THE DEVELOPMENT OF A CURRICULUM FRAMEWORK FOR CITIZEN SCIENCE TO MEET THE GUIDELINES FOR ENVIRONMENTAL LITERACY

By

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Abstract

Students learn skills and gain experience through numerous educational strategies. Citizen science encourages skill development and understanding of the natural world in students by engaging them in hands-on experiences with the scientific process, while conducting valuable field research for the scientific community. In addition, it engages students in learning that has merit and meaning to them. Citizen science also contributes to meeting the goal of environmental education. Environmental education's goal is environmental literacy which is defined by a citizenry that has the knowledge, skills and motivation to make responsible decisions about the built and natural environment. As a result of environmental education's integration of many disciplines such as science and social studies, citizen science curricula that focus on environmental literacy can effectively address various subjects. A framework that concentrates curriculum development on the skills, knowledge, experiences, and goals essential to citizen science and environmental literacy for students was required to meet this need.

The goal of this study was to create a curriculum framework for developing and teaching citizen science education programs that focus on increasing students' environmental literacy. A framework is a planning guide that identifies and organizes student learning goals and outcomes, and focuses curricula development on them. The framework was developed and validated using a Delphi survey technique; a method to generate ideas and facilitate a consensus among experts in a specific field. Citizen science professionals identified those guidelines of environmental literacy outlined in the North American Association for Environmental Education's *Excellence in Environmental Education:*

Guidelines for Learning, as well as additional program characteristics essential to curriculum development from this research. The resulting framework consists of a series of guidelines that aids educators and gives examples of how citizen science curricula can be used to meet state and national education standards. The development of this framework strengthens the relationship between citizen science and environmental literacy, presents clear goals for citizen science, provides curricula justification by meeting educational standards, and is a starting point for further research.

Acknowledgements

Writing a thesis is an impossible task to accomplish by oneself. With that I would like to acknowledge a few of those people who have helped me in completing my master's. First, I wish to thank my advisor, Dr. Dan Sivek. His patient guidance and constant support provided me with confidence and perspective throughout this process. I would also like to thank Dr. Dennis Yockers who not only offered endless words of encouragement and feedback, but a welcoming environment for me both on and off campus as well. In addition, Dr. Perry Cook who gave a "teacher" point of view on my thesis and motivating advice on education and teaching.

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Chapter 1 – Introduction

The Importance of the Study

An increase in environmental literacy, and corresponding environmental behaviors, is the ultimate aim of environmental education (EETAP, 2000). Necessary to achieving this aim are many environmental concepts, and various skills and dispositions. Examples include the development of empathy and awareness toward the environment, basic knowledge of ecological concepts, and experience in environmental issue resolution. Many strategies are employed by environmental educators to achieve this aim, and in recent years the role of citizen science (CS) has become an increasingly viable and popular approach. Environmental educators, primary and secondary school teachers, researchers and students have joined together in learning about nature through active, hands-on participation. Most people who have observed birds feeding at a feeder and formed questions as to what seed is most edible to chickadees, or enjoyed the changing of the seasons and noticed what trees first lose their leaves have participated in the beginning steps of CS. The organized practice of CS takes initial observations a step further.

This study identified which national standards of environmental literacy CS best addresses in grades 5 through 8, and developed a curriculum framework based on these results. A Delphi Technique was used to survey CS practitioners. This built consensus about which educational standards of environmental literacy are best addressed in order to develop, implement and evaluate a successful CS program. The results of this study served as a resource for practitioners who wish to implement a similar program, or for current programs to modify their strategies to be more effective by using the invaluable knowledge and experiences of current practitioners. The sharing of ideas and knowledge may also contribute to and strengthen the network of CS practitioners nationwide and promote development of new CS programs.

CS uses interested volunteers from the general public in the research process through schools, environmental organizations, nature centers, or individually. Participants actively collect valuable data and learn about the scientific process, and partake in both formal and non-formal experiences throughout the experience (Stewardship Canada, 2007). CS practitioners also realize the additional benefits this may have on students such as involvement in natural resource conservation, increased participation in the scientific process, and catering to multiple intelligences. CS practitioners have worked to create community partnerships with local universities and school districts, state and federal agencies and other environmental organizations that promote student involvement in current research throughout the country. This non-formal approach to science education encourages direct student participation in the sciences.

CS may not be traditionally categorized as environmental education because it uses different methodology by focusing on the advancement of science and scientific knowledge (Krasny & Bonney, 2005). However, it has the potential to positively influence participant's environmental behavior (Barnett, Lord, Strauss, Rosca, Langford, Chavez & Deni, 2006), which is the definitive aim of environmental education. The focus of developing knowledge and skills, as well as an emotional connection towards environmental concerns affecting communities is fundamental for the overall success of both educational techniques. With these solid foundations of knowledge, skills, and an emotional connection, students' environmental literacy may also grow.

CS integrates various disciplines to achieve the goals of increased scientific understanding and education, as well as environmental literacy of participants. CS practitioners are often familiar with natural sciences such as biology and ecology, but may also draw on environmental education's instructional goals to achieve the goals of increased scientific understanding and environmental literacy. Environmental education's goals of citizen action skills and citizen action experiences can play a major role in CS.

Students who participate in CS research may also be fulfilling some of the goals of environmental education; building a sound understanding of the natural world, developing investigative skills and learning how to turn those skills into action (Mordock & Krasny, 2001). Mordock and Krasny's (2001) research illustrates the potential of CS to be an important tool for increasing environmental literacy among participants.

CS also has many practitioners who employ varied methodologies depending upon the specific situation. Many of these teachers, environmental educators and other professionals have acquired valuable insight into the development, implementation and evaluation of CS programs in schools, communities and nature centers. This experience and knowledge is invaluable and can be instructive to other practitioners who wish to begin a similar program, or to improve an existing one in their community or classroom. By using and sharing the knowledge and experience of other programs, an improved network may be developed to promote more effectively the goals of CS and environmental education, and support its practitioners. A curriculum framework of standards for CS education will help to achieve these goals, and can be used as a starting resource for new programs.

The Statement of the Study Proposal and Study Objectives

Study Proposal

The researcher proposes to develop a curriculum framework for developing and teaching citizen science education programs to and for 5th through 8th grade students that focuses on increasing environmental literacy.

Study Objectives:

1. Develop and validate a survey to be used to obtain information from citizen science practitioners that will be used to develop a curriculum framework.
2. Identify and survey current citizen science practitioners throughout the nation using the Delphi Technique to identify environmental literacy standards addressed by citizen science.
3. Develop a valid curriculum framework and standards for citizen science programs.

Limitations

1. The study identified and surveyed a “sample of convenience” of current citizen science practitioners.
2. The framework was applicable only to environmental education programs, teachers, or nature centers that utilize citizen science.
3. The framework addressed standards for grades 5 – 8.

Definition of Terms

Citizen Science (CS). Citizen science is a process that engages the public in the scientific process and the advancement of scientific knowledge. (Krasney & Bonney, 2005)

Citizen Science Practitioner. A citizen science practitioner is any teacher, environmental educator or scientific researcher who utilizes citizen science as a method to increase scientific understanding and environmental literacy in students.

Curriculum Framework. A curriculum framework is a planning guide for educators that states subject area content and process outcomes in general terms (Erickson, 2001).

Delphi Technique. The Delphi Technique is a research method that uses a series of questionnaires to generate ideas and facilitate consensus among individuals who have special knowledge to share, but who are separated by geographical distance (Linestone, H.A. & Turoff, M.T., 1975).

Environmental Education. Environmental education is an education strategy used to develop a 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).

Environmental Literacy. Environmental literacy is the capacity of citizens to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems (Disinger et. al., 1992).

Education Standards: Educational standards refer to the knowledge and skills students should know upon completion of a school year (McTighe & Thomas, 2003).

Responsible Environmental Behavior: Responsible environmental behavior includes active and considered participation aimed at resolving environmental problems. Examples include persuasion, consumer action, eco-management, political action, and legal action. (Volk & McBeth, 2004)

Assumptions

1. The citizen science practitioners who participated in the Delphi Survey are knowledgeable and experienced in their field.
2. The completed framework included essential standards of citizen science and environmental literacy.
3. Existing and future citizen science practitioners will utilize the framework for their programs.
4. Environmental literacy should be an outcome of citizen science education programs.
5. Current citizen science programs are limited in addressing environmental literacy by not having appropriate curriculum.

Summary

Environmental literacy is important for environmental education, and CS can contribute to students' development of their environmental literacy. This research was completed to strengthen the relationship between CS and environmental literacy by providing teachers and CS programs a framework to develop curriculum to meet the standards of environmental literacy, and this ultimate goal.

Chapter Two – Review of Related Literature

Introduction

Citizen science (CS) encourages individuals to actively participate in the scientific process, emphasizing the collection of data related to specific scientific or environmental topics within their community, region, or larger geographic areas. This chapter reviews the important concepts of a CS program and environmental literacy and the necessary steps to develop a framework for the standards of environmental literacy. This chapter reviews the following topics:

1. Characteristics of Citizen Science Programs
2. Citizen Science as a Form of Environmental Education
3. Using Citizen Science to Increase Environmental Literacy
4. NAAEE's *Executive Summary & Self-Assessment Tool*
5. Curriculum Framework Development for Citizen Science
    a. *Understanding by Design Process in Creating Curriculum Frameworks*
6. Using the Delphi Technique to Identify Standards

Characteristics of Citizen Science Programs

The strategies used to meet educational needs are evolving and expanding. Many educators are incorporating new techniques to meet stricter standards passed by the federal and state governments and realize the need for more challenging curricula to meet these current trends. As education continues to evolve in a new environment of higher standards, new alternatives to traditional methodologies are being accepted as valuable options of education.

CS and other environment based learning are becoming increasingly more popular in school districts and local communities as a means to meet new higher standards of education, while educating students in multi-disciplinary themes (Liebermann & Hoody, 1998; NEETF, 2000). Many educators, scientists, universities and other programs are actively creating, or participating in experiences that connect students with the scientific process (Krasny & Bonney, 2005). Krasny and Bonney describe CS as "…a movement to explicitly engage the public in the process of science and the advancement of scientific knowledge" (2005). As opposed to traditional science education strategies where the public is less engaged in the advancement of new knowledge.

Science traditionally refers to a method of acquiring knowledge through observation and experimentation to describe an event, and is often taught in primary and secondary schools. Science education in schools seeks to provide students with an understanding of science and how the scientific process works such as conducting experiments in photosynthesis. It also provides a foundation of basic scientific principles for those students who will continue to study science in higher education and beyond (Greenfield & Westwell, 2006). Although there are similarities between science education and CS, CS attempts to connect participants more specifically to science through different strategies.

CS programs use various strategies to address specific community or regional issues. The wide variety of social and physical environments, as well as participants, in which CS projects take place can create the necessity to adapt to different established criteria (Tinker, 1997). Although specific situations differ from community to community, or project to project, potential characteristics of CS, if identified and applied, can offer an increased likelihood of success.

CS programs that specifically target students are attempting to unite science and education. These programs can often be classified into four separate models. The first is scientist-led in which the research program and protocols are defined by the scientist, while the actual data collection and analysis is completed by students. The next model is scientist guided in which the research is defined and supported by a scientist, but students are involved in the study design and procedure. A third program model is instrument-based in which scientific measurement instruments are placed in schools; however, the data may be used differently by the students and scientists. Finally, there is the student originated model where the research design and protocol is largely student determined and scientists are primarily seen as advisors (Tinker, 1997). Tinker (1997) goes on to identify limitations that affect the previous models, and decrease the likelihood of successful outcomes. The educational value of an effective CS model depends heavily on the teacher's skills and abilities and curriculum availability that support the students' learning goals and opportunities for direct student participation (Tinker, 1997; Rock, Blackwell, Miller & Hardison, 1997).

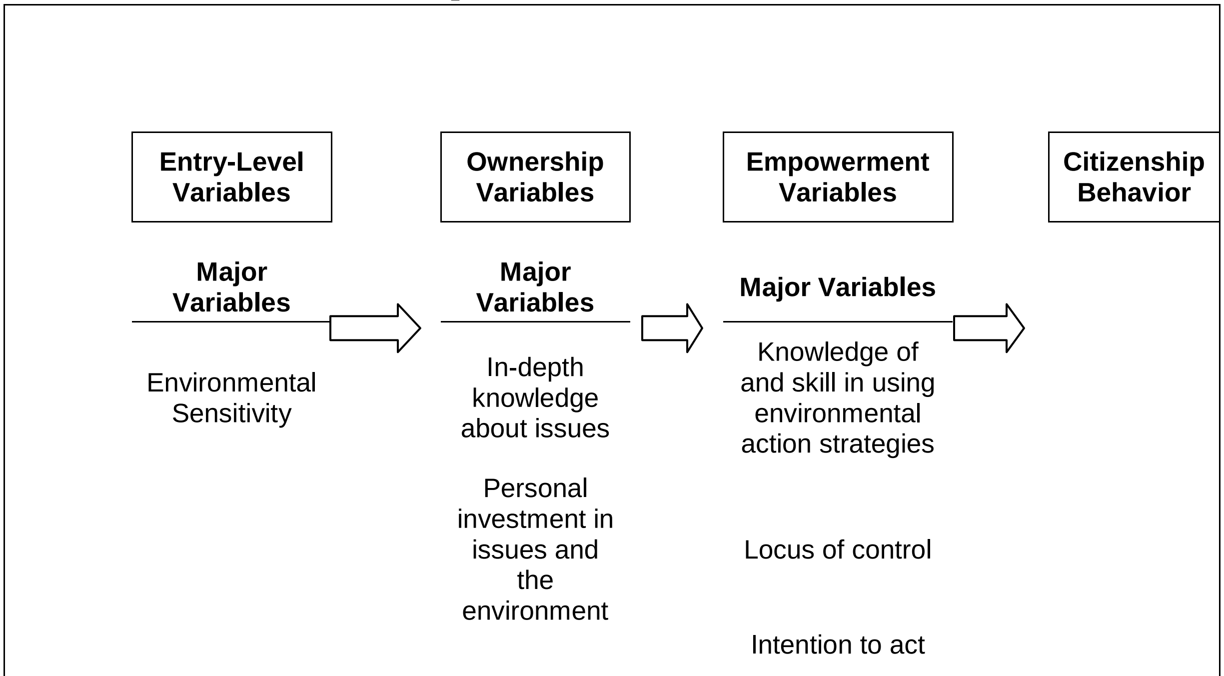
Models used by different programs can be dependent on many factors. However, many CS programs exhibit similar elements that are common throughout. Genuine student engagement through active participation in the collection of necessary data is the most essential element of successful CS programs. Other important elements also revolve around those data through critical analysis, interpretation and/or a possible course of student actions dependent upon those data (Schusler, 2005; ATC, 2006).

Data collection and interpretation are the key elements to successful CS projects which can provide invaluable assistance to scientists, researchers, teachers and students in projects that work on natural resource conservation and more. Although CS programs have been recognized for their importance in many fields, CS can also serve in meeting the goals of environmental education and increase the environmental literacy of students.

Citizen Science as a form of Environmental Education

Environmental education is a multi-disciplinary field. According to the Environmental Education and Training Partnership, EETAP (2000), environmental education encourages citizens to make knowledgeable and informed decisions about their environmental behavior based on the awareness, knowledge, skills and attitudes instilled in them. Environmental education uses both formal and non-formal learning strategies to accomplish its' goal, as well as traditional and non-traditional settings. Formal learning is best associated with schools in which the setting, goals, and means of instruction are controlled by the school. Formal learning can take place in either traditional classroom environments, or non-traditional environments such as the out-of-doors or an environmental education center. In contrast, non-formal learning has the learners choosing what to learn, but not the means by which to learn those objectives. Non-formal learning often takes place in non-traditional settings such as parks or nature centers in which the activities are organized by the participating institution or organization. Finally, non-formal learners often have a strong interest in learning about the subject matter (Heimlich, 1993). Since people learn in both formal and non-formal environments and in traditional and non-traditional settings, environmental education can be used as a way to change behaviors through bridging non-formal “hands-on” learning and setting experiences with the more formal education of a classroom (EETAP, 2000).

Figure 1: Behavior Flow Chart: Major and Minor Variables Involved in Environmental Citizenship Behavior



Adapted from Hungerford & Volk (1989) with exclusion of minor variables.

Hungerford and Volk (1989) identified many preliminary variables that environmental education should address in order to achieve increased environmental literacy and resulting citizenship behavior. The variables were separated into three groups: entry-level, ownership and empowerment (Figure 1). Each variable and its influencing factors build upon the previous, contributing to an overall responsible citizenship behavior. In their research, Hungerford and Volk (1989) also pointed out that the final variables of empowerment are an often neglected “cornerstone” in practices of environmental education. These key variables, and the factors that contribute to their realization, are necessary for environmental education to be effective; thus their incorporation into environmental education programs is essential (Hungerford & Volk, 1989).

However, in order to address the variables of empowerment, an in-depth knowledge of an issue is “crucial to ownership” (Hungerford & Volk, 1989). Students who have a deeper understanding of a particular issue and are aware of the ecological and human implications of it are more apt to make more responsible behaviors toward that issue (Ramsey, 1989). Hungerford and Volk’s identification of “In-depth Knowledge about Issues” supports CS’s role in environmental education through students’ hands-on participation in projects that focus on developing scientific knowledge, and therefore their ownership in an issue (Krasny & Bonney, 2005).

CS is able to address the empowerment variables of environmental education through the development of an internal locus of control and an increase of knowledge and experience in citizen action skills. Locus of control, one’s perceived ability to influence change, and its’ influence on the empowerment variable, is an important factor. The environment is often portrayed as vulnerable with many unsolvable problems and crises throughout the world and can influence citizens’ personal feeling of helplessness toward environmental issues. This lack of perceived personal usefulness in solving environmental issues may lead people to develop an external locus of control, or a feeling that they cannot positively influence the environment. However, environmental education can reverse locus of control from external to internal by instilling citizens with the sense that they can have positive influences on their environment (Smith-Sebasto, 1995). A formal class in environmental science is one method to create an internal locus of control, while the development of citizen action skills and experiences is another strategy (Hungerford & Volk, 1989).

Citizen action skills and experiences can be developed through active participation in environment based problem solving and CS programs incorporated directly into a school curriculum. At the Kualapu'u Elementary School on Molokai Island, Hawaii, fifth and sixth graders actively use the skills learned in class to investigate, analyze, and determine the best possible solutions to solve environmental problems within their community. Finally, at the end of the year, the students present their findings within their community, at different conferences or before government panels. This program found that participating students had an increased awareness towards environmental issues, as well as an increased ability to look critically at the issues investigated and what possible actions appropriately address the issue (Cheak, Volk & Hungerford, 2002). The school program in Hawaii clearly demonstrates development of major variables important in influencing both ownership and empowerment necessary for responsible environmental behaviors that EETAP identifies as essential aims of environmental education.

By focusing environmental education curriculum and methodology on skill and experience development, it has been shown that student's responsible environmental behavior is improved (Ramsey, 1993). Ramsey's study looked at student's knowledge of an issue, locus of control, knowledge of and skills in environmental action, and other variables identified by Hungerford and Volk. His study showed that middle school students participating in environmental issue investigation, resolution and action tended "…to foster independent overt environmental behavior" and increases their environmental literacy (Ramsey, 1993). CS curriculum that develops students' skills and experiences by addressing some of the key variables identified by Hungerford and Volk also has the potential to increase students' responsible environmental behaviors.

CS has the potential to create feelings of ownership and empowerment by offering direct, hands-on experiences. CS involves the collection of data locally or regionally; giving participants first-hand experience in the accumulation of data of their local natural resources and develops their skills to actively monitor and manage those resources (Cooper, Dickinson, Phillips, & Bonney, 2007). By actively collecting data, participants are obtaining in-depth experience and knowledge, and by using skills to manage their resources they are developing a greater sense of empowerment. Citizen participation encourages an increased level of understanding regarding human-environment interactions and has the potential to increase a sense of stewardship for the environment (Cooper et al., 2007; Barnett et al., 2006).

CS education has many other applications in the movement to reform school curricula nationwide. Culen (2001) writes:

> "Curricula that provide the necessary knowledge related to the issues, tools to adequately analyze and evaluate issues, and skills to help resolve issues are essential. These ingredients are proven links to success in promoting environmental behavior." (pp. 38).

As Culen stated, schools are facing a need to create learning environments that challenge their students and develop the skills necessary to address environmental problems.

Through the use of CS and other environmental-based programs, schools are able to meet standards and improve student scores in the sciences, social studies, writing skills and more, while decreasing behavioral problems in classrooms (Barnett et al., 2006; Cheak et al., 2002; Hansen, Kelley & Hall, 2003; Lieberman & Hoody, 1998; NEETF, 2000). Researchers also observed increased interest and scores in science by middle school girls who participated in environment based education programs; a group that is prone to losing interest in the sciences (Barnett et al., 2006; Lieberman & Hoody., 1998). Perhaps most important is the overall increase in interest of the learning process, as well as increased enthusiasm, pride and ownership in student accomplishment, which can lead to lifelong learning and responsible environmental behaviors (Cheak et al., 2002; Hansen et al., 2003; Lieberman & Hoody, 1998; NEETF, 2000).

In the course of offering students a variety of learning opportunities, CS practitioners are catering to multiple ways that students learn. This variety of teaching strategies and subject matter gives different opportunities for struggling students to excel in other areas of learning. As one practitioner recently stated, “Students who struggle in school often excel in projects of CS as data collectors or presenters,” (Direct Quote from Zach Wilson November 14, 2007).

Through the participation in CS programs, numerous examples have shown the benefits towards students. Many schools and curriculums are incorporating these strategies to boost student scores and comprehension in math, science and other fields. Additionally, CS is also accomplishing the aims set out for environmental education, through instilling a greater environmental sensitivity, ownership and sense of empowerment. It has been shown that CS can be successful in encouraging these preliminary variables for responsible citizen behavior, and can also be a valuable technique in increasing the environmental literacy of participating students.

Using Citizen Science to Increase Environmental Literacy

CS is becoming an increasingly popular and accepted technique in promoting the goals of environmental education. EETAP (2000) states that environmental education's ultimate goal is to encourage citizens to make informed decisions about their behaviors. Responsible environmental behaviors are the ultimate goal, but citizens must become environmentally literate in order to modify their behaviors. Therefore, the concept of environmental literacy is an essential precursor of responsible environmental behavior. Although awareness and knowledge are important components of environmental literacy, environmental literacy is based on observable actions and behaviors (Roth, 1992). Based on the need for action, EETAP further defined environmental literacy as the need "…to focus on participation, involvement, and relevance to daily environmental concerns…" (EETAP, 2000). As indicated by EETAP, there is need to connect citizens through direct experience to the natural environment in order to increase their overall environmental literacy and resulting behaviors.

Environmental literacy has many precursors that are necessary before students can attain a literacy that leads to action. In a study by Sivek, Wisconsin high school students cited various factors that led to an increase in environmental sensitivity, which "…appears to be an important precursor to environmental literacy" (2002). Environmental sensitivity has been defined as having a feeling of empathy towards the environment (Sivek, 2002). The role of environmental sensitivity is important for the development of literacy in students, therefore making it pertinent for all educators. Amongst other variables, time spent out-of-doors and having knowledgeable teachers as positive role models served as influential factors contributing to the students' level of environmental sensitivity (Sivek, 2002). Through the active participation in CS, students may spend large amounts of time outside, often guided by teachers from school or other program instructors, and can have a substantial influence in increasing students' environmental sensitivity.

Sivek's study identified the importance of time spent out-of-doors and positive environmental role models for high school students; however, what are the impacts of childhood experiences upon adults? In a review of national and international studies looking at factors of environmental sensitivity among environmental professionals, Chawla (1998) found that time in nature as a youth was the number one influence for their commitment to environmental protection. The motivation for adults to act later in life may result from an emotional connection to the natural world during their childhood and adolescent years due to earlier exploration and "attentiveness" of a mentor or role model to the natural world (Chawla, 2007). Exploration of the natural world with adult mentors can lead youth and students to a lifelong, emotional commitment to the environment.

CS can also provide students with many of the important skills necessary for environmental literacy. Through the opportunities of hands-on scientific research, CS allows students to develop essential scientific thinking skills, an important component in environmental literacy. Students involved in scientific research increase their scientific thought, giving them opportunities to look at various evidences and draw appropriate conclusions (Berkowitz, Brewer & Ford, 2005). The scientific process gives students the chance to develop an increased understanding of how their community and environment interact, and take appropriate actions (Berkowitz et. al., 2005).

In a CS education program conducted at Eastern District High School in Brooklyn, New York, students and teachers identified local environmental issues affecting their community, such as water conservation, toxins, lead contamination and waste disposal. The students then focused their attention on lead contamination by generating a geographic information system (GIS) map of the possible sources and known cases of the contamination. With this information, the students were then able to locate the source of the lead, which in this case was construction work on the nearby Williamsburg Bridge. As a final step, the students presented their findings to the city of New York and partially influenced the project by having the city stop construction and cover the construction site with a protective tent (Mordock & Krasny, 2001). The Brooklyn students demonstrated skill development that led to the action experiences that are essential to creating environmental literacy.

The development of practical problem solving skills can also lead to an increased sense of ownership (Monroe, 2003). The skills that are developed often have an inherent complexity creating a connection between two or more disciplines or topics, encouraging deeper understanding of issues facing communities and the environment (Monroe, 2003). These complexities, when overcome, can lead to a greater sense of accomplishment and success, therefore resulting in increased personal confidence, i.e. internal locus of control, as well as having potential long term effects on students' behavior (Monroe, 2003).

Many teachers and students have seen positive personal and academic results associated with CS because of its' interdisciplinary, issue-based focus. Teachers who use CS also recognize benefits towards students' increased environmental literacy and more positive attitudes towards the environment (Ernst, 2007). Although there are many positive outcomes with CS, there are many factors that contribute to the minimal or total lack of use of CS by educators and teachers. Ernst's found that some of the limiting factors to its use for many teachers were the increased emphasis on standardized testing and school standards, as well as decreases in funding availability, time and transportation.

The teachers surveyed in the Ernst study may benefit through a clearly defined framework of standards in CS. By identifying the important standards, a teacher can tie educational standards into a CS program (Erickson, 2002). Teachers and other educators may benefit from having a comprehensive plan that includes the essential environmental literacy standards for CS, from which they can build a successful program or class. The NAAEE's *Executive Summary & Self – Assessment Tool* previously identified the desired standards of environmental literacy and is used to assess a program's environmental literacy. This tool has greatly facilitated the process of program evaluation and learner outcome identification.

NAAEE's Executive Summary & Self-Assessment Tool

To ensure the quality of environmental education materials and curriculum, universally accepted goals need to be established. It has been shown that, as with numerous other undertakings, goals are needed to provide valuable direction in the development and instruction of environmental education curriculum materials.

Curriculum materials for environmental education should all address the “super ordinate” goal of increasing student’s environmental literacy (Hungerford, Peyton & Wilke, 1980).

In the 1990’s, the North American Association for Environmental Education (NAAEE) initiated the development of recommended guidelines for environmental education programs necessary to achieve participant environmental literacy. One of the end products entitled *Excellence in Environmental Education: Guidelines for Learning (Pre K-12)* and the corresponding *Executive Summary & Self – Assessment Tool* offers broad and tangible voluntary program guidelines. The *Guidelines for Learning* set goals for students in their 4th, 8th, and 12th year of schooling defining what environmentally literate students should be able to accomplish upon completion of that year. The presented concepts and accompanying standards were created for curriculum and program development and evaluation, and were drawn from numerous sources in environmental education and other disciplines such as Math, English Language Arts, and Science. They also correlate with national standards in many subject areas such as Math, English, Science, Geography, Civics, and Art (NAAEE, 2004).

The Guidelines for Excellence Project was the end result of an evolving environmental education field and a changing educational environment within the country. The Guidelines were meant to unite environmental education programs nationwide through the establishment of specific criteria for environmental literacy. Also, the project hoped to serve as a tool to respond to mounting criticism against environmental education (McCrea, 2006). Finally, the Guidelines Project was developed to ensure that environmental education was included within the educational standards movement to “help educators develop meaningful environmental education programs that integrate across the curriculum and build upon the high standards set for the core disciplines" (McCrea, 2006).

