in different kinds of environmentally responsible behavior as a check on students responses in a *behavior* scale)?

28. In addition to presenting the results of any additional data collection in descriptive form, will any attempt be made to analyze the relationship of these data to students' scores (i.e., qualitatively and/or quantitatively)?

H. Reporting the assessment

29. What will be the form or format for the primary technical report of this assessment?

    * Is there a standard or required format for this report?

30. In what ways, if any, will this technical report be converted to one or more simple reporting formats?

    * Will an Executive Summary or Briefing Paper be prepared for major assessment stakeholders, either as part of or in addition to this technical report?

    * Will the technical report serve as the basis for any abbreviated, less technical report(s) or white paper(s) designed for specific audiences (e.g., teachers, non-formal educators, faculty in related university programs)?

    * Will the technical report serve as the basis for any article(s) in peer-reviewed journals?

    * Will the technical report serve as the basis for conference presentations (e.g., in .ppt) and/or conference proceedings?

    * Will the technical report serve as the basis for any article(s) in popular journals?