Through reviewing the relevant literature of curriculum development in environmental education, as well as the conceptual frameworks of numerous environmental education programs such as Project WILD and Leaning Tree, the NAAEE identified four unifying strands or concepts. They were: (1) Questioning, Analysis and Interpretation Skills; (2) Knowledge of Environmental Processes and Systems; (3) Skills for Understanding and Addressing Environmental Issues; and (4) Personal and Civic Responsibility. Further explanation of the individual strand and the specific skills and abilities each strand develops is located in Table 2. Standards in the form of skills, knowledge, and dispositions accompany each strand as a way to measure and evaluate learner and program progress through the use of the NAAEE's *Self-Assessment Tool* (Table 1) (NAAEE, 2004). This tool allows environmental education programs to evaluate their programs and curricula to identify their strengths and weaknesses in addressing environmental literacy. An example is included in Table 1.

Table 1: Example of NAAEE Self-Assessment Tool

Strand 1 – Questioning, Analysis & Interpretation Skills: Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Learners must be familiar with inquiry, master fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.			
Learner Outcome	**Yes-Fully Addressed**	**Partly Addressed**	**No-Not Addressed**
1) Learners are able to develop questions that help them learn about the environment and do simple investigations.			

Table 2: NAAEE Strands with Specific Student Expectations. (NAAEE, 2008)

<table>
<tr><td colspan="2">Strand 1 – Questioning, Analysis & Interpretation Skills: Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Learners must be familiar with inquiry, master fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.</td></tr>
<tr><td>• Questioning
• Designing Investigations
• Collecting information
• Evaluating accuracy and reliability</td><td>• Organizing information
• Working with models and simulations
• Drawing conclusions and developing explanations</td></tr>
<tr><td colspan="2">Strand 2 – Knowledge of Environmental Processes & Systems: An important component of environmental literacy is understanding the processes and systems that comprise the environment, including human social systems and influences. That understanding is based on knowledge synthesized from across traditional disciplines.</td></tr>
<tr><td>2.1 The earth as a physical system
• Processes that shape the earth
• Changes in matter
• Energy</td><td>2.2 The living environment
• Organisms, populations, & communities
• Heredity and evolution
• Systems and connections
• Flow of matter and energy</td></tr>
<tr><td>2.3 Humans and their societies
• Individuals and groups
• Culture
• Political and economic systems
• Global connections
• Change and conflict</td><td>2.4 Environment and society
• Human/environment interactions
• Places
• Resources
• Technology
• Environmental Issues</td></tr>
<tr><td colspan="2">Strand 3 – Skills for Understanding & Addressing Environmental Issues: Skills and knowledge are refined and applied in the context of environmental issues. These environmental issues are real-life dramas where differing viewpoints about environmental problems and their potential solutions are played out. Environmental literacy includes the abilities to define, learn about, evaluate, and act on environmental issues.</td></tr>
<tr><td>3.1 Skills for analyzing & investigating environmental issues
• Identifying & investigating issues
• Sorting out the consequences of issues
• Identifying & evaluating alternative solutions and courses of action
• Working with flexibility, creativity, & openness</td><td>3.2 Decision-making and citizenship skills
• Forming and evaluating personal views
• Evaluating the need for citizen action
• Planning and taking action
• Evaluating the results of actions</td></tr>
<tr><td colspan="2">Strand 4 – Personal & Civic Responsibility: Environmentally literate citizens are willing and able to act on their own conclusions about what should be done to ensure environmental quality. As learners develop and apply concept-based earning and skills for inquiry, analysis, and action, they also understand that what they do individually and in groups can make a difference.</td></tr>
<tr><td>• Understanding societal values & principles
• Recognizing citizen’ rights & responsibilities
• Recognizing efficacy
• Accepting personal responsibility</td><td></td></tr>
</table>

The *Guidelines for Learning* and accompanying *Executive Summary & Self – Assessment Tool* can be an invaluable tool for environmental education programs to assess how well environmental literacy is being achieved. The thoroughly researched and relevant concepts and standards identified for environmental education programs by the NAAEE may be applicable in CS programs as well in identifying which standards CS addresses.

Curriculum Framework Development for Citizen Science

CS, an increasingly popular and complement to environmental education, is leading to increased benefits in other educational subjects for students. Practitioners incorporate different strategies and ideas that are specific to each individual situation, class or student to maximize student success. Although there are varied ways to carry out successful CS programs, many programs and teachers incorporate unifying standards common in many programs.

Curriculum frameworks are a planning guide used by educators that focus curriculum development on specific content areas and standards (Erickson, 2001). Through the use of a curriculum framework, teachers can organize what standards students should achieve. The most influential aspect of a framework is the individual standard. Standards can be defined as “specific statements of what you want students to know” (Erickson, 2001). By specifically defining the standards of a framework, greater success can be achieved in the curriculum goals (Erickson, 2002). The essential standards need to be identified and organized by teachers and other practitioners of CS (Erickson, 2002).

Because of the exponential increase in information due to technology, there is greater need for critical thinkers who can manipulate and understand the changing world (Erickson, 2002). A curriculum framework focuses attention onto the essential standards that are necessary and important, engaging both teachers and students into practical application of material, rather than rote memorization (Erickson, 2001). Curriculum frameworks can serve as an invaluable link between organizing essential standards and putting those standards into practice through the engagement of students in higher levels of thought processes. Erickson (2002) stresses that a framework should include standards that promote students' critical knowledge, understanding and performance abilities of those standards.

As large quantities of information are made available to the public via the internet, it may be difficult to distinguish what data are vital to students. Curriculum frameworks allow teachers to filter this information, selecting only the necessary information that supports the identified and essential standards. This can help to streamline the teaching process and allow for more teacher and student control in the learning process (Erickson, 2001).

This streamlined learning process can assist in focusing schools and CS programs to meet the demands of science standards. A strategy to meet science standards can take place by an improved focus on practical and extended scientific inquiry within schools (Tinker, 1997). Through the application of a curriculum framework, teachers and CS programs can focus on what to instruct to effectively meet new science standards and increase environmental literacy. Finally, through focusing on these essential standards, informal institutions and programs can be effective in their instruction, especially since they rely on volunteers, parents or other staff with limited research experience (Tinker, 1997).

As identified, a curriculum framework can benefit CS practitioners by focusing on the most essential standards necessary to increase the environmental literacy of students. However, there is a need to identify what standards those should be with the best and most effective way to reach those conclusions. Through the use of a Delphi Survey, it is possible for CS practitioners to reach a consensus about these standards.

Understanding by Design Process in Creating Curriculum Frameworks

The development of an effective curriculum is tied to, and increasingly more dependent upon set educational standards for subject areas. This is equally true for effective teaching of environmental literacy. Standards offer guidelines of how and what to teach (Shumway & Berrett, 2004), providing schools with a vision of the skills and knowledge students need to attain for future problem solving situations (Foriska, 1998). Foriska stated that standards need to focus on cognitive learning, be clear and measurable, while based on traditional academic disciplines.

Curriculum frameworks are tools that help to organize and identify subject content (i.e. standards) and to process broad outcomes (Erickson, 2001). Inclusion of organizing ideas for a curriculum framework can make the selection process difficult. However, in the late 1990's, Wiggins and McTighe developed a curriculum process called "Understanding by Design" that looks at curriculum development from a new standpoint. "Understanding by Design" develops curriculum through a process that identifies the specific standards students should learn as the first step, often state or federal educational standards. The second step is to develop appropriate forms of student assessment, followed by the development of the teaching or learning plan (Figure 2) (Wiggins & McTighe, 1998).

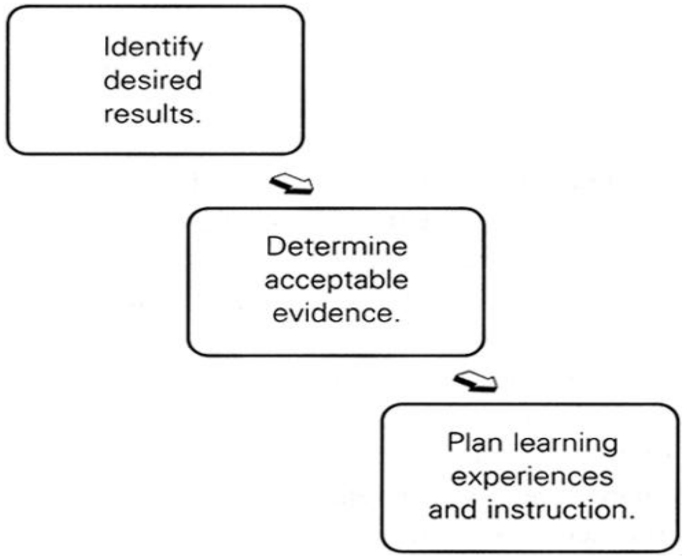


Figure 2: Stages of "Understanding by Design" (Wiggins & McTighe, 1998)

"Understanding by Design" is a curriculum development strategy that attempts to meet standards and accountability by addressing the multiple varieties of students' strengths and needs in the learning process (McTighe & Brown, 2005). Through a process that stresses and reinforces what and how students learn, "Understanding by Design" seeks this balance. When developing an effective curriculum, McTighe and Brown identified four important characteristics to consider in order to address standards and accountability, while attending to students learning needs. They are: (1) education needs to repeatedly cover key concepts and ideas; (2) students learn best from active, inquiry based activities; (3) student assessment needs to demonstrate concept understanding; and (4) effective instruction targets different learning styles of students (McTighe & Brown, 2005).

Because “Understanding by Design” looks at the standards first, it can be a strategy to effectively develop an environmental education curriculum as well. Hungerford and Volk (2001) stated that an important step is to identify the philosophy, goals, and what students will learn from the curriculum in order to develop a curriculum that leads to environmentally literate students. “Understanding by Design” forces curriculum developers to focus on essential standards as the driving force in curriculum development and identifying the questions that will lead to enduring understanding and knowledge in students (Shumway & Berrett, 2004; Wiggins & McTighe, 1998).

After the stating of learning standards, the second step of “Understanding by Design” focuses on student assessment and how well they are meeting the stated goals. It is important for teachers and curriculum developers to determine acceptable evidence of student learning through a variety of ways such as written, oral, observable or other forms of assessment (Wiggins & McTighe, 1998). The assessment should match and address the learning standards (McTighe & Brown, 2005). However, “Understanding by Design” allows teachers to modify assessments in order to better guide the discussion and address the learning objectives (Hendrickson, 2006). The final step of “Understanding by Design” is the planning of the learning experience “to help students achieve the desired results (Step 1) and equip them for their performances of understanding in [the second step]” (McTighe & Brown, 2005).

“Understanding by Design” has proven to be a well-received, effective method for curriculum development. Hendrickson (2006) described “Understanding by Design” as an effective alternative to traditional curriculum development for science teachers because science standards are often based on inquiry and open-ended questions.

Teachers were better able to teach the standards in their classrooms using "Understanding by Design" (Hendrickson, 2006). Pre-service teachers also showed a higher performance in curriculum development when compared with traditional methods, allowing them to teach more of the standards (Kelting-Gibson, 2005).

The positive teacher outcomes in curriculum development began with clearly stating the desired standards for students. This first step leads to student assessment and finally learning plans. The identification of the standards for environmental literacy can assist in the "Understanding by Design" of effective curriculum for CS programs. In order to accomplish this, the researcher used a Delphi Technique to identify which learning standards were the most important for CS programs.

Using the Delphi Technique to Identify Standards

Nature centers, schools, and individuals practice CS techniques, and through these programs they incorporate different strategies that contribute to increased environmental literacy. The practitioners of CS offer unique perspectives and opinions about how best to create a successful CS program, and they represent an essential resource in identifying the best means of attaining environmental literacy. By communicating with practitioners, one learns what components they identify as most valuable in a CS program, what practitioners are doing in the field, and other factors involved with a well functioning CS program. In order to ascertain the different opinions of practitioners, there are a variety of methods one can use, such as personal interviews, panel discussions, roundtable meetings or a Delphi Technique. Each method has its advantages and disadvantages, depending on the individual situation.

The Delphi Technique was originally developed during the Cold War by the Rand Corporation to address concerns of national security. The Delphi Technique is a survey method used to build a consensus among experts in the field that is being surveyed through a recommended three rounds of questionnaires (Linestone & Turnoff, 1975). Clayton defines an expert as someone with unique experiences and knowledge of process that one wants to test (1997). The use of a Delphi Technique encourages communication of a group of experts from within a technical field, allowing each expert to assess specific ideas and "vote" on what is felt to be most important. Delphi relies on the key assumptions that there will be the involvement of many experts (10's or 100's) and face to face contact is prohibitive because of cost and time constraints (Linestone & Turnoff, 1975). Although Delphi surveys have had over 100 participants, an optimal number of participants has not been determined. However, ten to fifteen participants has been found to be acceptable in order to develop a consensus (Delbecq, Van de Ven & Gustafson, 1975; Kane, 2003).

The Delphi Technique is used to identify major ideas, and can be an informative method for curriculum development and educational materials (Blair & Uhl, 1993). Of the recommended three rounds, the first usually focuses on developing the concepts, skills and ideas to consider on the survey topic, often in the form of open-ended questions. Upon completion of the first round, the researcher identifies the unifying statements or concepts, and presents them to the participants in subsequent rounds. The participants rate the statement using a Likert, or weighted numerical, scale and comment about word choice or idea clarity. The final round is a refined and more focused repetition of the second round (Brody, 1995). In subsequent rounds, participants are able to see their selection in comparison to the groups', showing the group mean and standard deviation. Participants are able to reevaluate their previous selections in comparison with the group, and to modify their selection, or not, and offer explanation if their choice differs from the overall group's (Eggers, 1998).

In using a Delphi Technique, it is possible to attain agreement from a larger group of CS practitioners by building consensus through a series of questionnaires (Yousuf, 2007). The Delphi Technique can be more advantageous than individual interviews because it encourages larger group participation, and allows participants to reflect and modify their responses through the questionnaire series and identify which ideas are most essential. In regards to panel discussions or roundtable meetings, Delphi questionnaires provide anonymity and permit participants equal opportunity to express opinions and thoughts, rather than succumbing to a more vocal member of a one-time discussion or meeting (Clayton, 1997; Blair & Uhl, 1993).

The Delphi Technique can also offer other benefits to a researcher and participants. Aside from the ability to build consensus, anonymity and individuality, the Delphi can be an excellent medium for idea generating; being flexible for participants and researchers, as well as its simplicity of use can lead to a successful agreement (Yousuf, 2007; Clayton, 1997). However, it is important that consensus is achieved by participants, and not a compromise, which can be a weakness if not addressed by the researcher (Linestone & Turoff, 1975). The responsibility of the researcher to build consensus is key to success, and the researcher should not ignore disagreement between participants that could lead participants to abandon the process (Linestone & Turoff, 1975). However, reaching consensus is debatable. Blair and Uhl (1993) used an agreement of 85% from participants on each statement as a criterion for consensus.

In order to ensure group success, the researcher needs to select a group of practitioners who understand their commitment and responsibility to the completion of the recommended three rounds of questionnaires (Yousuf, 2007). The validity of the Delphi Technique depends greatly upon the representatives selected to participate, and thus they should be aware of this commitment and the responsibility of all parties to achieve a successful consensus. Moore (1994) describes four reasons why using a group to build consensus is superior to individuals when doing research:

- With a larger group size, there is a higher chance of arriving closer to the truth.
- It is easier to understand and attain a consensus about social occurrences with a larger group.
- It is more likely the group will find the conclusions more beneficial and valid if they contributed to their synthesis.
- Groups can also simplify a complex problem by identifying patterns.

The Delphi Technique can be successful; however, it is not appropriate for every research situation. It is dependent upon the researcher to identify situations in which the Delphi can be applied successfully. Clayton (1997) recommends various situations in which a Delphi Technique may be appropriate, including education fields of curriculum development and educational effectiveness. Particularly in the development of curriculum frameworks, the Delphi Technique can be a valuable tool to identify and validate key concepts (Kane, 2003).

Traditionally, the Delphi Technique has been conducted entirely by mail. The researcher would send paper copies of the instructions, the survey, return envelope, and any additional materials necessary, requiring a few weeks to complete each round. This time consuming technique also has other drawbacks such as lost surveys and loss of expert interest in the process (Chou, 2002). However, with the prevalence and convenience of the internet and email, there are new options that are available to researchers. Kane (2003) recommended using the Delphi electronically to record and incorporate participant suggestions. Web servers such as www.surveymonkey.com allow researchers to easily create and administer surveys electronically. Through the use of technology, researchers benefit through increased efficiency and effectiveness, while participants benefit with increased convenience (Chou, 2002; Kane, 2003).

The Delphi Technique can be a valuable technique used to accomplish the goals of the study. Through the use of the Delphi, expert participants are able to identify and agree upon the most important standards necessary for environmental literacy. These national standards form the basis for developing a curriculum framework for the environmental literacy of CS programs.

Summary

This literature review looked at the most important topics related to the study, giving the researcher and reader a solid foundation of their contributions to the study. A curriculum framework for CS programs is valuable to current and future teachers and programs throughout the country because it will focus on the most important standards of successful programs, and how to incorporate them into new and current CS programs.

This project aims to provide a valuable guide for CS practitioners that will be useful, comprehensive and easily assist practitioners with the creation or modification of their programs.

Chapter Three – Methods

Introduction

The purpose of this study was to develop a curriculum framework that identifies standards necessary for the promotion of environmental literacy in a citizen science (CS) program. CS is incorporated into environmental education programs and organizations, as well as school curricula nationwide, each program using different methodologies. An important component of CS programs is the hands-on experience of students in the scientific process. Objectives of the study were to:

Objective 1: Develop and validate a survey to use in order to obtain information from citizen science practitioners that will be used to develop a curriculum framework.

Objective 2: Identify and survey current citizen science practitioners throughout the nation using the Delphi Technique.

Objective 3: Develop a valid curriculum framework and standards for a citizen science program.

Each objective and corresponding tasks and methodology are described in further detail below.

Objective 1: Develop and validate a survey to use in order to obtain information from citizen science practitioners that will be used to develop a curriculum framework.

Task 1.1 Use a pre-assessment questionnaire to determine the necessity for a CS curriculum framework.

In November 2007, the researcher asked CS teachers visiting Stevens Point, WI for the Governor's High School Conference on the Environment from throughout Wisconsin and Illinois if they were interested in participating in the study (Appendix A contains a Sample Letter). Questionnaires were then developed and sent to interested teachers in February 2008 via email, requesting information about their CS program (Appendix B). The questionnaires also addressed the need and usefulness of a conceptual framework for future CS programs, and ideas that teachers have found helpful in the development of their curriculum. Initially, the teachers were asked to comment upon the necessity of a conceptual framework, however, through teacher feedback, committee comments, and further reviews of previous literature and research, it was decided that a curriculum framework would be more appropriate and useful to meet the study's objectives.

Task 1.2 Identify essential standards of CS programs for environmental literacy through a literature review and assess Delphi Survey Technique for usefulness in surveying CS practitioners.

A thorough review of literature discussing CS and associated concepts was performed from October 2007 through May 2008. The researcher reviewed books, journal articles, newspapers, internet web-sites, and held conversations with professors and CS practitioners that discussed CS and factors that contribute to environmental literacy. The majority of written materials reviewed were found within the Learning Resource Center (LRC) on the campus of the University of Wisconsin at Stevens Point (UWSP) and other libraries in the University of Wisconsin system. The Wisconsin Center for Environmental Education (WCEE), also located in the LRC, was also searched. The researcher classified essential ideas from the reviewed material such as environmental literacy, responsible environmental behaviors, formal and non-formal concepts of environmental education and more. Useful material was downloaded and printed from UWSP databases, articles and books were photocopied and the sources were cited and thoroughly assessed for usefulness in the study. Important details were identified and synthesized for the study.

The researcher also conducted a review of various survey methods used to build consensus and best identify standards and characteristics of CS programs. The researcher reviewed the possible techniques, looked at previous research (Hoover, 2003; Kane, 2003) and with the assistance of his advisory committee, concluded that a Delphi Technique was most appropriate based on previous research.

Task 1.3 Complete a "gap" analysis of CS curricula for environmental literacy.

A final technique was used in identifying the essential standards for CS programs. It has been said that environmental literacy and corresponding behaviors are the ultimate goal of environmental education. A "gap" analysis of current CS programs throughout the country was undertaken to discover if CS programs were currently meeting the goals of environmental literacy. The North American Association for Environmental Education's (NAAEE) *Excellence in Environmental Education-Guidelines for Learning 5th -8th Grade Self Assessment Tool* (Appendix C) was used to identify criteria fully, partly or not addressed by each program.

Seven CS programs (Appendix D) were identified from internet searches, committee member advice and through the literature review. Criteria for inclusion of CS programs to assess were: clear statements of philosophies, goals or objectives, as well as sample lessons that can be used by teachers. Finally each program selected had to work with students in grades 5 – 8. Grades 5 – 8 were chosen because of time constraints, and the knowledge that student participation in environmental education and CS at those ages can have dramatic affects on their environmental literacy and behaviors at later ages (Lieberman & Hoody, 1998; NEETF, 2004).

The NAAEE's *Self Assessment Tool* is used to assess how well a program meets the specific standards for environmental literacy set out by the NAAEE through the development of student's skills, experiences and knowledge about the environment (NAAEE *Tool*, 2004). The *Self Assessment Tool* looks at four strands and correlating standards that are then identified as "Fully Addressed", "Partly Addressed" or "Not Addressed":

- Questioning, Analysis and Interpretation skills
- Knowledge of Environmental Processes and Systems
    - The Earth as a Physical System
    - Living Environment
    - Humans and their Societies

    - Environment and Society
- Skills for Understanding and Addressing Environmental Issues
    - Skills for Analyzing and Investigating Environmental Issues
    - Decision Making and Citizenship Skills
- Personal and Civic Responsibility (NAAEE, 2004).

The goals or objectives for each program were reviewed on their web sites, and sample lessons that targeted 5th through 8th graders were examined. Programs that addressed each specific condition in both sample lessons and their goals or objectives were given "Fully Addressed" marks. Programs that addressed a standard either in their goals or sample lessons were marked as "Partly Addressed", and finally programs that addressed neither, were marked as "Not Addressed".

Through a literature review, teacher questionnaire, and "Gap" analysis important standards and program characteristics were identified. The researcher, with assistance from his advisory committee, formulated a best course of action from which to proceed, identifying the logical steps needed to accomplish the study's goals.

Task 1.4 Create and validate the survey questions with committee members and validity panel input.

The standards of environmental literacy identified in the *Excellence in Environmental Education-Guidelines for Learning 5th -8th Grade Self Assessment Tool* along with additional standards and program characteristics identified in previous steps were used in the Delphi creation. The Delphi consisted of five strands with 56 corresponding standards and program characteristics. The first four strands corresponded to the NAAEE's identified strand topics in the *Excellence in Environmental Education-Guidelines for Learning (Pre K – 12)* and allowed Delphi participants to comment about the wording and included 39 standards. Along with the original NAAEE guidelines, 17 additional program characteristics were identified for their contribution to CS and to further define environmental literacy's role in CS. These characteristics are found in Appendix E. The characteristics were identified through the literature, web searches, personal communication with CS professionals and teachers, and with professors at UWSP. The sources of these characteristics can be found in Appendix F.

The first 39 standards were addressed by the statement "The following statements are important environmental literacy standards for CS programs. Please indicate the extent to which you agree that the following statements (related to the strand above) are important." The following 17 standards and program characteristics were addressed by the statement "The following statements are important environmental literacy standards/program characteristics for CS programs. Please indicate the extent to which you agree that the following statements are important." Each standard or characteristic asked survey participants to respond using a five-point Likert Scale: (5) Strongly Agree, (4) Agree, (3) Neutral, (2) Disagree and (1) Strongly Disagree. Additionally, there were two questions inquiring about participants' familiarity with NAAEE's *Excellence in Environmental Education-Guidelines for Learning 5th -8th Grade Self Assessment Tool* and other documents that were consulted during program development. Finally, at the end of the first round there was a 13 question demographic section describing participants and their program.

The survey questions were initially reviewed by a fellow graduate student and the researcher's committee. After incorporating their suggestions, the researcher resubmitted the survey to two colleagues; an English Professor and a Natural Resource Manager. Finally, the survey was resent to committee members for approval before sending it to a final validation panel. The validation panel was made up of Dr. Bora Simmons from the National Project for Excellence in Environmental Education; Alycia Crall, a PhD candidate at the University of Wisconsin – Madison in Environmental Sciences; and Brian Barch, a PhD candidate at the University of Michigan in Environmental Education. They looked for ambiguity and inconsistencies in the survey questions, grammatical errors, accuracy, and additional standards to be included in the survey, and provided overall feedback on the survey's face validity. Face validity simply provides feedback about a survey, and whether it appears as if it will measure the proposed objectives (Litwin, 1995). Finally, the panel provided feedback on the survey's face validity. The first round Delphi Survey can be found in Appendix G.

Objective 2: Identify and survey current citizen science practitioners throughout the nation using the Delphi Technique.

Task 2.1 Select and invite Delphi Technique survey participants.

Through the review of relevant research, internet searches, conferences, and committee and CS practitioner recommendations, a sample of convenience of practitioners was selected and invited to participate in the Delphi Technique survey process. A letter of invitation discussing the need for a curriculum framework and the Delphi process was sent to an initial 12 program or educational directors in the Spring of

2008 (Appendix H), along with a response form and a self-addressed stamped envelop. The programs were located throughout the country in urban, suburban, and rural settings, and used a wide variety of biological phenomena such as birds, exotic species, and rivers. Participants were also asked to include the emails of two other professionals in the field of CS who may be interested in participating in the Delphi Survey. In the spring of 2008, the researcher contacted five additional candidates electronically based on recommendations from the initial mailing, inviting a total of 17 CS professionals to take part in the Delphi Survey. Twelve expert participants accepted the invitation to participate. All Delphi participants received a signed thank-you for their interest in May of 2008 (Appendix I)

Completion of the necessary criteria set forth by the Institutional Review Board (IRB) on the campus of the University of Wisconsin at Stevens Point was done and permission was granted by the IRB to proceed with the survey. The IRB approval was essential due to the participation of people in the study. It ensured the participants would not come into any harm, their participation was voluntary, and they retained the right to end their participation in the study.

Before beginning the first round of the Delphi Survey, the CS experts completed an online self and program demographic survey. Twelve CS experts participated in the research. Appendix J shows a list of each participant's representative organization. A copy of the original 13 questions is located in Appendix K. For individual responses to the demographic questions, consult Appendix L.

The first six questions focused on the individual participant and their connection with CS. Table 3 gives a synthesized version of the participant responses. For complete individual responses, consult Appendix L. The first question asked for the participant's name, and therefore is not included within the following table.

Table 3: Individual Participant Questions & Their Connection with CS (n=12)

Question #:	**Question**:	**Responses**			
1	Gender	Female=**9**	Male=**3**		
2	Example Position Titles:	Citizen Science Director			
		Executive Director			
		Education Director			
		Program Manager/ Coordinator			
		Project Leader			
		Associate Professor			
3	Time Devoted to CS?	**3** - >80%	**2** - 71-80%	**1** - 61-70%	**3** - 51-60%
		1 - 41-50%	**1** - 11-20%	**1** - <10%	
4	Years Working at current CS program?	**7** - >5 years	**4** - 2-4 years	**1** - <1 year	
5	Total Years Working in CS?	**8** - >5 years	**3** - 2-4 years	**1** - <1 year	

The remaining seven questions looked more specifically at the individual CS programs and are synthesized in Table 4. For some questions the participants were able to give more than one response, leading to a total response value greater than 12. Question 11 and 12 only had 10 responses due to the participants not having the answers for them. Also, question 11 does not include all possible responses and numbers, but only those applicable to the study. Question 12 refers to an average of all responses. For complete individual responses, consult Appendix L.

Table 4: CS Program Questions (n=12)

Question #:	**Question**:	**Responses**			
6	Years of CS Program Existence	**4** - >15 years	**4** - 10-14 years	**3** -4-9 years	**1** - < 3 years
7	Program Affiliation(s)?	**8** - Non-Profit/Non-Governmental Organization	**4** - College/ University	**1** - State Gov't.	**1** - Federal Gov't.
		1 - Nature Center			
8	Topical Area(s) of Focus?	**6** - Water (lakes, rivers, streams, marine, &/or groundwater)	**6** - Birds	**6** - Invasive Species	**5** - Plants
		5 - Other (insects/ inverts, watershed, all taxa)	**4** - Reptiles & Amphibians	**3** - Mammals	
9	Program's Geographical Focus?	**6** - Individual States (PA, WI, MN, VA, WA)	**3** - Local Community/ City	**2** - Regional (Great Lakes & Appalachian Trail)	**2** - National
		1 - International (North America)			
10	CS Program Participants?	**11** - Individuals	**10** - K-12 Students	**9** - Families	**7** - College Students
		7 - Teachers	**2** - Other (Natural Resource Manager, Agencies)		

11	Approximate Number of Participants in 2007? (n=10 Participants)	~ **24,000** K-12 Students	~ **7,000** Individuals		
12	Demographic Distribution? (n=10 Participants)	**39 %** Urban	**35 %** Rural	**34 %** Suburban	

Two final questions sought further program description, but were included at the end of the first Delphi round. The first looked at participants' familiarity with the NAAEE *Excellence in Environmental Education – Guidelines for Learning (Pre K – 12)* and offered four Likert scale options: Very Familiar, Familiar, Somewhat, and Not At All. Five participants each choose "Somewhat Familiar" and "Not At All", while one each selected "Very Familiar" and "Familiar". A final question asked to state any books, guides, or additional publications used in their program development. Only four responded, in which two listed *The Director's Guide to Best Practices Programming – Citizen Science* by the Association of Nature Center Administrators. One wrote *Investigating and Evaluating Environmental Issues and Actions: Skill Development Process* by Hungerford, et.al. and NatureMapping publications. A final response further clarified that their organization's mission is not specifically CS, but also addresses community issues.

Task 2.2 Identify a web server and create a Delphi Technique survey.

After reviewing literature about the Delphi Survey, it was determined that an online survey would be easiest to administer and less time consuming for the participants and researcher than traditional paper surveys (Kane, 2003). The web site www.surveymonkey.com was identified as the easiest web-based site for the creation of the Delphi Survey because of its cost and convenience. The site allowed for easy survey creation, modification, administration to survey participants, and data analysis. A four month subscription was acquired to give the researcher and survey participants ample time to develop, send out, respond, analyze, and modify the survey for subsequent rounds.

The input given in Task 1.4 of Objective 1 allowed for a simplified survey creation process. The researcher created the survey over the course of three weeks, modifying the set-up, color schemes, and wording. The completed online survey was sent to the researcher's committee for final comments along with an invitation to participate in a practice round.

Task 2.3 Send the survey out via email/web browser and identify standards of citizen science.

Practitioners of CS from across the United States were invited to participate in the three rounds of the Delphi survey. The electronic surveys included detailed instructions, an IRB letter of consent, attached documents of environmental literacy standards and sources, and a hotlink to the survey. Appendix M shows examples of the instructions, IRB consent form, environmental literacy standards and sources, while Appendix G has an example of statements from the first round of the survey. Before participants began the survey, they reviewed the Institutional Review Board's letter of consent, and gave their assent to participate electronically. The surveys were distributed via email/Internet and completed over the course of three subsequent rounds, using the responses from previous rounds to ascertain a consensus in latter rounds. During the course of the surveys, essential standards were identified and agreed upon by the participating practitioners.

A week and a half before the first round of the survey was begun; the 12 participants were contacted as a reminder of their participation in the upcoming survey. The first round survey consisted of 13 demographic questions about the participant and his/her CS program and 57 standards statements. It was sent out on September 23, 2008, and asked the participants to finish the survey by September 30th. The researcher sent each participant detailed instructions, an "Appendix of Standards Sources", and a hotlink to the online survey. A reminder was sent to participants who had not yet completed the survey on September 29th. The researcher spent a week reviewing the first round responses, modifying grammar and wording of the survey statements, and adding additional statements for comment in the second round. There was no modification of the four individual stand concepts for the second round.

The second round was emailed out on October 21st and consisted of the original 57 statements plus 3 additional, and asked for responses by the 28th of October. The second round included the same instructional and informational documents as the first with some minor instruction changes as well as a *Word* document with all participant comments. Appendix N includes instructions for the second round of the Delphi. An *Excel* spreadsheet with the individual's selections and the group means for each standard was also included. However, due to time constraints and survey completion delays, one participant was not able to complete the second round but wished to continue in the third round. After discussion with the researcher's committee, it was decided to proceed with the third round and not wait for the final participant to respond due to the proximity of the Thanksgiving holiday and wanting to have all the surveys completed by then.

A final round was done in a similar manner, sent on the 17th of November and completed by the 4th of December, and consisted of 60 statements from the previous round and 1 additional. The third round included further grammar and wording clarification of individual statements, additional statements, and re-wording two of the four individual strands to better reflect the group's comments. The third round included the same documents as the first two rounds, but the *Word* and *Excel* documents included comments and data from the second round.

Objective 3: Develop a valid curriculum framework and standards for a citizen science program.

Task 3.1 Create a draft curriculum framework.

After completion of the Delphi Survey, the essential standards and program characteristics of a CS were used to create a draft curriculum framework. Standards and program characteristics were selected based upon their final mean of the three rounds and their standard deviation fluctuations. Standards and characteristics with means of 4 or greater were included, while those of 3.99 and less were not (Sulzer-Azaroff, Fleming, Tupa, Bass & Hamad, 2008). Of those selected with means higher than 4, their standard deviation was examined. Those final standards and program characteristics whose standard deviation increased after three rounds were put before the researcher's committee for further scrutiny, as well as previous literature was consulted. Finally the wording of the selected standards and characteristics, as well as each strand, were modified based on input from the final round of the Delphi, if necessary.

The national standards for each subject met by each environmental literacy standard were identified and placed into specific subject appendices. These national standards appendices were developed for cross-referencing ease with the final frameworks. The researcher also included appendices for the Wisconsin state standards in Science, Mathematics, Social Studies, and English Language Arts. These four subjects were chosen due to time constraints. Standards and program characteristics with means of greater than 4.40 were identified as “Enduring Knowledge” and given higher priority for students, and encourage curriculum development with these standards and characteristics in mind. Those with a mean from 4.00 to 4.39 were identified as “Important to Know” and given a secondary priority to program and curriculum development (Clark, 2006; Sulzer-Azaroff, et.al, 2008).

After the standards were identified, two draft frameworks were completed; an *Extended Version* and a *Condensed Version*. Each framework included the identified standards, along with example performance guidelines from the NAAEE’s *Guidelines*, ties to both Wisconsin and national educational standards, and correlations with identified program or curriculum goals and characteristics. Also included in both frameworks were an introduction, overview of how to use the framework, and the identified characteristics. The *Extended Version* included an expanded description of the framework, more background information, and appendices of both the Wisconsin and national standards met by CS, while the condensed version included a CS curriculum evaluation Likert scale for individual guidelines.

Task 3.2 Receive input on CS framework from Wisconsin practitioners and Delphi participants, and make final revisions.

In February of 2009, the researcher sent his committee members electronic copies of the frameworks and asked for comments. The researcher's committee looked for grammatical errors, ease of use, logicality of flow, overall appeal, length, and to add any additional comments, questions, suggestions or concerns.

A final review of the curriculum framework was completed by the Delphi participants. Also, a professor at UWSP who is an expert in interpretive media and an additional adjunct professor from UWSP's College of Professional Studies provided feedback. This review gave input on the *Condensed Version* only of the framework. The feedback suggested ways to more easily clarify and convey the framework's ideas and use to future users. A final framework review was conducted by the researcher's committee in order to identify any additional updates, clarifications, or corrections in March of 2009.

Task 3.3 Disseminate findings.

The identified standards and resulting curriculum framework were presented to fellow professionals in the field of Environmental Education. In October of 2008, the researcher shared the preliminary findings in a poster session at the 2008 North American Association of Environmental Educators (NAAEE) Conference in Wichita, Kansas. Approximately five conference attendees commented on the poster. One comment was "I would be very interested in the findings of your research", while another stated "I am conducting an evaluation of our program and was interested in hearing more about your research" (Personal communications NAAEE Conference, 2008). A concurrent session on the CS framework was presented at the Wisconsin Association for Environmental Educators (WAEE) Conference in Milwaukee, Wisconsin in which ten formal and non-formal educators and students attended. WAEE attendees were asked to provide feedback about framework format and dissemination possibilities for other practitioners. The attendees commented that the framework should have an easy flow and logical flow, and discussed internet and teacher publications as possible areas for framework dissemination. Their suggestions were incorporated into the final product.

Upon recommendation by the researcher's committee, publications were identified as potential sources for dissemination of the final framework. Journals such as the *Journal of Environmental Education, Environmental Education Research, and Applied Environmental Education & Communication,* as well as publications that specifically target science teachers such as the National Science Teachers Association and the Wisconsin Society of Science Teachers were identified as possible sources of dissemination.

The resulting framework was housed on the web site www.EEinWisconisin.org in May of 2009 and can be downloaded as a PDF from the site. All participating CS organizations were encouraged to create a hotlink with the resulting curriculum framework from their website as well.

Chapter Four – Results

Introduction

This chapter reviews the results for the development of a 5th through 8th grade curriculum framework related to citizen science programs for the guidelines of environmental literacy. The chapter results from the study are presented as follows:

Objective 1: Develop and validate a survey to use in order to obtain information from citizen science practitioners that will be used to develop a curriculum framework.

Objective 2: Identify and survey current citizen science practitioners throughout the nation using the Delphi Technique.

Objective 3: Develop a valid CS curriculum framework and standards for a citizen science program.

Objective 1: Develop and validate a survey to use in order to obtain information from citizen science practitioners that will be used to develop a curriculum framework.

Task 1.1 Use a pre-assessment questionnaire to determine the necessity for a CS curriculum framework.

The initial questionnaire was sent out electronically via email to seven CS teachers. Five of the teachers were located at high schools in Wisconsin, one taught at a community environmental center and within a local school district, and a final teacher was located in northern Illinois. This questionnaire provided the researcher with some background information about CS programs in schools and what current teachers would like to see incorporated into a curriculum framework. Appendix O presents the teacher responses in a table format.

Question 1: Please briefly describe your program and attach a syllabus if available.

Of the seven teachers, five described their programs as having some type of outdoors component, incorporating various activities into their programs. Four of the teachers had lake/stream/water monitoring, one looked specifically at arsenic in water sources, two used overall habitat assessments, two looked at vertebrates, and one each included macro-invertebrates, invasive species, and carnivore tracking into their CS programs. Also, one teacher had his students complete a school-wide energy audit. Finally, one teacher was yet to develop a CS program, but wanted to incorporate birds, bird populations, and banding into a program. One teacher wrote that his students' data were used to make recommendations for the watershed in which they completed their CS program to the Illinois Department of Natural Resources.

Question 2: In the development of your Citizen Science class program, what, if any, materials and/or programs (e.g. Wisconsin Nature Mapping, Journey North) did you consult that were useful in establishing a basic framework or outline?

Two of the teachers responded that state/local government agencies assisted with their program development. Two sought assistance from universities, one from local non-profit organizations, and two did not consult any outside sources.

Question 3: How helpful would you find a conceptual framework that identifies essential concepts of an effective Citizen Science Program? Please elaborate.

Three teachers wrote that it would be “Very/Extremely Helpful” by providing guidance for starting a program, to move a program forward, and as a planning guide with students to put ideas into “play”. “Somewhat helpful” was recorded by two teachers where one of the teachers was previously familiar with the standards of environmental education. A second teacher responded that he “likes to have the students develop the framework for learning, but that it is important to see what others are doing”. Finally, two teachers responded that it would be “Useful/Welcome” if it helps to improve programs and it has “real” ideas such as links to project resources to use the student data.

Question 4: How helpful would a conceptual framework have been when you were developing your classroom materials? Please explain.

In response to this question, two teachers referenced their answer for the previous question, while two responded “Very Helpful”. These two teachers wrote that the beginning process was very frustrating for both teachers and students, and one wrote that she “felt like she was floundering to create a cohesive program”. Another teacher wrote that a framework has more value to those beginning a program, and in her case, less at her current point. Finally, one wrote that its value is dependent upon “good ideas and suggestions”, while one teacher was still developing his program.

Question 5: In the future, how likely would you be to consult such a document? Why or why not?

Of the seven teachers questioned, all wrote that they would consult the document in some capacity, but the level of consultation varied. Two wrote that it would only be consulted infrequently to fine tune their program and provide some better guidance. Two were likely to consult the document to assist in planning, but need to know of its existence. The remaining three would consult it depending on the ability to offer a "real" class that incorporates CS, another to aid in program outlines, and finally one would consult it but not as a teacher due to retirement, but while working with a "Friends" group.

Question 6: What other comments or suggestions do you have?

Four teachers did not respond or wrote "none". One offered his assistance to provide feedback on a final framework. Another wanted to see the framework tied to state and national standards to assist teachers who "must teach a standards-based curriculum". Finally, one wrote that the framework needs to be applicable and include project lists and how to link together one CS project with additional CS projects.

Task 1.2 Identify essential standards and characteristics of CS programs for environmental literacy through a literature review and assess Delphi Survey Technique for usefulness in surveying CS practitioners.

Task 1.2 was answered thoroughly in Chapter III which should be consulted for further description.

Task 1.3 Complete a "gap" analysis of CS curricula for environmental literacy.

The "gap" analysis evaluated seven CS program curricula through the use of the guidelines found in NAAEE's *Self-Assessment Tool*. A list of the seven CS programs and their web pages can be found in Appendix D. The "gap" analysis looked at the percent of environmental literacy guidelines that were "Fully" or "Partially" addressed. One hundred percent (49/49) of the guidelines for the seven programs were either "fully" or “partially” met from Strand 1 in their goals/objectives or curriculum and recorded the highest percentage of the four strands. In Strand 2, 71 percent of the guidelines were met (84/119) in their program goals/objectives or sample curriculum and was tied for the lowest percentage met. In the third strand, 82 percent of the guidelines were met (46/56) and had the second highest percentage of the four strands. Finally, in Strand 4, 71 percent of the guidelines were met (20/28).

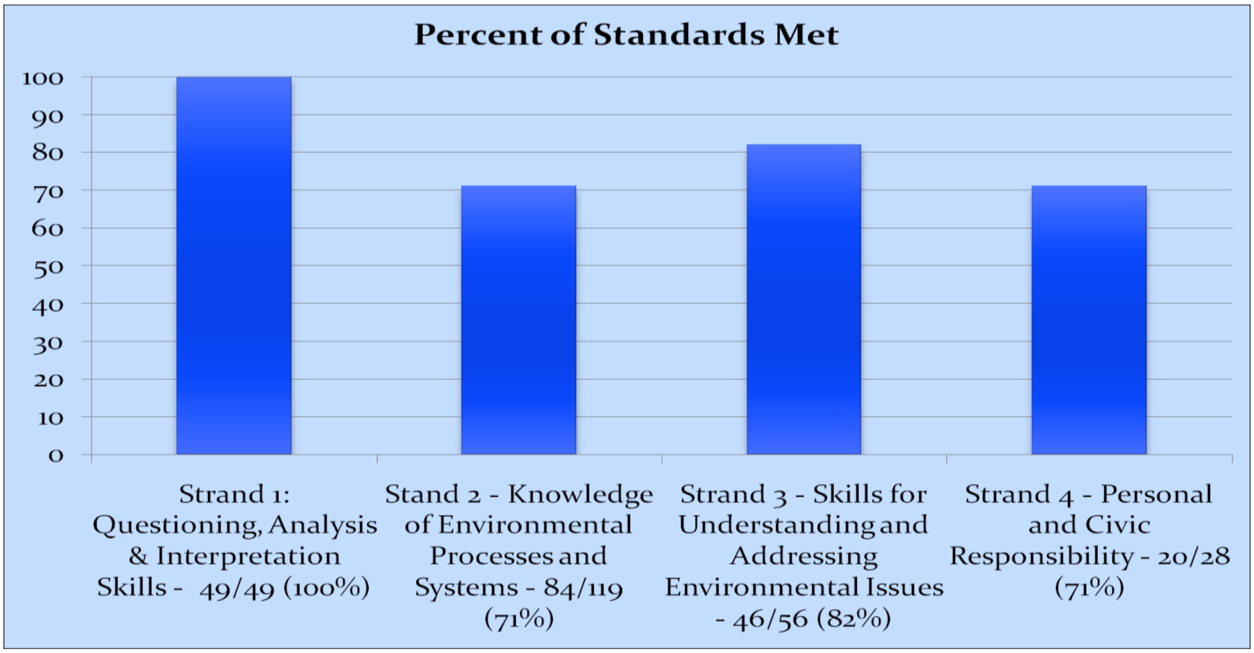


Figure 3: Curriculum “Gap” Analysis Results (n=7)

Task 1.4 Create and validate the survey questions with committee members and validity panel input.

Further information about the development, selection, and validation of the survey questions is located in Chapter III.

The researcher’s committee and a three person validity panel provided feedback on the survey including wording changes to more specifically address CS and students, formatting suggestions to “shorten” the survey by modifying the survey layout, and focusing the researcher's questioning strategy and eliminating the survey question "How well does your CS program address this guideline?". Based on the responses of the validity panel, the survey was deemed to have face validity after certain wording was modified or made clearer and the format was shortened, as well as additional grammatical changes and idea clarification were completed.

Objective 2: Identify and survey current citizen science practitioners throughout the nation using the Delphi Technique.

Task 2.1 Select and invite Delphi survey participants.

Task 2.1 was answered thoroughly in Chapter III which should be consulted for further description.

Task 2.2 Identify a web server and create a Delphi survey

Task 2.2 was answered thoroughly in Chapter III which should be consulted for further description.

Task 2.3 Send the survey out via email/web browser to identify standards of CS.

A summary of the three Delphi rounds including means and standard deviations is located in a table in Appendix P.

Delphi Survey Results for the First Round

The first round of the Delphi survey was sent out and all 12 participants responded. A Likert scale was used for participants to rate their level of agreement with the importance of the 56 standards and characteristics, with 5 representing "Strongly Agree" while 1 was "Strongly Disagree". A final section was included at the end of each round that provided space for participants to write additional comments or characteristics not addressed in the survey. The mean and standard deviation were identified for each item, and a space was provided for written comments. Some written comments were used for subsequent round wording changes of individual standards and characteristics, while other comments expressed concern about wording describing the strands' ideas and concepts. The researcher did not modify the strand wording for the second round, but rather allowed all Delphi participants to review the comments in the second round and express their concerns as well. Appendix Q includes Round 1 with individual comments and Appendix R has Round 2 with wording modifications.

Participant comments generally fell into one of four broad categories based on wording or phrases. The first category commented on how environmental literacy is not necessarily a part of CS, but one can "enhance" the other. A second category was the lack of a clear interpretation of what CS meant to an individual or program, and how CS "design dependency" leads to many variations and definitions. A third category looked at the connection that teachers, students and schools had with CS, and the importance of teachers placing CS in appropriate contexts to their students. A final category looked at grammar, wording clarification or additional statements to include for subsequent rounds.

After the first round, 12 standards and characteristics had means of 4.40 or higher: 1, 3, 22, 30, 34, 42-44, 48, 53, 56, and 57. Thirty had a mean between 4.39-4.00: 2, 4, 5, 7, 13-16, 18-21, 23, 28, 29, 31-33, 35, 38-41, 46, 47, 49-52, and 54. Of those standards and characteristics selected with means greater than 4.00, the lowest standard deviation was .50, while the highest was 1.16

Delphi Survey Results for the Second Round

For the second round, 11 participants responded, while one was unable due to time constraints on both the researcher's and the participant's parts. The second round consisted of the original 56 standards and CS characteristics, plus an additional 3 CS characteristics developed from first round suggestions, and a comment or additional characteristic section. Wording changes in the second round Delphi were identified by capitalized words in parentheses, e.g. (ENVIRONMENTAL JUSTICE CAN BE AN EXAMPLE OF THIS). Appendix R includes a copy of the second round Delphi with wording changes and additional characteristics.

The second round averaged the standard and characteristic means together from both rounds and the standard deviation from the second round. Written comments and additional CS program characteristics were also given by participants and can be seen in Appendix S. The participant comments and additional characteristics were used in modifying the wording of two strand descriptions for the third Delphi round, the addition of another CS program characteristic, and other individual standard wording changes. The third round updated Delphi survey can be found in Appendix T.

Participant comments once again fell into the same four broad categories as the first round and included further explanation or participant inquiry into the topic's role within CS. The first category explored the relationship between CS and environmental literacy. A second category looked at further defining CS and how it is not necessarily a tool for resolving environmental issues, but can assist in their resolution. The third category re-emphasized the important role that teachers have in students' CS involvement. A final category included general comments about first round results or survey statements, wording choice or clarification, and an additional statement.

After the second round, the following 14 standards and characteristics had a combined mean of 4.40 or higher: 1, 3, 7, 13, 22, 30, 34, 42-44, 48, 53, 56, and 57. The following 31 had a combined mean between 4.39-4.00: 2, 4, 5, 9, 14-16, 19-23, 27-29, 31, 32, 34, 35, 38-41, 46, 47, 49-51, 54, 59 and 60. Of those selected, the standard deviations ranged from a low of .47 to a high of .98.

Delphi Survey Results for the Third Round

All 12 Delphi participants completed the third round. Appendix T includes a copy of the third round Delphi with wording changes and additional characteristics. The third round included 4 new CS characteristics and the original 56. Wording changes were identified by capitalized words in parentheses, e.g. (ENVIRONMENTAL JUSTICE CAN BE AN EXAMPLE OF THIS). Strands 1 and 2 themes' were reworded to address participant concerns and more accurately focus on CS. Participants were asked to comment on the reworded strand themes and add any other comments. Written comments were taken into consideration for the final framework wording and can be found in Appendix U.

A grand mean was calculated over three rounds to determine which standards and characteristics to include in the final framework version. Those with a combined mean of 4.00 and above were included in the framework. Final round standard deviations were also looked at for those with a mean of 4.00 and higher to see that their variability remained the same or decreased.

Participant comments for the final round were fewer than the previous two. They were separated into 3 broad categories, in which two were repeated from previous rounds and one was new. The first one again sought further definition of CS and how CS can lead to stewardship, and how both contribute to students' environmental literacy. A second category was general comments or wording clarity, particularly approval of the reworded strand theme statements that were changed to more accurately reflect CS, and inquiry about why Strands 3 and 4 were not modified. A final category referred to the link between CS and the social sciences, and the generation of "Citizen Social Science" in which the social sciences can be an umbrella for CS.

In the third round, the following 15 standards and characteristics had a combined mean of 4.40 of higher: 1, 3, 13, 22, 29, 30, 34, 42-44, 48, 53, 56, 57, and 62. The following 29 had a combined mean between 4.39-4.00: 2, 4, 5, 7, 9, 14-16, 20, 21, 23, 24, 27, 28, 31-33, 35, 38-41, 46, 47, 49, 50, 54, 59, and 60. Of those selected, the lowest standard deviation was .51, while the highest was .97. The standard deviations of the 44 selected standards and characteristics from their first to third round showed that 24 had a lower standard deviation between .01 to .54, 15 rose between .02 to .16, 4 had no change, and one only went through one Delphi round.

<u>Objective 3: Develop a valid curriculum framework and standards for a citizen science program.</u>

Task 3.1 Create a draft curriculum CS framework.

Based on the Delphi participant responses, 28 standards of environmental literacy were identified and 16 CS program characteristics for a total of 44 of the 60 from the final Delphi round. Appendix V is a copy of all standards and characteristics identified through the Delphi survey included in the final framework. Tables 5-9 show the selected standards and characteristics from each strand, and their corresponding number or location within the *Condensed Version* of the completed framework (Appendix W). Also included in the table is the final mean and whether it is classified as "Enduring" or "Important Understanding." For further information on this classification, consult Task 3.1 in Chapter III.

The twenty-eight standards were from each of the four individual strands. Strand 1: "Questioning, Analysis & Interpretation Skills" had six standards of which two were identified as "Enduring" and four were "Important". The following are examples of an enduring and important standard with the highest grand mean.

- 1 - Enduring (Framework Guideline # 1: 4.54): Students are able to develop, focus and explain questions that help them learn about the environment and do environmental investigations.
- 4 - Important (Framework Guideline # 4: 4.32): Students are able to assess the strengths and weaknesses of the information they are using.

Table 5 shows the standards selected from the Delphi Survey from Strand 1, the standards corresponding number in the final *Condensed Framework*, the grand mean, and its classification.

Table 5: Strand 1 Final Framework Standards

Strand	Delphi Standard/ Characteristic	Framework Number/ Location	Delphi Survey Mean	Enduring or Important
1	1	1	4.54	Enduring
1	2	3	4.30	Important

1	3	2	4.51	Enduring
1	4	4	4.32	Important
1	5	5	4.17	Important
1	7	6	4.35	Important

In Strand 2: “Knowledge of Environmental Processes & Systems”, 11 standards were identified where two were “Enduring” and nine were “Important”. The following are examples of an enduring and important standard with the highest grand mean.

- 22 – Enduring (Framework Guideline # 8: 4.54): Students are able to explain that human-caused changes have consequences for the immediate environment as well as for other places and future times.
- 23 – Important (Framework Guideline # 15: 4.20): Students explore differences in perceptions and importance of places close to home and around the world.

Table 6 shows the standards selected from the Delphi Survey from Strand 2, the standards corresponding number in the final *Condensed Framework*, the grand mean, and its classification.

Table 6: Strand 2 Final Framework Standards

Strand	Delphi Standard/ Characteristic	Framework Number/ Location	Delphi Survey Mean	Enduring or Important
2.1	9	9	4.01	Important
2.2	13	7	4.52	Enduring
2.2	14	10	4.06	Important
2.2	15	11	4.17	Important
2.2	16	12	4.09	Important
2.3	20	13	4.09	Important
2.3	21	14	4.06	Important
2.4	22	8	4.54	Enduring
2.4	23	15	4.20	Important
2.4	24	16	4.03	Important
2.4	27	17	4.03	Important

Strand 3: “Skills for Understanding & Addressing Environmental Issues” had a total of 8 standards in which three were “Enduring” and five “Important”. The following are examples of an enduring and important standard with the highest grand mean.

- 30 – Enduring (Framework Guideline #19: 4.49): Students identify and develop action strategies for addressing particular issue such as environmental stewardship.
- 35 – Important (Framework Guideline # 25: 4.34): Students evaluate the effects of their own actions and actions taken by other individuals and groups.

Table 7 shows the standards selected from the Delphi Survey from Strand 3, the standards corresponding number in the final *Condensed Framework*, the grand mean, and its classification.

Table 7: Strand 3 Final Framework Standards

Strand	Delphi Standard/ Characteristic	Framework Number/ Location	Delphi Survey Mean	Enduring or Important
3.1	28	21	4.11	Important
3.1	29	18	4.40	Enduring
3.1	30	19	4.49	Enduring
3.1	31	22	4.26	Important
3.2	32	23	4.17	Important
3.2	33	24	4.17	Important
3.2	34	20	4.42	Enduring
3.2	35	25	4.34	Important

Strand 4: “Personal & Civic Responsibility” had only three standards, all identified as “Important”. The following is an example of an important standard with the highest grand mean.

- 40 – Important (Framework Guideline # 28:4.32): Students understand that their actions can have broad consequences and that they are responsible for those consequences.

Table 8 shows the standards selected from the Delphi Survey from Strand 4, the standards corresponding number in the final *Condensed Framework*, the grand mean, and its classification.

Table 8: Strand 4 Final Framework Standards

Strand	Delphi Standard/ Characteristic	Framework Number/ Location	Delphi Survey Mean	Enduring or Important
4	38	26	4.00	Important
4	39	27	4.12	Important
4	40	28	4.32	Important

For the CS Program Strand, a total of 16 characteristics were identified, eight each as "Enduring", and "Important". The following are examples of an enduring and important characteristic with the highest grand mean. The following enduring characteristic also recorded the highest grand mean from the Delphi survey.

- 53 – Enduring (CS Program Characteristic # 6: 4.70): In citizen science programs, students are involved in the data collection process.
- 47 – Important (CS Program Characteristics #2: 4.29): In citizen science programs, students learn about and apply scientific methodologies through first-hand experience.

Table 9 shows the characteristics selected from the Delphi Survey from the CS Program Strand, the characteristics corresponding number and location in the final *Condensed Framework*, the grand mean, and its classification.

Table 9: CS Strand Final Framework Characteristics

Strand	Delphi Standard/ Characteristic	Framework Number/ Location	Delphi Survey Mean	Enduring or Important
CS	41	Imp. 1	4.23	Important
CS	42	Page 3	4.48	Enduring
CS	43	End. 5	4.46	Enduring
CS	44	End. 1	4.57	Enduring
CS	46	Imp. 5	4.20	Important
CS	47	Imp. 2	4.29	Important
CS	48	End. 4	4.48	Enduring
CS	49	Imp. 4	4.17	Important
CS	50	Imp. 3	4.08	Important
CS	53	End. 6	4.70	Enduring
CS	54	Imp. 8	4.14	Important
CS	56	End. 2	4.55	Enduring
CS	57	End. 3	4.66	Enduring
CS	59	Imp. 6	4.09	Important
CS	60	Imp. 7	4.13	Important
CS	62	End. 7	4.42	Enduring

The standards of the first four strands selected by the Delphi survey showed differences with the previous "gap" analysis, but also shared some similarities. The Delphi survey results suggested 100% of Strand 3's standards were enduring or important, while the "gap" analysis found only 82% of those same standards to be met by CS curricula. A second disparity also appeared in the second strand in which the Delphi participants identified only 55% of the standards for inclusion in the final framework, whereas the "gap" analysis indicated that 71% of the standards were being addressed. Within the second strand, the subcategories showed disparities for standard inclusion and exclusion in the final framework depending upon the sub-strand theme. Sub-strand 2.1 "The Earth as a Physical System" included only one standard of five, 2.2 "The Living Environment" included all four, 2.3 "Humans and their Societies" included two of five, and 2.4 "Environment and Society" included four of six. Finally, Delphi participants identified 85% of the standards in the first strand as enduring or important, while the "gap" analysis found 100% to be addressed by CS curricula. Only in Strand 4 was there relative consistency between the percentage of standards that Delphi participants identified and standards identified as being addressed in the "gap" analysis - 75% and 71% respectively.

The selected standards were used to develop two versions – *Condensed* and *Extended Version* - of a curriculum framework. The *Condensed* and *Extended Versions* can be found in Appendix W and Appendix X respectively. A preliminary draft was developed of both the *Extended* and *Condensed Version* of the curriculum framework and both were sent to the researcher's committee, while only the *Condensed Version* was sent to the Delphi participants, CS practitioners, and other UWSP professors for comment.

Task 3.2 Receive input on CS framework from Wisconsin practitioners and Delphi participants, and make final revisions.

After several rounds of framework review, the comments and feedback on the final framework were incorporated into an updated version. The researcher's committee provided several rounds of feedback, while two additional UWSP professors and four Delphi participants also reviewed the framework.

The researcher's committee provided feedback multiple times. The first resulted in the creation of a *Condensed Version* based on the perceived need for the *Extended Version* to be more user-friendly. Subsequent committee review provided further feedback on the *Condensed Version* in which grammatical errors were corrected, framework flow and order were addressed, and additional suggestions were made such as adding a table of contents and further explanation and idea clarification.

The Delphi participants identified grammatical and formatting mistakes or concerns, but the framework was well received, with comments such as “I think this is going to be a helpful document for practitioners and teachers alike”, “Nice job with this”, and “it [the framework] helps those who are looking for a definition and the scope of citizen science.” However, one Delphi participant reiterated the difficulty in defining CS’s role within education and how much of CS depends upon its implementation. The UWSP professors also identified grammar, wording choice, framework and idea clarification, and formatting such as strand and guideline placement to limit breakup and to streamline the use. A sample guideline page was added to clearly show to a reader each part and its use within the framework.

Task 3.3 Disseminate findings.

Conference presentations took place in October of 2008 as a poster presentation at the NAAEE’s annual conference in Wichita, Kansas and a concurrent session at the Wisconsin Association of Environmental Education’s annual conference in Milwaukee. A presentation proposal was submitted for the NAAEE’s national conference in Portland, OR in October 2009. Conference feedback is discussed in Chapter III, Task 3.3. Manuscripts of the research will be sent to appropriate journals for possible publication, as well as publications that specifically target science teachers within Wisconsin and the nation such as the National Science Teacher Association’s *Science Scope* and *Science Teacher* for middle school and high school teachers respectively. Also, CS programs that participated in the Delphi Survey were sent a final framework and encouraged to create a hotlink from their web sites to the framework. The final frameworks are housed on the website www.eeinwisconsin.org administered by the Wisconsin Center for Environmental Education. The site provides resources for environmental educators throughout the state and nation. Task 3.3 in Chapter III provides greater detail about dissemination experiences from the 2008 WAEE and NAAEE conferences.

Chapter Five – Conclusions, Recommendations, and Discussion

Introduction

The goal of this study was to develop a curriculum framework for developing and teaching citizen science (CS) education programs to and for 5^{th} through 8^{th} grade students that focuses on increasing environmental literacy. The original framework was developed using numerous sources that included journals, websites, and books, as well as personal communication with CS teachers, professionals and UWSP professors. By means of a Delphi survey, framework standards were identified and weighted for relative importance to CS curricula, and used to create a final draft of the curriculum framework. This chapter will discuss conclusions and recommendations identified from the research process, and their implications for future use, as well as recommendations and implications from the study for future research with CS curriculum development.

Conclusions

Conclusions Regarding Objective 1

Based on results provided by the preliminary teacher questionnaire, it was concluded that there is a lack of organizational frameworks available for teachers who wish to implement a CS program within their classroom. This need can lead to a feeling of “floundering” and the inability to create a “cohesive program” by teachers wishing to use CS within their classroom. Although the original questionnaire asked about a *conceptual* framework, rather than a *curriculum* framework, it can be inferred that not having an organizational starting point or evaluation tool led to teacher confusion and frustration about successful strategies to use in CS development. Teachers also had numerous interpretations for CS and had many differences in their CS programs. This wide disparity in teacher interpretation of the role of CS can contribute to teacher confusion about what CS is and how to use it effectively.

Current CS curricula focused predominantly on the skills and abilities of environmental literacy necessary for students to develop and understand the scientific method. Less emphasis was given to knowledge of environmental processes and civic and personal responsibility, while skills for understanding and addressing issues fell between. The strong focus on the scientific method by CS curricula supported the goals of CS as a process of scientific engagement. However, current CS curricula are not addressing all of the standards of environmental literacy.

Conclusions Regarding Objective 2

Based on researcher experience and participant input, it was concluded that the Delphi survey was effective in identifying which standards and characteristics to include in the final framework. The Delphi survey facilitated the researcher in meeting his second objective in several ways. First, the survey was easy to develop and use, especially in conjunction with www.surveymonkey.com. The survey also provided a forum for CS participants to discuss what CS is and what it is not. Many of the participants wrote comments and clarifying statements, added additional characteristics of CS, and sought to clarify the link that CS has with environmental literacy. In addition, the Delphi survey allowed the researcher to communicate with various CS experts throughout the country and assess their thoughts and ideas about CS. Finally, time was an issue with the survey. Although conducted online, the survey took longer than anticipated for each round due to participant response delay and the researcher's need to modify each survey round based on previous round input. However, even with time delays, the online survey was still faster and easier than conducting it through the postal service.

Furthermore, all Delphi participants completed the survey. The high completion rate may have been due to a number of factors. Variables such as participant interest in the survey subject, survey ease, their equal ability to contribute to the survey outcomes and data, financial incentive, and a willingness to assist in the study, or a combination of these factors led to a successful Delphi survey. However, limiting the survey strictly to CS professionals prevented additional perspectives on CS.

Conclusions Regarding Objective 3

Based on framework reviewers, the final framework met face validity and strongly linked CS with environmental literacy. Nevertheless, concerns over length and framework applicability for middle school teachers were revealed. Receiving more feedback from teachers may provide further refinement of the final framework.

The Delphi survey resulted in standards identification from the four thematic strands and program characteristics that contribute to environmental literacy. However, the selected standards were not represented equally throughout the strands by the Delphi participants. The fourth strand, "Personal and Civic Responsibility", did not have any enduring standards, and one of the four was not selected for the final framework. The "gap" analysis also showed that a lower percentage of this strand was met by CS curricula. Based on this knowledge, the researcher concluded that CS curricula do not strongly address citizen action experiences with its curricula. Although some Delphi participants felt this fourth strand to be a "gold standard" and necessary for CS curriculum, there needs to be further exploration of how to better address these standards. The curriculum framework can assist in providing a starting point for prioritizing these standards, and assist "those who are looking for a definition and the scope of citizen science".

Conclusions Regarding Citizen Science

The study proposal to develop a curriculum framework for CS to meet the standards of environmental literacy was accomplished through development of two versions of a curriculum framework. Based on this study, the researcher concluded that CS is used in a variety of ways in order to increase students' environmental literacy. The completed framework supports this by giving CS curriculum developers an outline of different program characteristics and standards to focus on. Delphi participants felt that the developed framework will be "a helpful document" to teachers and CS curriculum developers. Also, the frameworks clarified the relationship between environmental literacy and citizen science.

The framework development process and actual frameworks established many goals for CS and future CS curriculum to achieve. In this study, it was determined that CS relies on many scholastic disciplines to achieve environmental literacy in participating students.   CS is also a piece that contributes to the whole body of scientific knowledge. Student participation in CS can meet not only the science education goals and objectives of teachers, but also the data needs of government agencies, universities, and non-governmental organizations. Student data assist in making management decisions and providing greater understanding of the resources. These and other enduring and important characteristics contribute to meeting the identified environmental literacy guidelines.

However, this research identified a "disconnect" between participants' perceptions of the congruency of citizen science goals and environmental literacy goals. Specifically, Delphi participants disagreed on the relative importance of the fourth EL strand's standards, with some referring to these standards as the "gold standard for student participation in citizen science activities", while others suggested that these are "important citizen characteristics…but not necessarily goals of citizen science projects". These conflicting views on CS's role in addressing strand four's standards may be reconciled by individual teachers using CS in their classroom and their professional judgment about how far to take CS into the realm of civic engagement or whether to partner with other disciplines such as social studies.

Recommendations

Regarding Standards Identification & the Delphi Process - The following recommendations are provided for future researchers using a Delphi survey for curriculum development.

1. *Invite and include a wider audience and a larger group for the Delphi survey.* More participants in the standard identification process may lead to more dialogue about CS and development of additional characteristics. Additional perspectives can lead to better defining goals and characteristics of CS. Invite

teachers who use CS in order to provide a perspective of practical applications for the framework standards, as well as CS curriculum developers and professionals. The researcher included only CS professionals in his research.

2. Regarding the Delphi Process:

   a. *Conduct a Delphi survey using an online survey site*. Online surveys offer benefits to both survey participants and the researcher such as ease, time involved, convenience, and cost. The researcher used an online survey site for his research.

   b. *Ensure that initial round instructions are clear and understandable, and that participants understand exactly what the survey is identifying when using a Delphi survey.* In the current study, unclear instructions and definitions in the first round led to some participant confusion about what student age group the survey was looking at and a specific definition for an educational standard. The second round instructions and survey explained this more clearly.

   c. *Conduct three survey rounds.* By conducting the recommended three rounds, the researcher was able to give all the participants time to comment on wording changes, make additional comments, and provide the most data for the final framework. The literature review of the Delphi technique found that some studies only conducted two rounds of Delphi. The researcher conducted the recommended three rounds in his research.

   d. *Provide an incentive to motivate Delphi participants to complete the three round Delphi survey*. The financial incentive depends on the researcher's budget. In his study, the researcher used a financial incentive of $30 to encourage Delphi participation and did not have any participants drop out of the process.

Regarding Framework Development – The following recommendations are provided for CS curriculum developers and teachers who use the completed framework or will participate in future research in CS curriculum development.

1. *Define CS's role in addressing students' "Personal and Civic Responsibility" and develop curriculum to effectively address those standards*. This strand received low grand means for the selected standards by the Delphi participants; however, it is an essential component of environmental literacy. If environmental literacy is an enduring goal of CS, CS curricula need to focus more on this strand's standards.
2. *Include more teacher and CS expert feedback into a final framework.* Due to time constraints on both the researcher's and reviewers' parts, it was not possible to have all possible reviewers provide feedback. Allowing more time for the researcher and reviewers can allow for the most feedback possible, and assist in making the final framework as user-friendly and applicable as possible.
3. *Conduct a pilot curriculum self assessment using the accompanying tool in the* Condensed Version *in order to provide feedback and applicability to assist in curriculum development using Delphi participants, or other CS programs*. Based on a trial-run, the program evaluation tool can be modified

to better assist CS programs address their needs. However, the researcher did not conduct a trial-run due to time constraints.

Regarding CS – The following recommendations are provided for CS curriculum and program developers.

1. *Develop a working definition and specific goals for CS from CS programs through a Delphi survey, or similar method*. Delphi participants did not have a unified and agreed upon CS definition to work with which contributed to wide disparities of Delphi participant responses and comments, and which CS standards should address.
2. *Develop a partnership between teachers and CS organizations or scientists to eliminate initial teacher confusion or lack of success in the beginning stages of using CS within their classroom*. This research found that students conduct valuable research through programs that bring scientists and sponsoring organizations together with students. Teachers who wish to use CS in their classroom need to clearly define whether what they are conducting is CS or not, and then proceed from there.
3. *Develop frameworks for CS curriculum that address high school and elementary students*. This study's limited scope in looking at only middle school students can provide a starting point for frameworks with older and younger students. Comparing and contrasting the similarities and differences of how CS works with older and younger students can create a more unified and continuous approach to using CS with students.

4. *Develop* performance *standards specific to CS in order to assess student understanding of the environmental literacy* content *standard through future research*. The framework identified content standards and includes performance standards developed by the NAAEE to be used by all environmental education programs, and may be generalized to include CS. However, CS-specific performance standards may make teaching the environmental literacy content standards more effective and successful.
5. *Develop curricula that address the framework standards.* As environmental literacy is an enduring goal of CS, the standards included in the curriculum framework should be addressed by current and future CS curricula.

Discussion Regarding CS

In conclusion, this study did not completely resolve some key aspects of CS, but rather provided a starting point for future research on CS curriculum development. Among the Delphi participants there were many points of view about what CS is and how it is best used. While some comments focused on CS's role of better understanding of the scientific process, others believed that CS should lead to student action and issue resolution. These answers were reflected in the individual standards chosen from the thematic strands. The final frameworks offer a foundation through their identification of specific goals for CS, particularly its relationship to environmental literacy and the standards CS can use to address environmental literacy. Continued research is needed to further define CS.

The final frameworks are a foundation for future research and curriculum development with CS. They provide unity for CS ideas and offer clear goals and give concrete strategies to achieve these goals by focusing on those standards necessary for successfully increasing environmental literacy. Also, by addressing specific standards for environmental literacy, state and national standards are also addressed. CS curricula that can be specifically linked to state and national standards may be more easily accepted by teachers and school districts that continuously face tighter budgets and higher educational expectations.

The unique ability of CS to connect students with science offers a unique learning environment for all involved. Nevertheless, it must be realized that it is a dynamic process that will continue to improve based on new insight and research.

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Appendix A: Letter Inviting CS Teachers to Participate in Background Research

Scott J. Reilly
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Stevens Point, WI 54481
715-630-4750
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November 14, 2007

Greetings Teachers!

My name is Scott Reilly and I am currently a graduate student at the UW-Stevens Point. I am working towards my Master of Science Degree in Environmental Education with Dr. Daniel Sivek. My thesis proposal is to create a conceptual framework for a citizen science program. Your professional expertise and advice would be very helpful in completing this project.

I would be interested in speaking personally with some of you in the coming months. Your opinions, reactions and observations in relation to citizen science involving students would be very helpful in identifying the best ways to build an effective program that can be replicated at other schools or organizations. A Delphi survey technique will be used to build consensus among different citizen science instructors for concepts to be included in the framework.

Please complete the attached short form today and deposit it in the box at the registration table before you leave.

Your assistance is greatly appreciated. Thank you for your time and I look forward to working with you.

Sincerely,

Scott Reilly
Environmental Education Graduate Student

Dr. Daniel Sivek
Professor of Environmental Education

CITIZEN SCIENCE INTEREST REPLY

Please complete the following information if you wish to participate in the Citizen Science Surveys over the coming months and leave it at the registration table.

____Yes, I'm interested in helping you develop a conceptual framework for citizen science for students.

____No, I'm sorry I can't help with the survey, but would be willing to discuss the project with you.

Name: ____

School/ Organization: ____

Email: ____

Mailing Address: ____

Phone: ____

CITIZEN SCIENCE INTEREST REPLY

Please complete the following information if you wish to participate in the Citizen Science Surveys over the coming months and leave it at the registration table.

____Yes, I'm interested in helping you develop a conceptual framework for citizen science for students.

____No, I'm sorry I can't help with the survey, but would be willing to discuss the project with you.

Name: ____

School/ Organization: ____

Email: ____

Mailing Address: ____

Phone: ____

Appendix B: Preliminary Teacher Questionnaire

February 1, 2008

Greetings Teachers and Happy New Year!

At the Governor's High School Conference on the Environment in November in Stevens Point you expressed interest in assisting with my study on Citizen Science. I am currently gathering preliminary information about the needs for the development of a conceptual framework pertaining to Citizen Science and would welcome your input on the following questions, as well as a brief description of your program, or example syllabus.

Please reply to the Informed Consent form and answer the questions at the end of this letter as honestly and thoroughly as you can. If you are unsure about the wording, or have another question, please e-mail me. Lastly, your response would be greatly appreciated by February 1, 2008.

Sincerely,

Scott Reilly
Environmental Education Graduate Student
sreilly@uwsp.edu
715-630-4750
TNR 159
UW-Stevens Point
800 Reserve St.
Stevens Point, WI 54481

By typing your initials in the following space, you have read and agree to the Informed Consent form.

Please type your responses after each question, or type/write them on a separate sheet.

Question 1: Please briefly describe your program and attach a syllabus if available.

Question 2: In the development of your Citizen Science class program, what, if any, materials and/or programs (e.g. Wisconsin Nature Mapping, Journey North) did you consult that were useful in establishing a basic framework or outline?

Question 3: How helpful would you find a conceptual framework that identifies essential concepts of an effective Citizen Science Program? Please elaborate.

Question 4: How helpful would a conceptual framework have been when you were developing your classroom materials? Please explain.

Question 5: In the future, how likely would you be to consult such a document? Why or why not?

Question 6: What other comments or suggestions do you have?

Please reply via e-mail or surface mail, and send any syllabi and related materials by February 15th.

Thank you!

Appendix C: NAAEE's *Excellence in Environmental Education-Guidelines for Learning 5th -8th Grade Self Assessment Tool*

Check the appropriate column to indicate the degree to which your program(s) address each item. **Our program provides 5th-8th grade students with learning experiences so that by the time they finish 8th grade they are able to. . .**	Yes - fully addressed	Partly addressed	No - not addressed
Strand 1—Questioning, Analysis and Interpretation Skills			
A. Develop, focus, and explain questions that help them learn about the environment and do environmental investigations.			
B. Design environmental investigations to answer particular questions—often their own questions.			
C. Locate and collect reliable information about the environment or environmental topics using a variety of methods and sources.			
D. Evaluate the strengths and weaknesses of the information they are using. **E.** Classify and order data, and organize and display information in ways that help analysis and interpretation.			
F. Understand many of the uses and limitations of models.			
G. Synthesize their observations and findings into coherent explanations.			
Strand 2—Knowledge of Environmental Processes and Systems 2.1—The Earth as a Physical System			
A. Understand the basics of most of the physical processes that shape the Earth, and relate differences in physical patterns to their causes.			
B. Understand the properties of the substances that make up objects or materials found in the environment.			
C. Begin to grasp formal concepts related to energy by focusing on energy transfer and transformations; and make connections among phenomena such as light, heat, magnetism, electricity, and the motion of objects.			

Check the appropriate column to indicate the degree to which your program(s) address each item. **Our program provides 5th-8th grade students with learning experiences so that by the time they finish 8th grade they are able to. . .**	Yes - fully addressed	Partly addressed	No - not addressed
2.2—The Living Environment			
A. Understand that biotic communities are made up of plants and animals that are uniquely adapted to live in particular environments.			
B. Understand and describe the importance of genetic variation in species and possible implications of species extinction.			
C. Understand major kinds of interactions among organisms or populations of organisms.			
D. Understand how energy and matter flow among the abiotic and biotic components of the environment.			
2.3—Humans and Their Societies			
A. Understand that how individuals perceive the environment is influenced in part by individual traits and group membership or affiliation.			
B. Gain an understanding of cultural perspectives on the environment and how the environment may, in turn, influence culture, as they become familiar with a wider range of cultures and subcultures.			
C. Become more familiar with political and economic systems and how these systems take the environment into consideration.			
D. Identify and explain ways in which the world's environmental, societal, economic, cultural, and political systems are linked.			
E. Understand that human social systems change over time and that conflicts sometimes arise over differing viewpoints about the environment.			

Check the appropriate column to indicate the degree to which your program(s) address each item. **Our program provides 5th-8th grade students with learning experiences so that by the time they finish 8th grade they are able to. . .**	Yes - fully addressed	Partly addressed	No - not addressed
2.4—Environment and Society			
A. Understand that human-caused changes have consequences for the immediate environment as well as for other places and future times.			
B. Describe, analyze, and make inferences about the characteristics of various places, and explore differences in perceptions and importance of places close to home and around the world.			
C. Understand that uneven distribution of resources around the world influences their use and perceived value.			
D. Link the human ability to shape and control the environment with our ability to create knowledge and develop new technologies.			
E. Describe a range of environmental issues at scales that range from local to national to global, and understand that people in other places around the world experience environmental issues similar to the ones they are concerned about locally.			
Strand 3—Skills for Understanding and Addressing Environmental Issues 3.1—Skills for Analyzing and Investigating Environmental Issues			
A. Use primary and secondary sources of information, and apply their growing research and analytical skills to investigate environmental issues, beginning with those in their own community.			
B. Apply their knowledge of ecological and human processes and systems to identify the consequences of specific environmental issues.			
C. Identify and develop action strategies for addressing particular issues.			
D. Consider the assumptions and interpretations that influence the conclusions they and others draw about environmental issues.			

Check the appropriate column to indicate the degree to which your program(s) address each item. **Our program provides 5th-8th grade students with learning experiences so that by the time they finish 8th grade they are able to. . .**	Yes - fully addressed	Partly addressed	No - not addressed
3.2—Decision-Making and Citizenship Skills			
A. Identify, justify, and clarify their views on environmental issues and alternative ways to address them.			
B. Evaluate whether they believe action is needed in particular situations, and decide whether they should be involved.			
C. Begin to see themselves as citizens taking active roles in their communities; plan for and engage in citizen action at levels appropriate to their maturity and preparation.			
D. Evaluate the effects of their own actions and actions taken by other individuals and groups.			
Strand 4—Personal and Civic Responsibility			
A. Understand that societal values can be both a unifying and a divisive force.			
B. Understand the rights and responsibilities of citizenship and their importance in promoting the resolution of environmental issues.			
C. Possess a realistic self-confidence in their effectiveness as citizens.			
D. Understand that their actions can have broad consequences and that they are responsible for those consequences.			

Appendix D: Citizen Science Programs Evaluated in "Gap" Analysis

1. Biodiversity Monitoring Project – Smithsonian National Zoological Park: www.nationalzoo.si.edu/Education/ClassroomPartnerships/BioDivMonPro/

2. GREEN – Global Rivers Environmental Education Network: www.earthforce.org/section/programs/green

3. Journey North: www.learner.org/jnorth/

4. Washington Nature Mapping – Washington Department of Fish & Wildlife, University of Washington: http://depts.washington.edu/natmap/

5. GLOBE – Various Federal Agencies, Colorado State University: www.globe.gov/r

6. Wisconsin Nature Mapping – Wisconsin Department of Natural Resources & Beaver Creek Reserve's Citizen Science Center: http://www.wisnatmap.org/

7. Worm Watch – University of Minnesota, Duluth: http://www.nrri.umn.edu/worms/

Appendix E: Strand 5 - Citizen Science Program Characteristics

1) Citizen science programs are a component of curriculum to help meet state and federal education standards.

2) Environmental literacy is an important goal of citizen science.

3) Citizen science programs bring scientists and sponsoring organizations together with students.

4) Citizen science programs are a multi-disciplinary educational approach that relies on many fields.

5) In citizen science programs, students primarily follow a previously established scientific protocol.

6) In citizen science programs, students are in the out-of-doors learning about natural resources.

7) In citizen science programs, students learn about and apply the scientific method through firsthand experience.

8) In citizen science programs, students conduct valuable research that assists in meeting research objectives.

9) In citizen science programs, student-collected data are valid and reliable.

10) In citizen science programs, students assist in answering scientific questions developed within the scientific community.

11) In citizen science programs, students are involved in developing scientific questions.

12) In citizen science programs, students develop appropriate methodology to address scientific questions.

13) In citizen science programs, students are involved in the data collection process.

14) In citizen science programs, students interpret data.

15) In citizen science programs, students disseminate the data to the public.

16) In citizen science programs, students reflect on what they have done or learned.

17) In citizen science programs, students are empowered through increased personal responsibility in learning.

Appendix F: Sources for Citizen Science Goals, Recommendations, & Characteristics:

Buff, J (April 2008). Education Program Manager at the Conservation and Research Center of the Smithsonian National Zoo– Personal Communication

Bonney, R. (2007). Citizen Science: A new paradigm for increasing science knowledge and scientific literacy. Retrieved Dec. 11, 2007 from www.birds.cornell.edu/citiscitoolkit/toolkit/toolkit/Citizen%20Science%20Model%20for%20Toolkit%20website%20Fall%202007.pdf

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Tinker, R.F. (1997). Student-Scientist Partnerships: Shrewd Maneuvers. In K.C. Cohen (ed.) *Internet Links for Science Education: Student-Scientist Partnerships*. New York: Plenum Press.

Wilson, Z. (November 2007). Naturalist/Woods and Water Coordinator, North Lakeland Discovery Center – Personal Communication

Yockers, D. (April 2008). Professor of Environmental Education at UWSP – Personal Communication.

Appendix G: Delphi Round 1

Delphi Survey Round 1:

<u>Strand 1 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Questioning, Analysis & Interpretation Skills:</u> Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Learners must be familiar with inquiry, master fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.

Comments:

1) **Students are able to develop, focus and explain questions that help them learn about the environment and do environmental investigations.**

2) **Students are able to design environmental investigations to answer particular questions – often their own questions.**

3) **Students are able to locate and collect reliable information about the environment or environmental topics using a variety of methods and sources.**

4) **Students are able to assess the strengths and weaknesses of the information they are using.**

5) **Students are able to classify and order data, and organize and display information in ways that help analysis and interpretation.**

6) **Students are able to recognize and evaluate many of the uses and limitations of physical, mathematical, and computer models.**

7) **Students are able to synthesize their observations into coherent explanations.**

<u>Strand 2 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Knowledge of Environmental Processes & Systems:</u> Understanding the processes and systems that comprise the environment, including human social systems and influences, is an important component of environmental literacy. That understanding is based on knowledge synthesized from across traditional disciplines.

Comments:

2.1 – The Earth as a Physical System

8) **Students have a basic understanding of most of the physical processes that shape the Earth.**

9) **Students are able to relate the differences in physical patterns to their causes, e.g. how seasonal change is affected by the Earth/sun relationship.**

10) **Students are able to explain the properties of the substances that make up objects or materials found in the environment.**
11) **Students begin to grasp formal concepts related to energy by focusing on energy transfer and transformation.**

12) **Students are able to make connections among phenomena such as light, heat, magnetism, electricity, and the motion of objects.**

2.2 – The Living Environment

13) **Students understand that biotic communities are made up of plants and animals that are uniquely adapted to live in particular environments.**
14) **Students recognize and describe the importance of genetic variation in species and possible implications of species extinction.**

15) **Students identify and describe major kinds of interactions among organisms or populations of organisms.**

16) **Students describe how energy and matter flow among the biotic and abiotic components of the environment.**

2.3 - Humans & Their Societies

17) Students explain how individual perceptions of the environment are influenced in part by individual traits and group membership or affiliation.

18) Students identify and explain different cultural perspectives on the environment and how the environment influences culture.

19) Students are familiar with political and economic systems and how these systems take the environment into consideration.

20) Students identify and explain ways in which the world's environmental, societal, economic, cultural, and political systems are linked.

21) Students explain and analyze that human social systems change over time and that conflicts sometimes arise over differing viewpoints about the environment.

2.4 – Environment & Society

22) Students are able to explain that human-caused changes have consequences for the immediate environment as well as for other places and future times.

23) Students explore differences in perceptions and importance of places close to home and around the world.

24) Students are able to discuss and explain why uneven distribution of resources around the world influences the use of these resources and their perceived value.

25) Students link the human ability to shape and control the environment with our ability to create knowledge and develop new technologies.

26) Students describe a range of environmental issues at scales that range from local to national to global.

27) Students relate to and discuss how people in other places around the world experience environmental issues similar to the ones they are concerned about locally.

<u>Strand 3 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Skills for Understanding & Addressing Environmental Issues:</u> Skills and knowledge are refined and applied in the context of environmental issues. These environmental issues are real-life dramas where differing viewpoints about environmental problems and their potential solutions are played out. Environmental literacy includes the abilities to define, learn about, evaluate, and act on environmental issues.
Comments:

3.1 – Skills for Analyzing & Investigating Environmental Issues

28) Students use primary and secondary sources of information, and apply their growing research and analytical skills to investigate environmental issues, beginning with those in their own community.

29) Students apply their knowledge of ecological and human processes and systems to identify the consequences of specific environmental issues.

30) Students identify and develop action strategies for addressing particular issues.

31) Students consider the assumptions and interpretations that influence the conclusions they and others draw about environmental issues.

3.2 – Decision-Making & Citizenship Skills

32) Students identify, justify, and clarify their views on environmental issues and alternative ways to address them.

33) Students evaluate whether they believe action is needed in particular situations, and decide whether they should be involved.

34) Students begin to see themselves as citizens taking active roles in their communities. They plan for and engage in citizen action at levels appropriate to their maturity and preparation.

35) Students evaluate the effects of their own actions and actions taken by other individuals and groups.

Strand 4 & Corresponding Skills, Knowledge & Dispositions:
Personal & Civic Responsibility: Environmentally literate citizens are willing and able to act on their own conclusions about what should be done to ensure environmental quality. As learners develop and apply concept-based learning and skills for inquiry, analysis, and action, they also understand that what they do individually and in groups can make a difference.

Comments:

37) Students identify, discuss and evaluate societal values that can be both a unifying and a divisive force.

38) Students identify and describe the rights and responsibilities of citizenship and their importance in promoting the resolution of environmental issues.

39) Students possess a realistic self-confidence in their effectiveness as citizens.

40) Students understand that their actions can have broad consequences and that they are responsible for those consequences.

Citizen Science Program Strand: Additional learner outcomes or program characteristics common in citizen science programs that may contribute to environmental literacy.

41) Citizen science programs are a component of curriculum to help meet state and federal education standards.

42) Environmental literacy is an important goal of citizen science.

43) Citizen science programs bring scientists and sponsoring organizations together with students.

44) Citizen science programs are a multi-disciplinary educational approach that relies on many fields.

45) In citizen science programs, students primarily follow a previously established scientific protocol.

46) In citizen science programs, students are in the out-of-doors learning about natural resources.

47) In citizen science programs, students learn about and apply the scientific method through first-hand experience.

48) In citizen science programs, students conduct valuable research that assists in meeting research objectives.

49) In citizen science programs, student-collected data are valid and reliable.
50) In citizen science programs, students assist in answering scientific questions developed within the scientific community.

51) In citizen science programs, students are involved in developing scientific questions.

52) In citizen science programs, students develop appropriate methodology to address scientific questions.

53) In citizen science programs, students are involved in the data collection process.

54) In citizen science programs, students interpret data.

55) In citizen science programs, students disseminate the data to the public.

56) In citizen science programs, students reflect on what they have done or learned.

57) In citizen science programs, students are empowered through increased personal responsibility in learning.

58) Please add any additional learner outcomes or program characteristics you believe important for environmental literacy, but are not included in the preceding survey.

Appendix H: Letter Inviting CS Programs to Participate in Delphi Survey

April 10, 2008

Greetings,

My name is Scott Reilly and I am a graduate student in Environmental Education at the University of Wisconsin – Stevens Point. My study is to develop a conceptual framework for 5th – 8th grade citizen science programs, and assess the extent to which the concepts of environmental literacy are addressed. A conceptual framework can assist teachers and citizen science programs in designing, implementing, and evaluating appropriate curriculum materials and activities that focus on increasing a student's environmental literacy.

However, before a conceptual framework can be created, your expertise is needed in identifying which environmental literacy concepts are most important for citizen science. The Delphi Survey uses knowledgeable professionals from the field of citizen science to read and comment on the concepts of environmental literacy, and to determine which ones should be included in the final draft. I will be using an online version of the Delphi Survey.

Through researching various citizen science programs and with suggestions from my graduate committee, your programs and knowledge about citizen science have been identified as potentially very helpful in developing a conceptual framework. All materials, including the example concepts and a brief introduction to the Delphi Survey will be sent to you via email in September of 2008. The Delphi Survey requires no face-to-face meetings and only a couple of hours of your time. The success of the framework depends on the participation of knowledgeable professionals such as yourself to ensure its validity. For your assistance you will receive $30 upon completion of the Delphi Survey.

Please respond by completing and returning the following form. Please also include two additional names of people who you consider knowledgeable professionals in citizen science and who may be interested in participating in the Delphi Survey.

Your participation would be greatly appreciated. Thank you for your time and I look forward to hearing from you.

Sincerely,

Scott Reilly

Environmental Education Graduate Student
UWSP
sreilly@uwsp.edu
715-630-4750

Dr. Daniel Sivek

Professor - Environmental Education
UWSP
dsivek@uwsp.edu
715-346-2028

Delphi Survey Reply

Please complete the following questions if you wish to participate in the Delphi Survey for the September of 2008 and return it to:

Scott Reilly
Environmental Education Graduate Student
TNR 159
UW-Stevens Point
800 Reserve St.
Stevens Point, WI 54481

_______ Yes, I am interested in participating in the Delphi Survey this fall.

_______ No, I am not able to participate in the Delphi Survey, but would be willing to offer assistance with your study, e.g. personal communication, framework review.

_______ No, I am not available to assist in your study.

Name:____

Organization:____

Email:____

Phone:____

Address:____

Please include the names and addresses/emails of 2 additional citizen science professionals that may be interested in participating.

Appendix I: Letter Thanking CS Programs for Delphi Participation

College of Natural Resources

May 15, 2008

Greetings!

I would like to personally thank you for your decision to participate in my Delphi Survey in the Fall of 2008. In September you will receive survey instructions and the first round of the survey electronically. Your input about how citizen science can best address environmental literacy will assist teachers who wish to create or improve their programs to better address environmental literacy.

If you have any questions or comments regarding your participation, please feel free to contact me over the next few months via email.

Sincerely,

Scott Reilly
Environmental Education Graduate Student
University of Wisconsin – Stevens Point
sreilly@uwsp.edu

Appendix J: Citizen Science Delphi Participants' Representative Organizations

1. University of Minnesota
2. Earth Force – GREEN (Global Rivers Environmental Education Network)
3. Great Smoky Mountains Institute at Tremont
4. University of Minnesota, Duluth – Great Lakes Worm Watch
5. Loon Watch at Sigurd Olson Environmental Institute – Northland College
6. Beaver Creek Reserve – Citizen Science Center
7. Bronx River Alliance
8. Minnesota Odonata Survey Project
9. Lake Erie-Alleghany Earth Force
10. Washington State Department of Fish & Wildlife
11. Smithsonian Institution
12. Cornell Lab of Ornithology

Appendix K: Delphi Participants Demographic Survey

Please tell us about yourself and your program by answering the following questions.

1. What is your name?
2. Your Gender: Male Female
3. What is your current job title?
4. What percentage of your position is devoted to your citizen science program?
   a. <10%
   b. 11-20%
   c. 21-30%
   d. 31-40%
   e. 41-50%
   f. 51-60%
   g. 61-70%
   h. 71-80%
   i. >80%
5. How many years have you worked with your current citizen science program?
   a. 0-1
   b. 2-4
   c. 5+
6. In total, how many years have you worked in citizen science?
   a. 0-1
   b. 2-4
   c. 5+
7. How many years has your citizen science program been in existence?
   a. 0-3
   b. 4-9
   c. 10-14
   d. 15+
8. What is the affiliation your citizen science program? (Check all that apply.)
   a. Non-profit/non-governmental organization (NGO)
   b. State government
   c. Federal government
   d. College or university
   e. Nature center
   f. Private organization
   g. Other__________________
9. What is the topical focus of your citizen science program? (Check all that apply.)
   a. Birds
   b. Reptiles & amphibians
   c. Mammals
   d. Plants
   e. Water (lakes, rivers, streams, marine, groundwater)
   f. Invasive species

g. Other (Please list.)___________________

10. What is the geographic focus of your citizen science program?
    a. Local community/city
    b. State (Which one?_______________)
    c. Region (e.g. New England, Upper Midwest) Please Indicate_______
    d. Nationwide
    e. International (Please indicate continents and total number of countries.__________)
11. Who provides data to your citizen science program? (Check all that apply.)
    a. K-12 students
    b. College & university students
    c. Teachers
    d. Scientists
    e. Individuals
    f. Families
    g. Volunteer organizations, e.g. environmental, service
    h. Other (Please list.)______________
12. What is the approximate number of individuals that your program worked with in each of the following groups in the last 12 months?
    a. K-12 students
    b. College & university students
    c. Teachers
    d. Scientists
    e. Individuals
    f. Families
    g. Volunteer organizations, e.g. environmental, service
    h. Other (Please list.)______________
13. About what percent of participants in the past 12 months came from each area listed?
    a. Suburban _______________
    b. Urban ________________
    c. Rural ___________________

Appendix L: Delphi Participants Demographic Responses – Individuals

Delphi Participants Demographic Question Responses

Please tell us about yourself and your program by answering the following questions.

14. What is your name? **N/A 1**

15. Your Gender: **Male**

16. What is your current job title?
    Citizen Science Director (Though I began a new job 2 weeks ago as Coweeta Long Term Ecological Site manager.)

17. What percentage of your position is devoted to your citizen science program?
    a. **51-60%**

18. How many years have you worked with your current citizen science program?
    a. **2-4**

19. In total, how many years have you worked in citizen science?
    a. **2-4**

20. How many years has your citizen science program been in existence?
    a. **10-14**

21. What is the affiliation your citizen science program? (Check all that apply.)
    a. **Non-profit/non-governmental organization (NGO)**

22. What is the topical focus of your citizen science program? (Check all that apply.)
    a. **Birds**
    b. **Reptiles & amphibians**
    c. **Plants**
    d. **Water (lakes, rivers, streams, marine, groundwater)**
    e. **Invasive species**
    f. **Other (Please list.) – All Taxa Biodiversity Inventory; Insects & Invertebrates**

23. What is the geographic focus of your citizen science program?
    a. **Local community/city**

24. Who provides data to your citizen science program? (Check all that apply.)
    a. **K-12 students**
    b. **College & university students**
    c. **Teachers**

d. **Scientists**
e. **Individuals**
f. **Families**
g. **Volunteer organizations, e.g. environmental, service**

25. What is the approximate number of individuals that your program worked with in each of the following groups in the last 12 months?
    a. **K-12 students – 3,000**
    b. **College & university students - 300**
    c. **Teachers - 60**
    d. **Scientists - 10**
    e. **Individuals - 50**
    f. **Families - 30**
    g. **Volunteer organizations, e.g. environmental, service - 6**

26. About what percent of participants in the past 12 months came from each area listed?
    a. **Suburban - 40**
    b. **Urban - 20**
    c. **Rural – 40**

Delphi Participants Demographic Question Responses

Please tell us about yourself and your program by answering the following questions.

1. What is your name? **N/A 2**

2. Your Gender: **Female**

3. What is your current job title? **Research Associate**

4. What percentage of your position is devoted to your citizen science program?
   - **41-50%**

5. How many years have you worked with your current citizen science program?
   - **5+**

6. In total, how many years have you worked in citizen science?
   - **5+**

7. How many years has your citizen science program been in existence?
   - **4-9**

8. What is the affiliation your citizen science program? (Check all that apply.)
   - **College or university**

9. What is the topical focus of your citizen science program? (Check all that apply.)
   - **Invasive species**

10. What is the geographic focus of your citizen science program?
    - **Region (e.g. New England, Upper Midwest) Please Indicate – Great Lakes Region of North America**

11. Who provides data to your citizen science program? (Check all that apply.)
    - **K-12 students**
    - **College & university students**
    - **Teachers**
    - **Scientists**
    - **Individuals**
    - **Families**
    - **Volunteer organizations, e.g. environmental, service**
    - **Other (Please list.) – Natural Resource Managers**

12. What is the approximate number of individuals that your program worked with in each of the following groups in the last 12 months?

- **K-12 students - >300**
- **College & university students - 180**
- **Teachers - 60**
- **Scientists - 5**
- **Individuals - 50**
- **Families - 20**
- **Volunteer organizations, e.g. environmental, service - 5**

13. About what percent of participants in the past 12 months came from each area listed?
    - **Suburban - ?**
    - **Urban - ?**
    - **Rural -?**

Delphi Participants Demographic Question Responses

Please tell us about yourself and your program by answering the following questions.

14. What is your name? **NA 3**

15. Your Gender: **Female**

16. What is your current job title? **Executive Director Pacific Education Institute Environmental Education Policy Lead-Washington Department of Fish & Wildlife**

17. What percentage of your position is devoted to your citizen science program?
    - **51-60%**

18. How many years have you worked with your current citizen science program?
    - **5+**

19. In total, how many years have you worked in citizen science?
    - **5+**

20. How many years has your citizen science program been in existence?
    - **15+**

21. What is the affiliation your citizen science program? (Check all that apply.)
    - **State government**
    - **College or university**

22. What is the topical focus of your citizen science program? (Check all that apply.)
    - **Birds**
    - **Reptiles & amphibians**
    - **Mammals**
    - **Plants**
    - **Water (lakes, rivers, streams, marine, groundwater)**
    - **Invasive species**

23. What is the geographic focus of your citizen science program?
    - **State (Which one?) - Washington**

24. Who provides data to your citizen science program? (Check all that apply.)
    - **K-12 students**
    - **Individuals**
    - **Volunteer organizations, e.g. environmental, service**
    - **Other (Please list.) – sometimes scientists**

25. What is the approximate number of individuals that your program worked with in each of the following groups in the last 12 months?
    - **K-12 students – 10,000**
    - **Individuals – 5, 000**
    - **Volunteer organizations, e.g. environmental, service - 50**

26. About what percent of participants in the past 12 months came from each area listed?
    - **Suburban - 35**
    - **Urban - 30**
    - **Rural - 35**

Delphi Participants Demographic Question Responses

Please tell us about yourself and your program by answering the following questions.

1. What is your name? **NA4**

2. Your Gender: **Male**

3. What is your current job title? **Education Director**

4. What percentage of your position is devoted to your citizen science program?
   - **51-60%**

5. How many years have you worked with your current citizen science program?
   - **2-4**

6. In total, how many years have you worked in citizen science?
   - **2-4**

7. How many years has your citizen science program been in existence?
   - **4-9**

8. What is the affiliation your citizen science program? (Check all that apply.)
   - **Non-profit/non-governmental organization (NGO)**

9. What is the topical focus of your citizen science program? (Check all that apply.)
   - **Plants**
   - **Water (lakes, rivers, streams, marine, groundwater)**
   - **Invasive species**

10. What is the geographic focus of your citizen science program?
    - **Region (e.g. New England, Upper Midwest) Please Indicate – The Bronx communities where the river flows.**

11. Who provides data to your citizen science program? (Check all that apply.)
    - **K-12 students**
    - **Teachers**
    - **Scientists**
    - **Individuals**
    - **Volunteer organizations, e.g. environmental, service**

12. What is the approximate number of individuals that your program worked with in each of the following groups in the last 12 months?
    - **K-12 students - 200**

- **College & university students -16**
- **Teachers - 30**
- **Scientists - 2**
- **Individuals - 25**
- **Volunteer organizations, e.g. environmental, service - 3**

13. About what percent of participants in the past 12 months came from each area listed?
    - **Urban – 100%**

Delphi Participants Demographic Question Responses

Please tell us about yourself and your program by answering the following questions.

1. What is your name? NA5

2. Your Gender: **Female**

3. What is your current job title? **Education Program Manager Conservation and Research Center- Smithsonian's National Zoo**

4. What percentage of your position is devoted to your citizen science program?
   - **11-20%**

5. How many years have you worked with your current citizen science program?
   - **5+**

6. In total, how many years have you worked in citizen science?
   - **5+**

7. How many years has your citizen science program been in existence?
   - **10-14**

8. What is the affiliation your citizen science program? (Check all that apply.)
   - **Federal government**

9. What is the topical focus of your citizen science program? (Check all that apply.)
   - **Birds**
   - **Reptiles & amphibians**
   - **Mammals**
   - **Plants**
   - **Invasive species**

10. What is the geographic focus of your citizen science program?
    - **Local community/city**
    - **State (Which one?) - Virginia**
    - **Region (e.g. New England, Upper Midwest) Please Indicate – Appalachian Trail Region**

11. Who provides data to your citizen science program? (Check all that apply.)
    - **K-12 students**
    - **College & university students**
    - **Teachers**
    - **Scientists**

- **Individuals**
- **Families**
- **Volunteer organizations, e.g. environmental, service**

12. What is the approximate number of individuals that your program worked with in each of the following groups in the last 12 months?
    - **K-12 students – (Unknown…others mange the receipt of data)**
    - **College & university students – (Unknown…others mange the receipt of data)**
    - **Teachers – (Unknown…others mange the receipt of data)**
    - **Scientists – (Unknown…others mange the receipt of data)**
    - **Individuals – (Unknown…others mange the receipt of data)**
    - **Families – (Unknown…others mange the receipt of data)**
    - **Volunteer organizations, e.g. environmental, service – (Unknown…others mange the receipt of data)**

13. About what percent of participants in the past 12 months came from each area listed?
    - **Suburban – (Unknown…others mange the receipt of data)**
    - **Urban – (Unknown…others mange the receipt of data)**
    - **Rural – (Unknown…others mange the receipt of data)**

Delphi Participants Demographic Question Responses

Please tell us about yourself and your program by answering the following questions.

1. What is your name? NA 6
2. Your Gender: **Female**
3. What is your current job title? **Director of GREEN (Global Rivers Environmental Education Network)**
4. What percentage of your position is devoted to your citizen science program?
    - **>80%**
5. How many years have you worked with your current citizen science program?
    - **5+**
6. In total, how many years have you worked in citizen science?
    - **5+**
7. How many years has your citizen science program been in existence?
    - **15+**
8. What is the affiliation your citizen science program? (Check all that apply.)
    - **Non-profit/non-governmental organization (NGO)**
9. What is the topical focus of your citizen science program? (Check all that apply.)
    - **Water (lakes, rivers, streams, marine, groundwater)**
10. What is the geographic focus of your citizen science program?
    - **Nationwide**
11. Who provides data to your citizen science program? (Check all that apply.)
    - **K-12 students**
12. What is the approximate number of individuals that your program worked with in each of the following groups in the last 12 months?
    - **K-12 students – 7,000**
    - **Teachers - 200**
    - **Other (Please list.) – Corporations (General Motors Volunteers)**
13. About what percent of participants in the past 12 months came from each area listed?
    - **Suburban - 25**
    - **Urban - 50**

- **Rural - 25**

Delphi Participants Demographic Question Responses

Please tell us about yourself and your program by answering the following questions.

1. What is your name? NA7

2. Your Gender: **Female**

3. What is your current job title? **Citizen Science Director**

4. What percentage of your position is devoted to your citizen science program?
    - **>80%**

5. How many years have you worked with your current citizen science program?
    - **0-1**

6. In total, how many years have you worked in citizen science?
    - **0-1**

7. How many years has your citizen science program been in existence?
    - **4-9**

8. What is the affiliation your citizen science program? (Check all that apply.)
    - **Non-profit/non-governmental organization (NGO)**
    - **Nature center**

9. What is the topical focus of your citizen science program? (Check all that apply.)
    - **Birds**
    - **Reptiles & amphibians**
    - **Mammals**
    - **Plants**
    - **Water (lakes, rivers, streams, marine, groundwater)**
    - **Invasive species**
    - **Other (Please list.) - worms**

10. What is the geographic focus of your citizen science program?
    - **Local community/city**
    - **State (Which one?) – Wisconsin**

11. Who provides data to your citizen science program? (Check all that apply.)
    - **K-12 students**
    - **College & university students**

- **Teachers**
- **Scientists**
- **Individuals**
- **Families**
- **Volunteer organizations, e.g. environmental, service**
- **Other (Please list.) - Agencies**

12. What is the approximate number of individuals that your program worked with in each of the following groups in the last 12 months?
    - **K-12 students -100**
    - **College & university students - 150**
    - **Teachers - 60**
    - **Scientists - 30**
    - **Individuals - 800**
    - **Families - 100**
    - **Volunteer organizations, e.g. environmental, service -30**
    - **Other (Please list.) – agencies, 3**

13. About what percent of participants in the past 12 months came from each area listed?
    - **Suburban - 60**
    - **Urban - 10**
    - **Rural – 30**

Delphi Participants Demographic Question Responses

Please tell us about yourself and your program by answering the following questions.

1. What is your name? NA8
2. Your Gender: **Female**
3. What is your current job title? **Program Director Lake Erie-Earth Force**
4. What percentage of your position is devoted to your citizen science program?
   - **71-80%**
5. How many years have you worked with your current citizen science program?
   - **5+**
6. In total, how many years have you worked in citizen science?
   - **5+**
7. How many years has your citizen science program been in existence?
   - **15+**
8. What is the affiliation your citizen science program? (Check all that apply.)
   - **Non-profit/non-governmental organization (NGO)**
   - **Other – the work that I have done for the last 15-20 years has not been called citizen science but that is what I have been doing.**
9. What is the topical focus of your citizen science program? (Check all that apply.)
   - **Other (Please list.) – we use a watershed approach therefore it encompasses all areas as well as taking action**
10. What is the geographic focus of your citizen science program?
    - **State (Which one?) – western PA**
11. Who provides data to your citizen science program? (Check all that apply.)
    - **K-12 students**
    - **College & university students**
    - **Teachers**
    - **Scientists**
    - **Individuals**
12. What is the approximate number of individuals that your program worked with in each of the following groups in the last 12 months?
    - **K-12 students -2500**
    - **College & university students -100**

- **Teachers - 200**
- **Scientists - 30**
- **Individuals - 200**
- **Families - 30**
- **Volunteer organizations, e.g. environmental, service - 30**
- **Other (Please list.) – gov't agencies 10; business 15**

13. About what percent of participants in the past 12 months came from each area listed?
    - **Suburban -10**
    - **Urban -65**
    - **Rural -25**

Delphi Participants Demographic Question Responses

Please tell us about yourself and your program by answering the following questions.

1. What is your name? NA9
2. Your Gender: **Male**
3. What is your current job title? **Coordinator of the MN Odonata Survey Project**
4. What percentage of your position is devoted to your citizen science program?
    - **61-70%**
5. How many years have you worked with your current citizen science program?
    - **2-4**
6. In total, how many years have you worked in citizen science?
    - **5+**
7. How many years has your citizen science program been in existence?
    - **0-3**
8. What is the affiliation your citizen science program? (Check all that apply.)
    - **Non-profit/non-governmental organization (NGO)**
9. What is the topical focus of your citizen science program? (Check all that apply.)
    - **Other (Please list.) – Odonata – Dragonflies & Damselflies**
10. What is the geographic focus of your citizen science program?
    - **State (Which one?) - MN**
11. Who provides data to your citizen science program? (Check all that apply.)
    - **Scientists**
    - **Individuals**
    - **Families**
    - **Volunteer organizations, e.g. environmental, service**
12. What is the approximate number of individuals that your program worked with in each of the following groups in the last 12 months?
    - **Scientists -10**
    - **Individuals - 175**
    - **Families - 10**
    - **Volunteer organizations, e.g. environmental, service -2**

13. About what percent of participants in the past 12 months came from each area listed?
    - **Suburban -30**
    - **Urban -30**
    - **Rural -40**

Delphi Participants Demographic Question Responses

Please tell us about yourself and your program by answering the following questions.

1. What is your name? NA10

2. Your Gender: **Female**

3. What is your current job title? **Project Leader & Extension Support Specialist**

4. What percentage of your position is devoted to your citizen science program?
   - **>80%**

5. How many years have you worked with your current citizen science program?
   - **5+**

6. In total, how many years have you worked in citizen science?

7. How many years has your citizen science program been in existence?
   - **10-14**

8. What is the affiliation your citizen science program? (Check all that apply.)
   - **Non-profit/non-governmental organization (NGO)**
   - **College or university**

9. What is the topical focus of your citizen science program? (Check all that apply.)
   - **Birds**

10. What is the geographic focus of your citizen science program?
    - **Nationwide**

11. Who provides data to your citizen science program? (Check all that apply.)
    - **K-12 students**
    - **College & university students**
    - **Individuals**
    - **Families**
    - **Volunteer organizations, e.g. environmental, service**

12. What is the approximate number of individuals that your program worked with in each of the following groups in the last 12 months?
    - **K-12 students – not sure**
    - **College & university students– not sure**
    - **Teachers– not sure**

- **Scientists– not sure**
- **Individuals– not sure**
- **Families– not sure**
- **Volunteer organizations, e.g. environmental, service– not sure**

13. About what percent of participants in the past 12 months came from each area listed?
    - **Suburban – not sure**
    - **Urban – not sure**
    - **Rural – not sure**

Delphi Participants Demographic Question Responses

Please tell us about yourself and your program by answering the following questions.

1. What is your name? NA11

2. Your Gender: **Female**

3. What is your current job title? **Environmental Education Program Coordinator**

4. What percentage of your position is devoted to your citizen science program?
   - **71-80%**

5. How many years have you worked with your current citizen science program?
   - **2-4**

6. In total, how many years have you worked in citizen science?
   - **2-4**

7. How many years has your citizen science program been in existence?
   - **15+**

8. What is the affiliation your citizen science program? (Check all that apply.)
   - **Non-profit/non-governmental organization (NGO)**

9. What is the topical focus of your citizen science program? (Check all that apply.)
   - **Birds**
   - **Water (lakes, rivers, streams, marine, groundwater)**

10. What is the geographic focus of your citizen science program?
    - **State (Which one?) - Wisconsin**

11. Who provides data to your citizen science program? (Check all that apply.)
    - **Individuals**
    - **Families**

12. What is the approximate number of individuals that your program worked with in each of the following groups in the last 12 months?
    - **K-12 students -250**
    - **College & university students - 25**
    - **Teachers -10**
    - **Scientists - 10**
    - **Individuals -450**

- **Families - 350**
- **Volunteer organizations, e.g. environmental, service -20**

13. About what percent of participants in the past 12 months came from each area listed?
    - **Suburban -25**
    - **Urban -25**
    - **Rural -50**

Delphi Participants Demographic Question Responses

Please tell us about yourself and your program by answering the following questions.

1. What is your name? NA12

2. Your Gender: **Female**

3. What is your current job title? **Associate Professor**

4. What percentage of your position is devoted to your citizen science program?
    - **<10%**

5. How many years have you worked with your current citizen science program?
    - **5+**

6. In total, how many years have you worked in citizen science?
    - **5+**

7. How many years has your citizen science program been in existence?
    - **10-14**

8. What is the affiliation your citizen science program? (Check all that apply.)
    - **College or university**

9. What is the topical focus of your citizen science program? (Check all that apply.)
    - **Other (Please list.) –Insects (monarch butterflies)**

10. What is the geographic focus of your citizen science program?
    - **International (Please indicate continents and total number of countries.) – North America, 3**

11. Who provides data to your citizen science program? (Check all that apply.)
    - **K-12 students**
    - **College & university students**
    - **Teachers**
    - **Scientists**
    - **Individuals**
    - **Families**
    - **Volunteer organizations, e.g. environmental, service**

12. What is the approximate number of individuals that your program worked with in each of the following groups in the last 12 months?
    - **K-12 students -40**

- **College & university students -10**
- **Teachers -6**
- **Scientists -2**
- **Individuals -100**
- **Families -40**
- **Volunteer organizations, e.g. environmental, service -6**

13. About what percent of participants in the past 12 months came from each area listed?
    - **Suburban -50**
    - **Urban -20**
    - **Rural -30**

Appendix M: Delphi Round 1 Instructions, IRB Consent Form, & Standards Sources

September 23, 2008

Greetings!

I would like to begin by thanking you again for your participation in the following and subsequent surveys over the coming weeks. Your participation in the Delphi Survey asks you to help identify standards for citizen science programs which address environmental literacy (as established by the North American Association for Environmental Education) for students in 5th-8th grades. The following directions are written to help simplify the process, and fulfill specific criteria.

1. Please read over the attached Institutional Review Board (IRB) Informed Consent Form, type your initials of agreement, and return it to me at sreilly@uwsp.edu.

2. The Delphi Survey consists of three rounds of surveys to generate new ideas and facilitate consensus among participants for the environmental literacy standards (Linstone& Turoff, 1975). *As a reminder, your participation will remain anonymous to all the participants of the survey. However, your name will be required in the survey for my data and be available only to myself.*

3. At the end of this email, you will find a hotlink to the Delphi Survey. Please comment on the wording of the four broad strands, rate the relative importance of corresponding standards, and make any additional comments. The survey consists of 60 questions focusing on standards. There is also a second link to a short demographic survey that consists of 13 questions.

4. For the purpose of this survey, **environmental literacy** is defined as: "The capacity of citizens to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems" (Disinger & Roth, 1992).

5. For your convenience, you will find an attached document containing which national standards the first 40 environmental literacy standards correlate with.

6. The first 40 standards were taken, and for some, modified from the *NAAEE Excellence in Environmental Education: Guidelines for Learning (Pre K-12)* & *Guidelines for Excellence Self-Assessment Tool Grades 5th-8th*. The subsequent 18 learner outcomes and program characteristics were developed through my literature review. Some of those references are also included in an attached document.

7. For more information about the North American Association of Environmental Educators, please visit www.naaee.org. The *Guidelines for Learning & Self-*

Assessment Tool was developed by the NAAEE to provide program assessment for environmental educators in order to meet the goal of environmental literacy and meet national education standards.

Your response to the Delphi Survey by Tuesday September 20, 2008 would be greatly appreciated. Again, thank you for your time and interest. If you have any questions or concerns, please contact me via email (sreilly@uwsp.edu) or at 715-630-4750.

Sincerely,

Scott Reilly

Informed Consent Form to Participate in Human Subject Research

I, Scott Reilly, a Graduate Student of Environmental Education at the University of Wisconsin-Stevens Point, am conducting a study to identify the standards of environmental literacy in order to create a curriculum framework for Citizen Science programs and teachers.

As part of the study, your knowledge and experience will be requested. Through the use of online surveys and email, your answers will be used to assist in the study. Your responses to the Delphi Survey will be helpful in identifying which standards of environmental literacy are most important to Citizen Science programs. The data and your identity will remain confidential except to myself, and be handled through the UWSP server. Hardcopies will be stored in a locked cabinet within the office of Dr. Daniel Sivek. However, I cannot guarantee your information against cyber theft. For your assistance in this study, you will receive a check for $30.

Participating in this will pose no medical risk to you. For the purpose of this study, your personal responses will not be made public and no information will be released to any one other than yourself without your consent. Publication or presentation of the study data would in no way identify you as a participant unless otherwise notified.

If you wish to withdraw from the study at any time, you may do so and any information given will not be used in the study.

Once the study is completed, I would be glad to share the results with you. In the meantime, if you have any questions, please contact me at:

Scott Reilly
CNR – Environmental Education
University of Wisconsin – Stevens Point
sreilly@uwsp.edu
715-630-4750

If you have any complaints or concerns about your treatment as a participant in this study, please contact:

Dr. Jason Davis, Chair
Institutional Review Board for the Protection of Human Subjects
Department of Business & Economics
University of Wisconsin – Stevens Point
Stevens Point, WI 54481
jdavis@uwsp.edu
715-346-4598

Although Dr. Davis will ask your name, all complaints are kept in confidence.

I have read the above form and agree to participate in the survey. _______________

<u>Appendix of Standards Sources & Correlation:</u> The following is a list of national standards that correlate to the first 40 environmental literacy standards of the Delphi Survey:

- Example:

1. Geography 49; Math 248; Science 145

EL Standard　　Subject Addressed & Source　　Document Page

Standards Sources:

Social Studies:

Expectations of Excellence: Curriculum Standards for Social Studies. (1994) Washington, D.C.; National Council for the Social Studies.

Geography:

Geography for Life: National Geography Standards. (1994) Washington, D.C.; National Geographic Research and Exploration.

Science:

National Science Education Standards. (1996) Washington, D.C.; National Academy Press.

Arts:

National Standards for Arts Education: What Every Young American Should Know and Be Able to Do in the Arts. (1994) Reston, VA; Music Educations National Conference.

Civics:

National Standards for Civics and Government. (1994) Calabasas, CA; Center for Civic Education.

History:

National Standards for History. (1996) Los Angeles, CA; National Center for History in the Schools.

Math:

Principles and Standards for School Mathematics. (2000) Reston, VA; National Council of Teachers of Mathematics.

Science Benchmarks:

Project 2061, American Association for the Advancement of Science. *Benchmarks for Science Literacy*. (1993) New York, NY; Oxford University Press.

English:

Standards for the English Language Arts. (1996) Urbana, IL; National Council of Teachers of English.

Economics:

Voluntary National Content Standards in Economics. (1997) New York, NY; National Council on Economics Standards.

Environmental Literacy Standard & National Standard (pps.):

1. Geography 49; Math 248; Science 145
2. Math 248; Science 145, 148
3. Arts 47; English Language Arts 27-28, 38-40; Geography 49-50, 144-145; History 67-68; Math 214, 222, 232, 240; Science 145; Science Benchmarks 294; Social Studies 85-87
4. History 67-68; Math 248, 256; Science 143, 148
5. Arts 50; English Language Arts 35-36; Geography 50-51, 144-145; Math 222, 248, 274, 280; Science 145
6. Geography 144-145; Math 222, 232; Science 145; Science Benchmarks 286-287
7. English Language Arts 39-40; Geography 51-52; History 68-70; Math 222, 248, 274, 280; Science 145, 148
8. Geography 156-157; Science 158-160; Science Benchmarks 73
9. Geography 156-157; Science 158-160; Science Benchmarks 73
10. Science 154; Science Benchmarks 77-79
11. Science 155; Science Benchmarks 84-85
12. Science 155; Science Benchmarks 84-85
13. Geography 158-159; Science 156-157; Science Benchmarks 104
14. Science 157-158; Science Benchmarks 108, 124
15. Geography 158; Science 157-158; Science Benchmarks 117
16. Science 158; Science Benchmarks 120
17. Arts 46; Science Benchmarks 141-142, 155, 159; Social Studies 88-90
18. Arts 48, 51; English Language Arts 27-29, 38-39; Geography 154-155, 162-163; Science Benchmarks 155; Social Studies 79-81
19. Civics & Government 47-52, 61-70; Economics 5-7, 19-20, 30-31; Geography 164-166; Science Benchmarks 169; Social Studies
20. Civics & Government 71-73; Geography 164-166, 171-172; Science Benchmarks 177; Social Studies 102-104
21. Science Benchmarks 163, 166, 173; Social Studies 82-84, 91-93
22. Geography 173-175; Science 168-169
23. Arts 50; Geography 150-155; Social Studies 85-87, 99-101
24. Arts 50; Geography 150-155; Social Studies 85-87, 99-101
25. Economics 1-3; Geography 176-178; History 67-68; Science 168
26. Science 169; Science Benchmarks 55-56, 185-186, 189-190, 194, 198, 202-203, 206; Social Studies 99-101

27. Geography 181-182
28. Geography 181-182
29. Geography 164-166, 169-170; 179-182; History 68-70; Social Studies 79-93, 105-107
30. Geography 171-172; Social Studies 85-87
31. English Language Arts 41; History 70; Social Studies 105-107
32. Arts 51; English Language Arts 31-33, 41-42, 44-45; Geography 181; Science 148; Science Benchmarks 286-287; Social Studies 88-90
33. Arts 40; Geography 179-182; History 70; Social Studies 88-90
34. Civics & Government 68-70; Social Studies 105-107
35. Civics & Government 80-83; Social Studies 105-107
36. History 70; Social Studies 105-107
37. Civics & Government 58-60; English Language Arts 44; Social Studies 105-107
38. Civics & Government 74-78; Social Studies 105-107
39. Civics & Government 80-83; Social Studies 91-93, 105-107
40. Civics & Government 79-80

References: The following are a selected list of references consulted in generating the Delphi Survey and standards.

Disinger, J.F & Roth, C.E. (1992) *Environmental Literacy*. ERIC/CSMEE Digest. Columbus, OH: ERIC Clearinghouse for Science, Mathematics and Environmental Education.

Ernst, J. & Monroe, M. (2004). The effects of environment-based education on students' critical thinking skills and disposition toward critical thinking. *Environmental Education Research.* 10(4), pps. 507-521.

Krasny, M.E. & Bonney, R. (2005). Environmental Education through Citizen Science and Participatory Action Research. In E. Johnson & M. Mappin (eds.) *Environmental Education and Advocacy: Changing Perspectives of Ecology and Education.* Cambridge, England: Cambridge University Press.

Lieberman, G. & Hoody, L. (1998). Closing the Achievement Gap: Using the Environment as an Integrating Context for Learning. *State Education and Environment Roundtable.* San Diego, CA.

Linestone, H. A. & Turoff, M.T. (1975). *The Delphi Method Techniques and Application.* London: Addison-Wesley.

North American Association for Environmental Education (2004). *Excellence in Environmental Education: Guidelines for Learning (Pre K – 12).* Washington, D.C.; NAAEE Publications.

Schusler, T.M. & M.E. Krasny (2005). Youth Participation in Local Environmental Action: Integrating Science and Civic Education. In B.B. Jensen & A. Reid (eds.) Critical International Perspectives on Participation in Environmental and Health Education. Denmark: Danish University Press.

Tinker, R.F. (1997). Student-Scientist Partnerships: Shrewd Maneuvers. In K.C. Cohen (ed.) *Internet Links for Science Education: Student-Scientist Partnerships*. New York: Plenum Press.

Yockers, D. (April 2008). Professor of Environmental Education at UWSP – Personal Communication.

Appendix N: Delphi Round 2 Instructions

October 21st, 2008

Greetings!

Thank you for completing the first round of the Delphi Survey. Your responses have been interesting and have set a framework for how the second round will proceed. Below you will find directions for this round. **In this round you will further identify and rate the standards of environmental literacy best addressed by citizen science and make any additional comments.** The results from the three survey rounds will assist for 5th through 8th grade curriculum development by providing learner guidelines.

Please read the following directions. If you do not understand them, please contact me.

1. A spreadsheet is attached that gives your responses for each statement from Round 1of the Delphi. The spreadsheet also includes the mean from all survey participants. Please consult the spreadsheet responses and take them into consideration when making your second round decisions. This information is provided as guidance about whether you wish to change your previous selection or not based on the results from the entire group. If your selection is significantly different from the group's mean, please give reasons supporting your selection.

2. Also attached is a *Word* document that includes typed comments directed at the survey and survey statements. Please consult this as well when making decisions regarding your level of agreement/disagreement for each standard or characteristic. However, not all participants chose to write comments and only those written are included. Some of the statements have had wording changes based on comments provided from the first round. This document includes all 58 statements as originally written in Round 1.

3. At the end of this email you will find a hotlink to the survey. You will find at the end of each statement the group's mean. It will be abbreviated as mean (MEN). Also, survey statements 17 and 20 include grammatical changes presented in parentheses and capitalized, i.e. (ADDED WORD). Please make your selections and add any additional comments necessary.

4. There are also 3 additional statements at the end of the survey developed from participant input.

5. I have also re-sent some information from the first round of the survey.

    a. The Delphi Survey consists of three rounds of surveys to generate new ideas and facilitate consensus among participants for the environmental literacy standards (Linstone& Turoff, 1975). *As a reminder, your participation will remain anonymous to all the participants of the survey.*

However, your name will be required in the survey for my data and be available only to myself.

b. For the purpose of this survey, **environmental literacy** is defined as: "The capacity of citizens to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems" (Disinger & Roth, 1992).

c. For your convenience, you will find an attached document containing which national standards the first 40 environmental literacy standards correlate with.

d. The first 40 standards were taken, and for some, modified from the *NAAEE Excellence in Environmental Education: Guidelines for Learning (Pre K-12)* & *Guidelines for Excellence Self-Assessment Tool Grades 5th-8th*. The subsequent 18 learner outcomes and program characteristics were developed through my literature review. Some of those references are also included in an attached document.

e. For more information about the North American Association of Environmental Educators, please visit www.naaee.org. The *Guidelines for Learning & Self-Assessment Tool* was developed by the NAAEE to provide program assessment for environmental educators in order to meet the goal of environmental literacy and meet national education standards.

Your response to the Delphi Survey by Tuesday October 28th, 2008 would be greatly appreciated. Again, thank you for your time and interest. If you have any questions or concerns, please contact me via email (sreilly@uwsp.edu) or at 715-630-4750.

Appendix O: CS Preliminary Teacher Questionnaire Responses

Teacher Questionnaire Responses	
Description: What are teachers looking at?	***Assistance: Who assists in their program?***
Outdoors – 5	Government Agencies (State/Local) – 2
Water Monitoring – 4	Universities – 2
Environmental Toxins (Arsenic) – 1	Non-Profit Organizations – 1
Habitat Assessment – 2	No Assistance – 2
Vertebrates – 2	
Macro-invertebrates/Invasive Species/Carnivore Tracking – 1	
Energy Audit – 1	
Necessity: How helpful is a conceptual framework for citizen science program development?	***Development: How helpful would a framework have been when first developing your program?***
"Somewhat Helpful" – 2	"Extremely/Very Helpful" – 3
"Very/Extremely Helpful" – 3	"Somewhat" – 1
"Useful/Welcome" if improve programs & offer real ideas – 2	"Valuable in starting programs"/ "Valuable if has good ideas" – 2
	"Program not fully developed yet" – 1
Future Consultation: How likely to consult a framework in the future?	***Additional Comments & Suggestions:***
"Likely for program development" – 4	"Future assistance of framework review" – 1
"Infrequently for program fine tuning" – 2	"Tied to State/National standards" – 1
"Very likely if framework is accessible" – 1	"Needs to be applicable" – 1
	No Comments – 4

Appendix P: Delphi Survey Summary Table

Standard/Characteristic Number	Rd.	Mean	Std Dev	Rd.	Std Dev	Rd. 1 & 2 Mean	Rd.	Std Dev	Rd. 1, 2 & 3 Mean
Strand 1									
1	1	4.50	0.67	2	0.69	4.52	3	0.67	4.54
2	1	4.00	0.74	2	0.83	4.05	3	0.85	4.03
3	1	4.42	0.67	2	0.69	4.44	3	0.65	4.51
4	1	4.17	1.03	2	0.69	4.31	3	0.78	4.32
5	1	4.17	0.72	2	0.87	4.17	3	0.83	4.17
6	1	3.58	1.08	2	0.87	3.70	3	0.78	3.58
7	1	4.33	0.65	2	0.50	4.48	3	0.79	4.35
Strand 2.1									
8	1	3.75	0.75	2	0.83	3.92	3	0.83	3.89
9	1	3.83	0.83	2	0.79	4.05	3	0.90	4.01
10	1	3.50	0.67	2	0.67	3.57	3	0.98	3.49
11	1	3.83	0.83	2	0.63	3.92	3	0.83	3.89
12	1	3.33	0.78	2	0.83	3.62	3	0.90	3.58
Strand 2.2									
13	1	4.33	0.78	2	0.67	4.48	3	0.67	4.52
14	1	4.00	0.85	2	0.89	4.00	3	0.72	4.06
15	1	4.08	0.67	2	0.65	4.18	3	0.72	4.17
16	1	4.17	0.83	2	0.70	4.13	3	0.95	4.09
Strand 2.3									
17	1	3.83	0.83	2	0.83	3.87	3	0.75	3.83
18	1	4.00	0.95	2	0.83	3.95	3	0.75	3.89
19	1	4.08	1.16	2	0.63	4.04	3	0.72	3.97
20	1	4.08	1.16	2	0.75	4.13	3	0.60	4.09
21	1	4.00	1.13	2	0.70	4.05	3	0.79	4.06
Strand 2.4									
22	1	4.58	0.67	2	0.82	4.56	3	0.80	4.54
23	1	4.08	1.00	2	0.79	4.18	3	0.75	4.20
24	1	3.83	1.27	2	0.63	3.92	3	0.75	4.03
25	1	3.58	0.79	2	1.21	3.56	3	0.75	3.63
26	1	3.75	0.87	2	0.45	3.88	3	0.67	3.89
27	1	3.92	0.79	2	0.70	4.00	3	0.67	4.03
Strand 3.1									
28	1	4.08	0.67	2	0.70	4.09	3	0.72	4.11
29	1	4.33	0.78	2	0.69	4.39	3	0.67	4.40
30	1	4.42	0.67	2	0.69	4.48	3	0.80	4.49

31	1	4.25	0.75	2	0.65	4.26	3	0.62	4.26
Strand 3.2									
32	1	4.17	0.58	2	0.60	4.17	3	0.58	4.17
33	1	4.25	0.62	2	0.54	4.17	3	0.58	4.17
34	1	4.58	0.67	2	0.79	4.43	3	0.79	4.42
35	1	4.42	0.79	2	0.65	4.34	3	0.78	4.34
36 (Wrongly numbered, not included)	1	*	*	2	*	*	3	*	*
Strand 4									
37	1	3.67	0.78	2	0.79	3.70	3	0.79	3.66
38	1	4.00	0.60	2	0.70	4.05	3	0.51	4.00
39	1	4.08	0.79	2	0.60	4.13	3	0.67	4.12
40	1	4.25	0.75	2	0.81	4.31	3	0.65	4.32
Citizen Science Strand									
41	1	4.17	0.83	2	0.47	4.22	3	0.87	4.23
42	1	4.58	0.51	2	0.67	4.47	3	0.67	4.48
43	1	4.42	0.79	2	0.82	4.44	3	0.67	4.46
44	1	4.50	0.80	2	0.69	4.52	3	0.65	4.57
45	1	3.50	1.09	2	0.97	3.45	3	0.94	3.58
46	1	4.00	0.95	2	0.92	4.18	3	0.97	4.20
47	1	4.17	0.72	2	0.67	4.27	3	0.78	4.29
48	1	4.58	0.51	2	0.52	4.52	3	0.51	4.48
49	1	4.17	0.83	2	0.65	4.22	3	0.67	4.17
50	1	4.17	1.03	2	0.89	4.08	3	0.90	4.08
51	1	4.00	0.74	2	0.94	4.05	3	1.03	3.97
52	1	4.00	0.85	2	1.01	3.86	3	0.89	3.80
53	1	4.64	0.50	2	0.47	4.68	3	0.45	4.70
54	1	4.08	0.79	2	0.94	4.09	3	0.62	4.14
55	1	3.50	0.80	2	0.90	3.61	3	0.78	3.63
56	1	4.42	0.67	2	0.67	4.53	3	0.67	4.55
57	1	4.50	0.67	2	0.40	4.66	3	0.65	4.66
58	1			2			3		
59 New Statement 1				2	0.98	4.18	3	0.95	4.09
60 New Statement 2				2	0.70	4.09	3	0.72	4.13
61 New Statement 3				2	0.67	3.64	3	0.58	3.73
62 New Statement 4							3	0.51	4.42

Appendix Q: Delphi Round 1 Comments

Delphi Survey Comments from Round 1:

<u>Strand 1 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Questioning, Analysis & Interpretation Skills:</u> Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Learners must be familiar with inquiry, master fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.

Comments:
1: Environmental literacy and inquiry learning are an integral part of student learning, curriculum and state standards of learning. But they are not necessarily a part of citizen science activities. Because citizen science programs are not always designed with students in mind, this can be the trick. Students can still gain valuable experience in a more "traditional" citizen science activity, where they are collecting data for a project designed by someone else, but it is not a perfect situation.
2: Environmental literacy and citizen science are not synonymous. The first sentence above speaks to literacy, the second more to citizen science. You could make the argument that citizen science greatly enhances literacy (and I'd agree), but it is not required for literacy.
3: All I would say is that this definition of environmental literacy seems very unattainable for the average citizen. You are basically asking ordinary citizens to "master" skills that take scientists years of training to acquire.
4: Do you have to have environmental literacy standards for citizen science? I think you have to have some sort of minimum standard, but it depends on the project - collecting dung beetles as part of an All Taxa Biodiversity Inventory takes less skill than correctly capturing, collecting, identifying, and measuring aquatic salamanders. To me, citizen science is not necessarily having a citizen actively take part in all the steps of the scientific method. For the most part, citizen scientists just take part in the field work, at least at Tremont - the hypothesis and methods are already developed. And citizen scientists often lack the skills to perform statistics and summarize the results.

1) **Students are able to develop, focus and explain questions that help them learn about the environment and do environmental investigations.**

2) **Students are able to design environmental investigations to answer particular questions – often their own questions.**

3) **Students are able to locate and collect reliable information about the environment or environmental topics using a variety of methods and sources.**

4) **Students are able to assess the strengths and weaknesses of the information they are using.**

5) **Students are able to classify and order data, and organize and display information in ways that help analysis and interpretation.**

6) **Students are able to recognize and evaluate many of the uses and limitations of physical, mathematical, and computer models.**

7) **Students are able to synthesize their observations into coherent explanations.**

The comments below refer to statements 1-7.

1: NOTE: my responses to the 7 statements below relate directly to my statement above...it is critically important for students to engage in the items below during their academic term. But these statements aren't necessarily integral to participating and gaining valuable experience by a non-inquiry-based citizen science program. Linking inquiry learning with citizen science is the "gold star" that we should strive for (and not including inquiry may be a deal-breaker for teachers). Hopefully this makes sense.
2: The question of information collection and its reliability(3,4) is more complicated today due to the incredible wealth of information available. This is true for all of us.
3*:* As to your survey above, I'm not sure why you are using the word "students" with reference to citizen science in general. They are one sub-set of potential citizen scientists, but far from a representative example, besides do you mean K-12 or college students?
4: I am not sure what age group of students you are talking about, but most of these seem to be secondary education goals.
5: For number 6: This statement is not really relevant to citizen science at [education center]. For many projects, the students are acting as the "hands" of the scientists - performing surveys, tagging Monarch butterflies, etc. It is not necessary for them to evaluate models.

<u>Strand 2 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Knowledge of Environmental Processes & Systems:</u> Understanding the processes and systems that comprise the environment, including human social systems and influences, is an important component of environmental literacy. That understanding is based on knowledge synthesized from across traditional disciplines.

Comments:

1: Engaging in a citizen science program does not require that the participant understand multi-disciplinary principals of conservation biology, nor does it require that students understand the connection to human social systems. It is expected that getting students invested in a real world project, where their activities make a difference, will naturally lead them to make connections...across disciplines and between physical/biological and social sciences.

2.1 – The Earth as a Physical System

8) **Students have a basic understanding of most of the physical processes that shape the Earth.**

9) **Students are able to relate the differences in physical patterns to their causes, e.g. how seasonal change is affected by the Earth/sun relationship.**

10) **Students are able to explain the properties of the substances that make up objects or materials found in the environment.**

11) **Students begin to grasp formal concepts related to energy by focusing on energy transfer and transformation.**

12) **Students are able to make connections among phenomena such as light, heat, magnetism, electricity, and the motion of objects.**

The comments below refer to statements 8-12.

1: A need for literacy in the above items is really dependent on the type of project in which students are participating.

2: Working in an urban environment, I find that the understanding of processes is very limited.

3: These standards do not seem to be relevant across all of the grades addressed in this survey.
4: These standards do not seem to be relevant across all of the grades addressed in this survey.
5: I think it depends on the grade level. Are you talking about 5th graders or high school seniors.

2.2 – The Living Environment

13) **Students understand that biotic communities are made up of plants and animals that are uniquely adapted to live in particular environments.**

14) **Students recognize and describe the importance of genetic variation in species and possible implications of species extinction.**

15) **Students identify and describe major kinds of interactions among organisms or populations of organisms.**

16) **Students describe how energy and matter flow among the biotic and abiotic components of the environment.**

The comments below refer to statements 13-16.

1: A need for literacy in the above items is really dependent on the type of project in which students are participating.

2.3- Humans & Their Societies

17) Students explain how individual perceptions of the environment are influenced in part by individual traits and group membership or affiliation.

21) Students identify and explain different cultural perspectives on the environment and how the environment influences culture.

22) Students are familiar with political and economic systems and how these systems take the environment into consideration.

23) Students identify and explain ways in which the world's environmental, societal, economic, cultural, and political systems are linked.

21) Students explain and analyze that human social systems change over time and that conflicts sometimes arise over differing viewpoints about the environment.

The comments below refer to statements 17-21.

1: A need for literacy in the above items is really dependent on the type of project in which students are participating.

2: 20) This is understood more on a local basis: Environmental Justice.
3: You need to clarify the wording in 17 above, it's not obvious if you are talking about "individual traits" of the environment or of the people observing it.
4: I think you are getting out of the realm of citizen science and into environmental ethics with the above.

2.4– Environment & Society

22) Students are able to explain that human-caused changes have consequences for the immediate environment as well as for other places and future times.

23) Students explore differences in perceptions and importance of places close to home and around the world.

24) Students are able to discuss and explain why uneven distribution of resources around the world influences the use of these resources and their perceived value.

25) Students link the human ability to shape and control the environment with our ability to create knowledge and develop new technologies.

26) Students describe a range of environmental issues at scales that range from local to national to global.

27) Students relate to and discuss how people in other places around the world experience environmental issues similar to the ones they are concerned about locally.

The comments below refer to statements 22-27.

1: A need for literacy in the above items is really dependent on the type of project in which students are participating.

<u>Strand 3 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Skills for Understanding & Addressing Environmental Issues:</u> Skills and knowledge are refined and applied in the context of environmental issues. These environmental issues are real-life dramas where differing viewpoints about environmental problems and their potential solutions are played out. Environmental literacy includes the abilities to define, learn about, evaluate, and act on environmental issues.

Comments:
1: To me, this one hits the mark much more closely about the outcomes of participation in citizen science. But again, many citizen science activities are not necessarily designed for students (or any participant for that matter) to actively engage in processing or evaluating, drawing conclusions, or publishing results in

papers or in other community contexts. This would be an advantage if students were to participate, but not a requirement.

2: Environmental issues (Hungerford et al) is where there is a disagreement over an environmental solution.

3.1 – Skills for Analyzing & Investigating Environmental Issues

28) Students use primary and secondary sources of information, and apply their growing research and analytical skills to investigate environmental issues, beginning with those in their own community.

29) Students apply their knowledge of ecological and human processes and systems to identify the consequences of specific environmental issues.

30) Students identify and develop action strategies for addressing particular issues.

31) Students consider the assumptions and interpretations that influence the conclusions they and others draw about environmental issues.

The comments below refer to statements 28-31.

1: It is often assumed that participating in citizen science activities gives participants a greater awareness of cause and effect, and leads them to a place where they would choose to act, or advocate for the environment or environmental issues (even those more traditional citizen science activities where a scientist or other professional designs the project and participants are "technicians"). But as with many of the "statements" included in the survey, although they are K-12 educational goals, they are not necessarily a requirement for student participation. Getting the teacher to take the students deeper, if they are participating in a "traditional" (non-inquiry designed citizen science project) can be a challenge, but should be a priority.

3.2 – Decision-Making & Citizenship Skills

32) Students identify, justify, and clarify their views on environmental issues and alternative ways to address them.

33) Students evaluate whether they believe action is needed in particular situations, and decide whether they should be involved.

34) Students begin to see themselves as citizens taking active roles in their communities. They plan for and engage in citizen action at levels appropriate to their maturity and preparation.

35) Students evaluate the effects of their own actions and actions taken by other individuals and groups.

The comments below refer to statements 32-35.

1: It is often assumed that participating in citizen science activities gives participants a greater awareness of cause and effect, and leads them to a place where they would choose to act, or advocate for the environment or environmental issues (even those more traditional citizen science activities where a scientist or other professional designs the project and participants are "technicians"). But as with many of the "statements" included in the survey, although they are K-12 educational goals, they are not necessarily a requirement for student participation. Getting the teacher to take the students deeper, if they are participating in a "traditional" (non-inquiry designed citizen science project) can be a challenge, but should be a priority.

Strand 4 & Corresponding Skills, Knowledge & Dispositions:
Personal & Civic Responsibility: Environmentally literate citizens are willing and able to act on their own conclusions about what should be done to ensure environmental quality. As learners develop and apply concept-based learning and skills for inquiry, analysis, and action, they also understand that what they do individually and in groups can make a difference.

Comments:
1: This is a "gold standard" for student participation in citizen science activities. But in the absence of citizen science projects that are designed with students, specifically, in mind, this will be a HUGE challenge for teachers to ensure that participation leads to students feeling able and empowered to make a difference.

37) **Students identify, discuss and evaluate societal values that can be both a unifying and a divisive force.**

38) **Students identify and describe the rights and responsibilities of citizenship and their importance in promoting the resolution of environmental issues.**

39) **Students possess a realistic self-confidence in their effectiveness as citizens.**

40) **Students understand that their actions can have broad consequences and that they are responsible for those consequences.**

The comments below refer to statements 37-40.

1: As with many of the other "statements" included in this survey, these elements are important "citizen" characteristics...but these are not necessarily goals of citizen science projects as many are designed.

Citizen Science Program Strand: Additional learner outcomes or program characteristics common in citizen science programs that may contribute to environmental literacy.

41) **Citizen science programs are a component of curriculum to help meet state and federal education standards.**

42) **Environmental literacy is an important goal of citizen science.**

43) **Citizen science programs bring scientists and sponsoring organizations together with students.**

44) **Citizen science programs are a multi-disciplinary educational approach that relies on many fields.**

45) In citizen science programs, students primarily follow a previously established scientific protocol.

46) In citizen science programs, students are in the out-of-doors learning about natural resources.

47) In citizen science programs, students learn about and apply the scientific method through first-hand experience.

48) In citizen science programs, students conduct valuable research that assists in meeting research objectives.

49) In citizen science programs, student-collected data are valid and reliable.

50) In citizen science programs, students assist in answering scientific questions developed within the scientific community.

51) In citizen science programs, students are involved in developing scientific questions.

52) In citizen science programs, students develop appropriate methodology to address scientific questions.

53) In citizen science programs, students are involved in the data collection process.

54) In citizen science programs, students interpret data.

55) In citizen science programs, students disseminate the data to the public.

56) In citizen science programs, students reflect on what they have done or learned.

57) In citizen science programs, students are empowered through increased personal responsibility in learning.

The below comments refer to statements 41-57.

1: These were tricky to answer. The variety of citizen science programs all follow all these statements to one degree or another. I have my preferences and beliefs about the elements that would better integrate students into meaningful citizen science experiences. But there are still programs where students participate, that are developed by and focus on "scientist" or "professional" priorities that provide valuable experiences...especially if teachers are able to take the students deeper than the citizen science project was designed.

2: #45 and #46 - not all of the time #45 - students can develop their own protocol following experience with others #46 - citizen science can involve indoor energy audits - so we can make the statement "real world" that can include indoors.

58) Please add any additional learner outcomes or program characteristics you believe important for environmental literacy, but are not included in the preceding survey.

1: Developing these standards/goals will be difficult. Organizations and individuals who design citizen science projects aren't only targeting students (and my gut feeling is that most target adults or other non-student volunteers). These standards shouldn't be written in a way that inadvertently discourage these organizations and individuals who have other priorities than educating students. By the same token, although a "gold standard" for citizen science projects that engage students would be ones that involve inquiry, stewardship, etc...beyond "collecting data"...teachers should not be discouraged by participating in "traditional" citizen science projects where students are only asked to collect data. Teachers should strive for, and seek resources to take their students deeper...beyond mere data collection...but this shouldn't be a barrier to starting the dialog and initiating partnerships with professional organizations or individuals who have unique opportunities for student participation in real-world science. I feel strongly about this...don't have the answers...but if this doesn't make sense, please feel free to call me and we can discuss further!
2: Other than just collecting data/specimens, students should gain some understanding of the taxa/issue that they are researching as part of a citizen science program. In other words, a trained monkey can gather pebbles, but a student should learn/gain knowledge about the pebbles which they are collecting.
3: I would add that citizen science is a useful tool in connecting students with the outdoors and nature. This is one of the primary goals of citizen science at [CS Education Center].

Appendix R: Delphi Round 2

Delphi Survey Round 2:

<u>Strand 1 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Questioning, Analysis & Interpretation Skills:</u> Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Learners must be familiar with inquiry, master fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.

Comments:

1) **Students are able to develop, focus and explain questions that help them learn about the environment and do environmental investigations.**

2) **Students are able to design environmental investigations to answer particular questions – often their own questions.**

3) **Students are able to locate and collect reliable information about the environment or environmental topics using a variety of methods and sources.**

4) **Students are able to assess the strengths and weaknesses of the information they are using.**

5) **Students are able to classify and order data, and organize and display information in ways that help analysis and interpretation.**

6) **Students are able to recognize and evaluate many of the uses and limitations of physical, mathematical, and computer models.**

7) **Students are able to synthesize their observations into coherent explanations.**

<u>Strand 2 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Knowledge of Environmental Processes & Systems:</u> Understanding the processes and systems that comprise the environment, including human social systems and influences, is an important component of environmental literacy. That understanding is based on knowledge synthesized from across traditional disciplines.

Comments:
2.1 – The Earth as a Physical System

8) **Students have a basic understanding of most of the physical processes that shape the Earth.**

9) **Students are able to relate the differences in physical patterns to their causes, e.g. how seasonal change is affected by the Earth/sun relationship.**

10) **Students are able to explain the properties of the substances that make up objects or materials found in the environment.**

11) **Students begin to grasp formal concepts related to energy by focusing on energy transfer and transformation.**

12) **Students are able to make connections among phenomena such as light, heat, magnetism, electricity, and the motion of objects.**

2.2 – The Living Environment

13) **Students understand that biotic communities are made up of plants and animals that are uniquely adapted to live in particular environments.**

14) **Students recognize and describe the importance of genetic variation in species and possible implications of species extinction.**

15) **Students identify and describe major kinds of interactions among organisms or populations of organisms.**

16) **Students describe how energy and matter flow among the biotic and abiotic components of the environment.**

2.3- Humans & Their Societies

17) Students explain how (AN) individual's perceptions of the environment are influenced in part by (AN) individual's traits and group membership or affiliation.

18) Students identify and explain different cultural perspectives on the environment and how the environment influences culture.

19) Students are familiar with political and economic systems and how these systems take the environment into consideration.

20) Students identify and explain ways in which the world's environmental, societal, economic, cultural, and political systems are linked. (ENVIRONMENTAL JUSTICE CAN BE AN EXAMPLE OF THIS.)

21) Students explain and analyze that human social systems change over time and that conflicts sometimes arise over differing viewpoints about the environment.

2.4– Environment & Society

22) Students are able to explain that human-caused changes have consequences for the immediate environment as well as for other places and future times.

23) Students explore differences in perceptions and importance of places close to home and around the world.

24) Students are able to discuss and explain why uneven distribution of resources around the world influences the use of these resources and their perceived value.

25) Students link the human ability to shape and control the environment with our ability to create knowledge and develop new technologies.

26) Students describe a range of environmental issues at scales that range from local to national to global.

27) Students relate to and discuss how people in other places around the world experience environmental issues similar to the ones they are concerned about locally.

Strand 3 & Corresponding Skills, Knowledge & Dispositions:
Skills for Understanding & Addressing Environmental Issues: **Skills and knowledge are refined and applied in the context of environmental issues. These environmental issues are real-life dramas where differing viewpoints about environmental problems and their potential solutions are played out. Environmental literacy includes the abilities to define, learn about, evaluate, and act on environmental issues.**

Comments:

3.1 – Skills for Analyzing & Investigating Environmental Issues

28) Students use primary and secondary sources of information, and apply their growing research and analytical skills to investigate environmental issues, beginning with those in their own community.

29) Students apply their knowledge of ecological and human processes and systems to identify the consequences of specific environmental issues.

30) Students identify and develop action strategies for addressing particular issues.

31) Students consider the assumptions and interpretations that influence the conclusions they and others draw about environmental issues.

3.2 – Decision-Making & Citizenship Skills

32) Students identify, justify, and clarify their views on environmental issues and alternative ways to address them.

33) Students evaluate whether they believe action is needed in particular situations, and decide whether they should be involved.

34) Students begin to see themselves as citizens taking active roles in their communities. They plan for and engage in citizen action at levels appropriate to their maturity and preparation.

35) Students evaluate the effects of their own actions and actions taken by other individuals and groups.

<u>Strand 4 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Personal & Civic Responsibility:</u> Environmentally literate citizens are willing and able to act on their own conclusions about what should be done to ensure environmental quality. As learners develop and apply concept-based learning and skills for inquiry, analysis, and action, they also understand that what they do individually and in groups can make a difference.

Comments:

37) Students identify, discuss and evaluate societal values that can be both a unifying and a divisive force.

38) Students identify and describe the rights and responsibilities of citizenship and their importance in promoting the resolution of environmental issues.

39) Students possess a realistic self-confidence in their effectiveness as citizens.

40) Students understand that their actions can have broad consequences and that they are responsible for those consequences.

<u>Citizen Science Program Strand:</u> Additional learner outcomes or program characteristics common in citizen science programs that may contribute to environmental literacy.

41) Citizen science programs are a component of curriculum to help meet state and federal education standards.

42) Environmental literacy is an important goal of citizen science.

43) Citizen science programs bring scientists and sponsoring organizations together with students.

44) Citizen science programs are a multi-disciplinary educational approach that relies on many fields.

45) In citizen science programs, students primarily follow a previously established scientific protocol.

46) In citizen science programs, students are in the out-of-doors learning about natural resources.

47) In citizen science programs, students learn about and apply the scientific method through first-hand experience.

48) In citizen science programs, students conduct valuable research that assists in meeting research objectives.

49) In citizen science programs, student-collected data are valid and reliable.

50) In citizen science programs, students assist in answering scientific questions developed within the scientific community.

51) In citizen science programs, students are involved in developing scientific questions.

52) In citizen science programs, students develop appropriate methodology to address scientific questions.

53) In citizen science programs, students are involved in the data collection process.

54) In citizen science programs, students interpret data.

55) In citizen science programs, students disseminate the data to the public.

56) In citizen science programs, students reflect on what they have done or learned.

57) In citizen science programs, students are empowered through increased personal responsibility in learning.

58) Please add any additional learner outcomes or program characteristics you believe important for environmental literacy, but are not included in the preceding survey.

New Statements:

59) *New Statement 1: Citizen science programs also involve students in an in-door setting to learn about natural resources, i.e. energy audits.

60) *New Statement 2: In citizen science programs, students can develop their own scientific protocol following previous experiences.

61) *New Statement 3: In citizen science programs, students gain a taxonomic understanding of species classification.

Appendix S: Delphi Round 2 Comments

Delphi Survey Comments from Round 2:

<u>Strand 1 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Questioning, Analysis & Interpretation Skills:</u> Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Learners must be familiar with inquiry, master fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.

Comments:

1: I feel uncomfortable with the unstated but clearly implied assumption that "Environmental Literacy" requires master of the "skills" of science rather than the "knowledge" of environmental issues. A person can be very "skill rich" yet not "knowledgeable" (I.E. scientists who don't think global climate change is human induced). Citizen Science is simply a mechanism to achieve one or the other or both and I think you need to clarify & justify in your own mind what you are assuming and what you are not as you move forward with this. I would rank the questions below very differently under different conceptual frameworks. Therefore, I wonder how effective this survey will be unless this framework is made more explicit since every participant may be coming at it from a different perspective. I for one, DO NOT feel that citizen science (defined as a mechanism for mastery of skills) is a strong requirement for Environmental Literacy which I see as more knowledge-based. It certainly may add value, but the knowledge has to be the priority and there are many ways to acquire knowledge that do not require mastery of skills.

2: I'm still feeling that I'm missing something...connecting the strand to citizen science programs. Environmental literacy and citizen science have a great deal of overlap, but they are not synonymous. I'm sold on this stand about questioning, analysis and interpretation skills for environmental literacy. If we are really tackle citizen science programs in the strands, then would we add a 3rd sentence to the strand that addresses citizen science specifically (as a subset of literacy? as a way to get to literacy?) I'm still stuck with the sense that to be a meaningful participant in a run-of-the-mill citizen science activity, you don't need to be literate in environmental stuff...but your participation might lead you to becoming more literate. Which comes first?

1) **Students are able to develop, focus and explain questions that help them learn about the environment and do environmental investigations.**

2) **Students are able to design environmental investigations to answer particular questions – often their own questions.**

3) **Students are able to locate and collect reliable information about the environment or environmental topics using a variety of methods and sources.**

4) **Students are able to assess the strengths and weaknesses of the information they are using.**

5) **Students are able to classify and order data, and organize and display information in ways that help analysis and interpretation.**

6) **Students are able to recognize and evaluate many of the uses and limitations of physical, mathematical, and computer models.**

7) **Students are able to synthesize their observations into coherent explanations.**

The comments below refer to statements 1-7.

1: I'm surprised that statements three and four differ in mean value. I interpret the statements to be about conducting research. I believe these two support each other greatly, especially with the information on the internet. Finding information is easy--finding good information takes time and can make or break a project from the beginning. Research is the foundation to any project.

2: Any one of these statements might be incorporated into a citizen science project, but are not necessary for meaningful participation. On the other hand, they are critical, in my mind, to a student's academic development (read...getting environmentally literate). There is a missing link/statement about participation.

Strand 2 & Corresponding Skills, Knowledge & Dispositions:
Knowledge of Environmental Processes & Systems: Understanding the processes and systems that comprise the environment, including human social systems and influences, is an important component of environmental literacy. That understanding is based on knowledge synthesized from across traditional disciplines.

Comments:

1: At this age level, students should be making connections across disciplines...getting the bigger picture. Citizen science projects that help students make these connections will have an advantage in drawing in middle-school audiences. The statements below would pertain only to those citizen science projects that are related...if we are re-writing the standards to focus on citizen science rather than the much broader scope of environmental literacy, then there needs to be an acknowledgement this...

2.1 – The Earth as a Physical System

8) **Students have a basic understanding of most of the physical processes that shape the Earth.**

9) **Students are able to relate the differences in physical patterns to their causes, e.g. how seasonal change is affected by the Earth/sun relationship.**

10) **Students are able to explain the properties of the substances that make up objects or materials found in the environment.**

11) **Students begin to grasp formal concepts related to energy by focusing on energy transfer and transformation.**

12) **Students are able to make connections among phenomena such as light, heat, magnetism, electricity, and the motion of objects.**

The comments below refer to statements 8-12.

1: Interesting that the mean drops for some of these physical science standards, but goes up again for the living environment standards. hmmm...

2: Depends on type of project...

2.2 – The Living Environment

13) **Students understand that biotic communities are made up of plants and animals that are uniquely adapted to live in particular environments.**

14) **Students recognize and describe the importance of genetic variation in species and possible implications of species extinction.**

15) **Students identify and describe major kinds of interactions among organisms or populations of organisms.**

16) **Students describe how energy and matter flow among the biotic and abiotic components of the environment.**

The comments below refer to statements 13-16.

1: Depends on type of project...

2.3- Humans & Their Societies

17) Students explain how (AN) individual's perceptions of the environment are influenced in part by (AN) individual's traits and group membership or affiliation.

18) Students identify and explain different cultural perspectives on the environment and how the environment influences culture.

19) Students are familiar with political and economic systems and how these systems take the environment into consideration.

20) Students identify and explain ways in which the world's environmental, societal, economic, cultural, and political systems are linked. (ENVIRONMENTAL JUSTICE CAN BE AN EXAMPLE OF THIS.)

21) Students explain and analyze that human social systems change over time and that conflicts sometimes arise over differing viewpoints about the environment.

The comments below refer to statements 17-21.

1: With a global economy the social/environmental interface shapes the context of the work we do--how it is funded, what the priorities are, etc. Having done environmental education in different cultures makes me wonder if these statements aren't more applicable to teachers than students.

2: 17. I would specify that students need to understand a stakeholders beliefs, role and responsibility - as a way to get to the meaning of that statement.

3: Depends on type of project...

2.4– Environment & Society

22) Students are able to explain that human-caused changes have consequences for the immediate environment as well as for other places and future times.

23) Students explore differences in perceptions and importance of places close to home and around the world.

24) Students are able to discuss and explain why uneven distribution of resources around the world influences the use of these resources and their perceived value.

25) Students link the human ability to shape and control the environment with our ability to create knowledge and develop new technologies.

26) Students describe a range of environmental issues at scales that range from local to national to global.

27) Students relate to and discuss how people in other places around the world experience environmental issues similar to the ones they are concerned about locally.

The comments below refer to statements 22-27.

1: I disagree with statement 25 in that we change, not control the environment with new technologies. Ask any farmer.

2: Depends on type of project...

<u>Strand 3 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Skills for Understanding & Addressing Environmental Issues:</u> Skills and knowledge are refined and applied in the context of environmental issues. These environmental issues are real-life dramas where differing viewpoints about environmental problems and their potential solutions are played out. Environmental literacy includes the abilities to define, learn about, evaluate, and act on environmental issues.

Comments:
1: Although important for students to begin considering at this age, this is not necessary for a meaningful participation in citizen science. Citizen science projects that engage students in this kind of assessment/action can do double-duty for students also required to participate in service learning.

3.1 – Skills for Analyzing & Investigating Environmental Issues

28) **Students use primary and secondary sources of information, and apply their growing research and analytical skills to investigate environmental issues, beginning with those in their own community.**

29) **Students apply their knowledge of ecological and human processes and systems to identify the consequences of specific environmental issues.**

30) **Students identify and develop action strategies for addressing particular issues.**

31) **Students consider the assumptions and interpretations that influence the conclusions they and others draw about environmental issues.**

The comments below refer to statements 28-31.

1: # 28 If by "Primary" and "Secondary" you mean scientific literature and books/reviews, respectively. Then this may be too narrow and too difficult. They should understand how scientists share information but it is another thing to ask them to understand the documents themselves!
2: 30: action strategies include citizen science plus stewardship - I consider citizen science both science inquiry to address a question and a stewardship action in and of itself.
3: Important for student learning, but not necessary for participation as a citizen scientist...Does this mean that if the project doesn't include opportunities to do these kinds of things that it shouldn't be considered by a teacher wishing to engage their students? I'm not sure I know the answer...

3.2 – Decision-Making & Citizenship Skills

32) **Students identify, justify, and clarify their views on environmental issues and alternative ways to address them.**

33) **Students evaluate whether they believe action is needed in particular situations, and decide whether they should be involved.**

34) **Students begin to see themselves as citizens taking active roles in their communities. They plan for and engage in citizen action at levels appropriate to their maturity and preparation.**

35) **Students evaluate the effects of their own actions and actions taken by other individuals and groups.**

The comments below refer to statements 32-35.

1: I see citizen science as science inquiry using methodologies appropriate for the component of the environment, to answer questions that are a part of the bigger question around environmental issues - where there is a disagreement on how to resolve the issue among stakeholders. I do not equate citizen science with environmental issue resolution - citizen science is one tool for that purpose - decision making is another skill, and applying those decisions through citizen action is another - but that is not citizen science. For me what you are proposing is a curricula for students to undertake citizen science in preparation for decision making and taking citizen action.
2: Important for student learning, but not necessary for participation as a citizen scientist...

<u>Strand 4 & Corresponding Skills, Knowledge & Dispositions:</u>

<u>Personal & Civic Responsibility:</u> Environmentally literate citizens are willing and able to act on their own conclusions about what should be done to ensure environmental quality. As learners develop and apply concept-based learning and skills for inquiry, analysis, and action, they also understand that what they do individually and in groups can make a difference.

Comments:

1: As with my previous comments, I'd like to see students engaging in activities that allow them to feel that they are making a positive difference...but I also recognize that this can be done in many ways. Citizen science projects can be meaningful to students, but may not necessarily be the only way that students can accomplish this. I'd be reluctant to make a statement that restricts teachers and students from participating in citizen science that does not do this, even while I'd love to see more citizen science projects that offer guidance on making a difference.

37) **Students identify, discuss and evaluate societal values that can be both a unifying and a divisive force.**

38) **Students identify and describe the rights and responsibilities of citizenship and their importance in promoting the resolution of environmental issues.**

39) **Students possess a realistic self-confidence in their effectiveness as citizens.**

40) **Students understand that their actions can have broad consequences and that they are responsible for those consequences.**

The comments below refer to statements 37-40.

1: In undertaking citizen science, it is important to understand the beliefs, role and responsibilities of the stakeholder who is asking the science inquiry questions. This helps in understanding how the question changes with the stakeholder and their interests.

<u>Citizen Science Program Strand:</u> Additional learner outcomes or program characteristics common in citizen science programs that may contribute to environmental literacy.

41) **Citizen science programs are a component of curriculum to help meet state and federal education standards.**

42) **Environmental literacy is an important goal of citizen science.**

43) **Citizen science programs bring scientists and sponsoring organizations together with students.**

44) **Citizen science programs are a multi-disciplinary educational approach that relies on many fields.**

45) **In citizen science programs, students primarily follow a previously established scientific protocol.**

46) In citizen science programs, students are in the out-of-doors learning about natural resources.

47) In citizen science programs, students learn about and apply the scientific method through first-hand experience.

48) In citizen science programs, students conduct valuable research that assists in meeting research objectives.
49) In citizen science programs, student-collected data are valid and reliable.

50) In citizen science programs, students assist in answering scientific questions developed within the scientific community.

51) In citizen science programs, students are involved in developing scientific questions.

52) In citizen science programs, students develop appropriate methodology to address scientific questions.

53) In citizen science programs, students are involved in the data collection process.

54) In citizen science programs, students interpret data.

55) In citizen science programs, students disseminate the data to the public.

56) In citizen science programs, students reflect on what they have done or learned.

57) In citizen science programs, students are empowered through increased personal responsibility in learning.

The below comments refer to statements 41-57.

1: #41: The national and science standards do not reflect the opportunity of citizen science strongly enough - for it to be obvious to those who are not citizen science advocates.
2: #47 the term scientific method often just means experimental design to many scientists. To those of who practice citizen science in the field, experimental design is rare, and the other methodologies described by Windschitl et al are those that have been validated for grades 5-8. The methodologies are simply not understood. Please review the white papers and published article I will send to you to get the essence of this statement.
3: A lot of objectives can be accomplished even without scientific rigor of professional projects. Teachers should decide what's best for their class and age group: plugging in to an existing program, or as comment 2 suggests in the previous round, students develop their own protocol.

58) Please add any additional learner outcomes or program characteristics you believe important for environmental literacy, but are not included in the preceding survey.

59) *New Statement 1: Citizen science programs also involve students in an in-door setting to learn about natural resources, i.e. energy audits.

60) *New Statement 2: In citizen science programs, students can develop their own scientific protocol following previous experiences.

1: Depends on the questions being asked and the supervision required to implement the scientific protocol developed.

61) *New Statement 3: In citizen science programs, students gain a taxonomic understanding of species classification.

Appendix T: Delphi Survey Round 3

Delphi Survey Round 3:

<u>Strand 1 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Questioning, Analysis & Interpretation Skills:</u> Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Learners must be familiar with inquiry, master fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.

REWORDED STRAND DESCRIPTION: Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Citizen science provides learners with opportunities to develop some of the skills and knowledge of environmental literacy through first-hand participation. Learners participating in citizen science gain familiarity with inquiry, become skilled in fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.

Comments:

1) **Students are able to develop, focus and explain questions that help them learn about the environment and do environmental investigations.**

2) **Students are able to design environmental investigations to answer particular questions – often their own questions.**

3) **Students are able to locate and collect reliable information about the environment or environmental topics using a variety of methods and sources.**

4) **Students are able to assess the strengths and weaknesses of the information they are using.**

5) **Students are able to classify and order data, and organize and display information in ways that help analysis and interpretation.**

6) **Students are able to recognize and evaluate many of the uses and limitations of physical, mathematical, and computer models.**

7) **Students are able to synthesize their observations into coherent explanations.**

<u>Strand 2 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Knowledge of Environmental Processes & Systems:</u> Understanding the processes and systems that comprise the environment, including human social systems and

influences, is an important component of environmental literacy. That understanding is based on knowledge synthesized from across traditional disciplines.

REWORDED STRAND DESCRIPTION: Gaining an understanding of the processes and systems that comprise the environment, including human social systems and influences, is an important component of environmental literacy. That understanding is based on knowledge synthesized from across traditional disciplines. The standards of environmental processes and systems addressed by citizen science are dependent on the types of projects learners are involved in.

Comments:

2.1 – The Earth as a Physical System

8) **Students have a basic understanding of most of the physical processes that shape the Earth.**

9) **Students are able to relate the differences in physical patterns to their causes, e.g. how seasonal change is affected by the Earth/sun relationship.**

10) **Students are able to explain the properties of the substances that make up objects or materials found in the environment.**

11) **Students begin to grasp formal concepts related to energy by focusing on energy transfer and transformation.**

12) **Students are able to make connections among phenomena such as light, heat, magnetism, electricity, and the motion of objects.**

2.2 – The Living Environment

13) **Students understand that biotic communities are made up of plants and animals that are uniquely adapted to live in particular environments.**

14) **Students recognize and describe the importance of genetic variation in species and possible implications of species extinction.**

15) **Students identify and describe major kinds of interactions among organisms or populations of organisms.**

16) **Students describe how energy and matter flow among the biotic and abiotic components of the environment.**

2.3- Humans & Their Societies

17) Students explain how (AN) individual's perceptions of the environment are influenced in part by (AN) individual's traits and group membership or

affiliation (THROUGH UNDERSTANDING AN INDIVIDUAL'S BELIEFS, ROLES, AND RESPONSIBILITIES).

18) **Students identify and explain different cultural perspectives on the environment and how the environment influences culture.**

19) **Students are familiar with political and economic systems and how these systems take the environment into consideration.**

20) **Students identify and explain ways in which the world's environmental, societal, economic, cultural, and political systems are linked. (ENVIRONMENTAL JUSTICE CAN BE AN EXAMPLE OF THIS.)**

21) **Students explain and analyze that human social systems change over time and that conflicts sometimes arise over differing viewpoints about the environment.**

2.4– Environment & Society

22) **Students are able to explain that human-caused changes have consequences for the immediate environment as well as for other places and future times.**

23) **Students explore differences in perceptions and importance of places close to home and around the world.**

24) **Students are able to discuss and explain why uneven distribution of resources around the world influences the use of these resources and their perceived value.**

25) **Students link the human ability to shape and (CHANGE) the environment with our ability to create knowledge and develop new technologies.**

26) **Students describe a range of environmental issues at scales that range from local to national to global.**

27) **Students relate to and discuss how people in other places around the world experience environmental issues similar to the ones they are concerned about locally.**

<u>Strand 3 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Skills for Understanding & Addressing Environmental Issues:</u> Skills and knowledge are refined and applied in the context of environmental issues. These environmental issues are real-life dramas where differing viewpoints about environmental problems and their potential solutions are played out. Environmental literacy includes the abilities to define, learn about, evaluate, and act on environmental issues.

Comments:

3.1 – Skills for Analyzing & Investigating Environmental Issues

28) **Students use primary and secondary sources of information, and apply their growing research and analytical skills to investigate environmental issues, beginning with those in their own community. (PRIMARY SOURCES OF INFORMATION ARE BASED ON FIRST-HAND STUDENT EXPERIENCES WHILE SECONDARY SOURCES ARE GATHERED FROM BOOKS/LITERATURE, COMMUNITY MEMBERS, TEACHERS, ETC.)**

29) **Students apply their knowledge of ecological and human processes and systems to identify the consequences of specific environmental issues.**

30) **Students identify and develop action strategies for addressing particular issues.** (STEWARDSIP IS AN APPROPRIATE STUDENT ACTION.)

31) **Students consider the assumptions and interpretations that influence the conclusions they and others draw about environmental issues.**

3.2 – Decision-Making & Citizenship Skills

32) **Students identify, justify, and clarify their views on environmental issues and alternative ways to address them.**

33) **Students evaluate whether they believe action is needed in particular situations, and decide whether they should be involved.**

34) **Students begin to see themselves as citizens taking active roles in their communities. They plan for and engage in citizen action at levels appropriate to their maturity and preparation.**

35) **Students evaluate the effects of their own actions and actions taken by other individuals and groups.**

Strand 4 & Corresponding Skills, Knowledge & Dispositions:
Personal & Civic Responsibility: **Environmentally literate citizens are willing and able to act on their own conclusions about what should be done to ensure environmental quality. As learners develop and apply concept-based learning and skills for inquiry, analysis, and action, they also understand that what they do individually and in groups can make a difference.**

Comments:

37) **Students identify, discuss and evaluate societal values that can be both a unifying and a divisive force.**

38) Students identify and describe the rights and responsibilities of citizenship and their importance in promoting the resolution of environmental issues.

39) Students possess a realistic self-confidence in their effectiveness as citizens.

40) Students understand that their actions can have broad consequences and that they are responsible for those consequences.

Citizen Science Program Strand: Additional learner outcomes or program characteristics common in citizen science programs that may contribute to environmental literacy.

41) Citizen science programs are a component of curriculum to help meet state and federal education standards.

42) Environmental literacy is an important goal of citizen science.

43) Citizen science programs bring scientists and sponsoring organizations together with students.

44) Citizen science programs are a multi-disciplinary educational approach that relies on many fields.

45) In citizen science programs, students primarily follow a previously established scientific protocol.

46) In citizen science programs, students are in the out-of-doors learning about natural resources.

47) In citizen science programs, students learn about and apply the scientific method through first-hand experience.

48) In citizen science programs, students conduct valuable research that assists in meeting research objectives.

49) In citizen science programs, student-collected data are valid and reliable.

50) In citizen science programs, students assist in answering scientific questions developed within the scientific community.

51) In citizen science programs, students are involved in developing scientific questions.

52) In citizen science programs, students develop appropriate methodology to address scientific questions.

53) In citizen science programs, students are involved in the data collection process.

54) In citizen science programs, students interpret data.

55) In citizen science programs, students disseminate the data to the public.

56) In citizen science programs, students reflect on what they have done or learned.

57) In citizen science programs, students are empowered through increased personal responsibility in learning.

58) Please add any additional learner outcomes or program characteristics you believe important for environmental literacy, but are not included in the preceding survey.

New Statements:

59) *New Statement 1: Citizen science programs also involve students in an in-door setting to learn about natural resources, i.e. energy audits.

60) *New Statement 2: In citizen science programs, students can develop their own scientific protocol following previous experiences.

61) *New Statement 3: In citizen science programs, students gain a taxonomic understanding of species classification.

62) *New Statement 4: Student participation in citizen science develops a greater awareness of cause and effect relationships.

Appendix U: Delphi Round 3 with Comments

Delphi Survey Round 3:

<u>Strand 1 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Questioning, Analysis & Interpretation Skills:</u> Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Learners must be familiar with inquiry, master fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.

REWORDED STRAND DESCRIPTION: Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Citizen science provides learners with opportunities to develop some of the skills and knowledge of environmental literacy through first-hand participation. Learners participating in citizen science gain familiarity with inquiry, become skilled in fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.

Comments:

1: I really like the reworded strand. I would change "become skilled in fundamental skills" to "develop fundamental skills".

1) **Students are able to develop, focus and explain questions that help them learn about the environment and do environmental investigations.**

2) **Students are able to design environmental investigations to answer particular questions – often their own questions.**

3) **Students are able to locate and collect reliable information about the environment or environmental topics using a variety of methods and sources.**

4) **Students are able to assess the strengths and weaknesses of the information they are using.**

5) **Students are able to classify and order data, and organize and display information in ways that help analysis and interpretation.**

6) **Students are able to recognize and evaluate many of the uses and limitations of physical, mathematical, and computer models.**

7) **Students are able to synthesize their observations into coherent explanations.**

The comments below refer to statements 1-7.

1: #3: In WA state we have just completed science education standards and the methods we have included as expected knowledge and skills (being able to do - therefore have actually completed a performance in) at 5-8 grades are scientific methods of descriptive design and comparative design, with knowledge of experimental design through simulations. Correlation design - is not a reasonable expectation at these grade levels - although possible if these grades are highly technology proficient with GIS

Strand 2 & Corresponding Skills, Knowledge & Dispositions:
Knowledge of Environmental Processes & Systems: Understanding the processes and systems that comprise the environment, including human social systems and influences, is an important component of environmental literacy. That understanding is based on knowledge synthesized from across traditional disciplines.

REWORDED STRAND DESCRIPTION: Gaining an understanding of the processes and systems that comprise the environment, including human social systems and influences, is an important component of environmental literacy. That understanding is based on knowledge synthesized from across traditional disciplines. The standards of environmental processes and systems addressed by citizen science are dependent on the types of projects learners are involved in.
Comments:

1: I don't understand "The standards of environmental processes and systems.." - there is content of environmental processes and systems for which we can set standards of what students should know and be able to do - citizen science will help learners better understand environmental processes and systems

2.1 – The Earth as a Physical System

8) **Students have a basic understanding of most of the physical processes that shape the Earth.**

9) **Students are able to relate the differences in physical patterns to their causes, e.g. how seasonal change is affected by the Earth/sun relationship.**

10) **Students are able to explain the properties of the substances that make up objects or materials found in the environment.**

11) **Students begin to grasp formal concepts related to energy by focusing on energy transfer and transformation.**

12) **Students are able to make connections among phenomena such as light, heat, magnetism, electricity, and the motion of objects.**

The comments below refer to statements 8-12.

1: The above are helpful for an adult - but a student learning inquiry do not need these as a prerequisite for undertaking citizen science - citizen science to me is about the process of inquiry - determining the variables of focus through descriptive design (inquiry), learning the attributes of the variables by comparing them (comparative design) and looking for relationships like correlations through correlative design or cause and effect through experimental design. This is a sequential process for citizen scientists conducting real inquiry.

2.2 – The Living Environment

13) **Students understand that biotic communities are made up of plants and animals that are uniquely adapted to live in particular environments.**

14) **Students recognize and describe the importance of genetic variation in species and possible implications of species extinction.**

15) **Students identify and describe major kinds of interactions among organisms or populations of organisms.**

16) **Students describe how energy and matter flow among the biotic and abiotic components of the environment.**

The comments below refer to statements 13-16.

2.3- Humans & Their Societies

17) Students explain how (AN) individual's perceptions of the environment are influenced in part by (AN) individual's traits and group membership or affiliation (THROUGH UNDERSTANDING AN INDIVIDUAL'S BELIEFS, ROLES, AND RESPONSIBILITIES).

18) Students identify and explain different cultural perspectives on the environment and how the environment influences culture.

19) Students are familiar with political and economic systems and how these systems take the environment into consideration.

20) Students identify and explain ways in which the world's environmental, societal, economic, cultural, and political systems are linked. (ENVIRONMENTAL JUSTICE CAN BE AN EXAMPLE OF THIS.)

21) Students explain and analyze that human social systems change over time and that conflicts sometimes arise over differing viewpoints about the environment.

The comments below refer to statements 17-21.

1: Since we are talking about citizen science - then I am leaving social science inquiry out of this. It is about the scientific method used in the field. Social science inquiry involves all of the above - and we call that citizen social science I suppose. This is about citizen science that flows from learning science at school. Social science should be the umbrella for citizen science - but rarely happens. In fact the real umbrella is geographical inquiry that examines places from a spatial, ecological, economic and historical perspective - which should drive science inquiry for citizen science. School systems are not there yet - although it is in the national geography standards.

2.4– Environment & Society

22) Students are able to explain that human-caused changes have consequences for the immediate environment as well as for other places and future times.

23) Students explore differences in perceptions and importance of places close to home and around the world.

24) Students are able to discuss and explain why uneven distribution of resources around the world influences the use of these resources and their perceived value.

25) Students link the human ability to shape and (CHANGE) the environment with our ability to create knowledge and develop new technologies.

26) Students describe a range of environmental issues at scales that range from local to national to global.

27) Students relate to and discuss how people in other places around the world experience environmental issues similar to the ones they are concerned about locally.

The comments below refer to statements 22-27.

Strand 3 & Corresponding Skills, Knowledge & Dispositions:
Skills for Understanding & Addressing Environmental Issues: **Skills and knowledge are refined and applied in the context of environmental issues. These environmental issues are real-life dramas where differing viewpoints about environmental problems and their potential solutions are played out. Environmental literacy includes the abilities to define, learn about, evaluate, and act on environmental issues.**

Comments:

1: In the previous two strands, you include some specifics about how citizen science is connected to the strand, which I liked. I think you should do this here as well. (In other words, defining, learning about, evaluating and acting are all "gold star" things to incorporate into a citizen science project targeting middle school students but aren't required).

3.1 – Skills for Analyzing & Investigating Environmental Issues

28) Students use primary and secondary sources of information, and apply their growing research and analytical skills to investigate environmental issues, beginning with those in their own community. (PRIMARY SOURCES OF INFORMATION ARE BASED ON FIRST-HAND STUDENT EXPERIENCES WHILE SECONDARY SOURCES ARE GATHERED FROM BOOKS/LITERATURE, COMMUNITY MEMBERS, TEACHERS, ETC.)

29) **Students apply their knowledge of ecological and human processes and systems to identify the consequences of specific environmental issues.**

30) **Students identify and develop action strategies for addressing particular issues. (STEWARDSIP IS AN APPROPRIATE STUDENT ACTION.)**
31) **Students consider the assumptions and interpretations that influence the conclusions they and others draw about environmental issues.**

The comments below refer to statements 28-31.

1: Citizen science should lead to stewardship action - however there is a civic participation skill involved in being able to plan actions and implement them taking into consideration the trade offs and stakeholders' interests. I think stewardship action is separate from citizen science - citizen science is a component of environmental literacy as is stewardship action and knowing how to undertake it responsibly.

3.2 – Decision-Making & Citizenship Skills

32) **Students identify, justify, and clarify their views on environmental issues and alternative ways to address them.**

33) **Students evaluate whether they believe action is needed in particular situations, and decide whether they should be involved.**

34) **Students begin to see themselves as citizens taking active roles in their communities. They plan for and engage in citizen action at levels appropriate to their maturity and preparation.**

35) **Students evaluate the effects of their own actions and actions taken by other individuals and groups.**

<u>Strand 4 & Corresponding Skills, Knowledge & Dispositions:</u>
<u>Personal & Civic Responsibility:</u> Environmentally literate citizens are willing and able to act on their own conclusions about what should be done to ensure environmental quality. As learners develop and apply concept-based learning and skills for inquiry, analysis, and action, they also understand that what they do individually and in groups can make a difference.

Comments:

1: Again, as with previous strands, I think you need to be deliberate about indicating where citizen science fits in with this strand, specifically. Valuable citizen science activities don't necessarily require that participants understand inquiry, analysis and action, although there is value added if the citizens science project takes participants (especially students) deeper into these ideas related to action and citizenship.

37) **Students identify, discuss and evaluate societal values that can be both a unifying and a divisive force.**

38) **Students identify and describe the rights and responsibilities of citizenship and their importance in promoting the resolution of environmental issues.**

39) Students possess a realistic self-confidence in their effectiveness as citizens.
40) Students understand that their actions can have broad consequences and that they are responsible for those consequences.

<u>Citizen Science Program Strand:</u> Additional learner outcomes or program characteristics common in citizen science programs that may contribute to environmental literacy.

41) Citizen science programs are a component of curriculum to help meet state and federal education standards.

42) Environmental literacy is an important goal of citizen science.

43) Citizen science programs bring scientists and sponsoring organizations together with students.

44) Citizen science programs are a multi-disciplinary educational approach that relies on many fields.

45) In citizen science programs, students primarily follow a previously established scientific protocol.

46) In citizen science programs, students are in the out-of-doors learning about natural resources.

47) In citizen science programs, students learn about and apply the scientific method through first-hand experience.

48) In citizen science programs, students conduct valuable research that assists in meeting research objectives.

49) In citizen science programs, student-collected data are valid and reliable.

50) In citizen science programs, students assist in answering scientific questions developed within the scientific community.

51) In citizen science programs, students are involved in developing scientific questions.

52) In citizen science programs, students develop appropriate methodology to address scientific questions.

53) In citizen science programs, students are involved in the data collection process.

54) **In citizen science programs, students interpret data.**

55) **In citizen science programs, students disseminate the data to the public.**

56) **In citizen science programs, students reflect on what they have done or learned.**

57) **In citizen science programs, students are empowered through increased personal responsibility in learning.**

The below comments refer to statements 41-57.

1: Again, some of these elements are project-specific, and although I have positive responses to all of them, it would be good to acknowledge that a good project for middle school students would have at least some of these be met, but not necessarily all.

2: #46: I would say for K-12 that is a fair assumption. However citizen science can be applied in all science fields environmental or not. #47: be careful how you say scientific method - academics (biologists, science education professors, general science course professors) often equate the scientific method with experimental design - which it incorrect - use the term "scientific methods" or "scientific methodologies" #49: This is true if they follow rigorous protocols that have been verified by an expert #54 - in ideal programs #55 - not always - it may be up to the receiving scientist to share the data

3: In Citizen Science programs, sometimes students will be involved in developing methods and disseminating results to the public, but sometimes they will only be involved in collecting data. All of that is dependent on the project and should be an optional part of a citizen science program.

58) **Please add any additional learner outcomes or program characteristics you believe important for environmental literacy, but are not included in the preceding survey.**

New Statements:

59) ***New Statement 1: Citizen science programs also involve students in an in-door setting to learn about natural resources, i.e. energy audits.**

60) ***New Statement 2: In citizen science programs, students can develop their own scientific protocol following previous experiences.**

61) ***New Statement 3: In citizen science programs, students gain a taxonomic understanding of species classification.**

62) ***New Statement 4: Student participation in citizen science develops a greater awareness of cause and effect relationships.**

Comments for New Statements 59 -62:

1: Again, these four are all pretty project specific, but not required for all citizen science projects. (I liked the use of the word "can develop" in the new statement #2...perhaps this could be used in he other statements as well to tone them down.

2: #4: if you mean that students learn that most science in the field is not experimental design to look for a cause and effect relationship because of the cost and ethical constraints - then I agree. It should help their understanding that cause and effect can only be determined with strict control and manipulation of variables - which is only possible in limited circumstances - thus contemporary research is mostly anything but experimental design - e.g. medical and environmental studies are mostly correlations and comparisons.

Appendix V: Standards & Characteristics Selected from the Delphi Process & Original Survey Number

Strand 1: Questioning, Interpretation & Analysis Skills

- **Enduring**
  - 1) Students are able to develop, focus and explain questions that help them learn about the environment and do environmental investigations.
  - 3) Students are able to locate and collect reliable information about the environment or environmental topics using a variety of methods and sources.
- **Important**
  - 2) Students are able to design environmental investigations to answer particular questions – often their own questions**.**
  - 4) Students are able to assess the strengths and weaknesses of the information they are using.
  - 5) Students are able to classify and order data, and organize and display information in ways that help analysis and interpretation.
  - 7) Students are able to synthesize their observations into coherent explanations.

Strand 2: Knowledge of Environmental Processes & Systems

- **Enduring:**
  - 13) Students understand that biotic communities are made up of plants and animals that are uniquely adapted to live in particular environments.
  - 22) Students are able to explain that human-caused changes have consequences for the immediate environment as well as for other places and future times.
- **Important:**
  - 9) Students are able to relate the differences in physical patterns to their causes, e.g. how seasonal change is affected by the Earth/sun relationship.
  - 14) Students recognize and describe the importance of genetic variation in species and possible implications of species extinction.
  - 15) Students identify and describe major kinds of interactions among organisms or populations of organisms.
  - 16) Students describe how energy and matter flow among the biotic and abiotic components of the environment.
  - 20) Students identify and explain ways in which the world's environmental, societal, economic, cultural, and political systems are linked. Environmental justice would be an appropriate example.
  - 21) Students explain and analyze that human social systems change over time and that conflicts sometimes arise over differing viewpoints about the environment.
  - 23) Students explore differences in perceptions and importance of places close to home and around the world.
  - 24) Students are able to discuss and explain why uneven distribution of resources around the world influences the use of these resources and their perceived value.
  - 27) Students relate to and discuss how people in other places around the world experience environmental issues similar to the ones they are concerned about locally.

Strand 3: Skills for Addressing & Understanding Environmental Issues

- **Enduring:**
  - 29) Students apply their knowledge of ecological and human processes and systems to identify the consequences of specific environmental issues.
  - 30) Students identify and develop action strategies for addressing particular issue such as environmental stewardship.
  - 34) Students begin to see themselves as citizens taking active roles in their communities. They plan for and engage in citizen action at levels appropriate to their maturity and preparation.
- **Important**:
  - 28) Students use primary and secondary sources of information, and apply their growing research and analytical skills to investigate environmental issues, beginning with those in their own community. Primary sources of information are based on first-hand student experiences while secondary sources are gathered from books/literature, community members, teachers, etc.
  - 31) Students consider the assumptions and interpretations that influence the conclusions they and others draw about environmental issues.
  - 32) Students identify, justify, and clarify their views on environmental issues and alternative ways to address them.
  - 33) Students evaluate whether they believe action is needed in particular situations, and decide whether they should be involved.
  - 35) Students evaluate the effects of their own actions and actions taken by other individuals and groups.

Strand 4: Personal & Civic Responsibility

- **Important:**
  - 38) Students identify and describe the rights and responsibilities of citizenship and their importance in promoting the resolution of environmental issues.
  - 39) Students possess a realistic self-confidence in their effectiveness as citizens.
  - 40) Students understand that their actions can have broad consequences and that they are responsible for those consequences.

Strand 5: CS Program Characteristics

- **Enduring:**
  - 44) Citizen science programs are a multi-disciplinary educational approach that relies on many fields.
  - 42) Environmental literacy depends in part on scientific literacy and is an important goal of citizen science programs and curricula.
  - 56) In citizen science programs, students reflect on what they have done or learned.
  - 57) In citizen science programs, students are empowered through increased personal responsibility for learning.
  - 48) In citizen science programs, students conduct valuable research that assists in meeting research objectives.
  - 43) Citizen science programs bring scientists and sponsoring organizations together with students.

- 53) In citizen science programs, students are involved in the data collection process.
- 62) Student participation in citizen science develops a greater awareness of cause and effect relationships and its limitations to manipulation in citizen science programs.

- **Important:**
  - 41) Citizen science programs are a component of curriculum to help meet state and national education standards.
  - 47) In citizen science programs, students learn about and apply scientific methodologies through first-hand experience.
  - 50) In citizen science programs, students assist in answering scientific questions developed within the scientific community.
  - 49) In citizen science programs, student-collected data are valid and reliable if following rigorous protocols or verified by experts.
  - 46) In citizen science programs, students are in the out-of-doors learning about natural resources.
  - 59) Citizen science programs also involve students in an in-door setting to learn about natural resources, i.e. energy audits.
  - 60) In citizen science programs, students can develop their own scientific protocol following previous experiences.
  - 54) In citizen science programs, students interpret data.

Appendix W: Curriculum Framework - Condensed Version

Field Inquiry through Citizen Science: A Framework for Environmental Literacy (5^{th}-8^{th} Grades) - Condensed Version

Table of Contents

The Need for a Citizen Science Framework

Citizen science reaches large and varied audiences from local communities and regions to the entire nation and beyond. There are many opportunities for educators to incorporate lessons and aspects of citizen science into their classrooms and programs. The development of age appropriate curriculum to meet state and national standards, while contributing to students' environmental literacy, can also promote citizen science objectives.

The *Field Inquiry through Citizen Science* framework was developed to assist teachers and program developers clarify the focus of their curriculum. The framework guidelines give desired outcomes for student participation in citizen science, and provide a starting point for curriculum development based on Wiggins & McTighe's "Understanding by Design". By developing curricula and programs that address the enclosed guidelines, educators and program developers can increase students' environmental literacy while meeting educational standards.

The framework is meant as a guide, a place to start to improve current curricula. Finally, while the framework addresses grades five through eight, it may serve as a guiding document for high school and primary school students.

Framework Acknowledgements

The framework was created as a partial requirement for a Master of Science in Natural Resources – Environmental Education by Scott Reilly of the University of Wisconsin, Stevens Point (UWSP) with the assistance of his graduate committee. Committee members included Drs. Dan Sivek and Dennis Yockers of the College of Natural Resources, and Dr. Perry Cook of the College of Professional Studies on the campus of UWSP.

Finally, with much appreciation to the representatives of the following organizations who assisted in the framework development: University of Minnesota, Smithsonian Institute, GREEN/Earth Force, Washington Department of Fish & Wildlife, Cornell Lab of Ornithology, Great Smoky Mountains Institute at Tremont, University of MN, Duluth – Great Lakes Worm Watch, Sigurd Olson Environmental Institute – Northland College, Beaver Creek Reserve, Bronx River Alliance, Minnesota Odonata Survey Project, and Lake Erie-Allegheny Earth Force.

Standards-Based Education

In the 1990s state and the national governments developed educational standards that have been widely adopted by school districts around the country. In order to meet the changing educational climate, the North American Association for Environmental Education (NAAEE) developed the *Excellence in Environmental Education- Guidelines for Learning (Pre K-12).* These guidelines set voluntary student expectations for environmental education curricula and programs in order to increase student's environmental literacy while meeting these new educational standards. The guidelines provide specific content expectations and examples of achievement, and can be applied successfully to developing citizen science curricula.

The *Field Inquiry through Citizen Science* framework aims to unify those guidelines specific to citizen science and how they can contribute to enhancing students' environmental literacy. The framework guidelines correlate with Wisconsin state and national educational standards. Also included are those contributing characteristics valuable in guiding curriculum development. The framework is meant to provide achievable goals for program developers, teachers, and students alike.

Citizen Science & Its Importance to Environmental Literacy

According to the Cornell Laboratory of Ornithology, citizen science is a form of environment-based learning in which students (and adults) are actively engaged in the scientific process by working with scientists to address "real-world questions."

The active engagement in citizen science by students can have numerous benefits.

- Develops students' skills in leadership, critical thinking, & teamwork;
- Increases students' sense of ownership and empowerment in addressing environmental issues;
- Addresses state & national standards;
- Addresses multiple disciplines & intelligences;
- Contributes to students' environmental literacy;
- Promotes students' environmental stewardship;
- **Facilitates students' environmental literacy.**

Environmental literacy is seen as the ultimate goal of environmental education. Disinger and Roth defined environmental literacy as "the capacity of citizens to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems" (1992).

Environmental literacy depends in part on scientific literacy and is an important goal of citizen science programs and curricula. It is an *Enduring* concept that students need to understand.

Intended Framework Audience

- Educators who work with middle school students;
- Nature centers and environmental education stations that have a citizen science component, or wish to implement one;
- Non-Governmental Organizations;
- Curriculum & citizen science program developers.

Framework Design

The framework was designed using Wiggins & McTighe's "Understanding by Design" curriculum development process which consists of three steps.

- Step 1: Identify desired results and skills, i.e., content standards & guidelines.

What is worthy and requiring of understanding?

- Step 2: Determine acceptable evidence of learning, i.e., performance standards & guidelines.

What is evidence of understanding?

- Step 3: Plan learning experiences and instruction, i.e., curriculum material.

What learning experiences and teaching promote understanding, interest, and excellence?

The framework provides desired results for citizen science curricula (Step 1). It also shows acceptable evidence as suggested by the NAAEE to meet the guidelines (Step 2), as well as corresponding state and national standards located in the *Extended Version*. The planning of curriculum materials (Step 3) is to be completed by program developers once the necessary guidelines and assessments have been identified.

Framework Layout

The framework is comprised of various sections. (See sample on page 6.)

- Characteristics recommended for citizen science programs and curriculum.
- A sample guideline that shows each page layout.
- Four theme strands that address specific knowledge and skills addressed in the NAAEE *Guidelines*, with wording modifications that focus specifically on citizen science.
- Individual guidelines from the previous strands followed by example performance guidelines that provide suggestions for student assessment.
- The Wisconsin and national standards addressed and their page locations in the *Extended Version*, abbreviated *EV*.
- Characteristics addressed by each guideline. Throughout the framework they are abbreviated as "CRS".
- Enduring & Important Understanding:
    - Enduring: Foundations, skills, knowledge, and characteristics seen as imperative for effective citizen science curriculum and/or programs. These guidelines refer to the "big ideas" and concepts that students should retain beyond the experience.
    - Important Understanding: Wiggins & McTighe describe these as "prerequisite knowledge and skills needed by students for them to successfully accomplish key performances". They can also be seen as less imperative at a particular time period but may become Enduring later.
- A brief evaluation tool that looks at how well individual guidelines are addressed by a program's curriculum.

Extended Version

The *Extended Version* presents the same information in a different, more descriptive format. It also includes extensive content and performance standards for Wisconsin and the nation, additional references, and information on various citizen science programs. This document can be accessed at www.eeinwisconsin.org.

Citizen Science Program Characteristics

The development, implementation, and evaluation of citizen science curricula relies on numerous factors. The following 15 characteristics, goals, and recommendations offer guidance to successful program and curriculum development. They were identified by citizen science professionals and can contribute to students' environmental literacy. Their implementation may also assist in successfully meeting the 28 guidelines of environmental literacy and correlate with appropriate guidelines where applicable

***The italicized "Guidelines" indicate correlations with NAAEE's* Guidelines for Learning (Pre K – 12) *(2004)*.**

The following are *Enduring* goals, characteristics, and recommendations for successful citizen science programs and curriculum. They are referred to as "CRS" throughout the framework.

1. **Citizen science programs are a multi-disciplinary educational approach that relies on many fields. *All Guidelines***
2. **In citizen science programs, students reflect on what they have done or learned. *Guidelines 1, 8, 22, 23, 25, & 28***
3. **In citizen science programs, students are empowered through increased personal responsibility for learning. *Guidelines 1, 2, 3, 4, 5, 6, 8, 19, 20, 21, 23, 24, 27, & 28***
4. **In citizen science programs, students conduct valuable research that assists in meeting research objectives. *Guidelines 1, 2, 3, 4, 11, & 21***
5. **Citizen science programs bring scientists and sponsoring organizations together with students. *Guidelines 1, 2, 13, 19, & 21***
6. **In citizen science programs, students are involved in the data collection process. *Guidelines 2, 3, 4, & 21***
7. **Student participation in citizen science develops a greater awareness of cause and effect relationships and its limitations to manipulation in citizen science programs. *Guidelines 1, 2, 4, 5, 6, 8, 9, 10, 13, 14, 16, 17, 18, 19, 20, & 21***

The following are *Important* goals, characteristics, and recommendations for successful citizen science programs and curriculum. They are referred to as "CRS" throughout the framework.

1. **Citizen science programs are a component of curriculum to help meet state and national education standards. *All Guidelines***
2. **In citizen science programs, students learn about and apply scientific methodologies through first-hand experience. *Guidelines 1, 2, 3, 4, 5, 11, 13, & 21***
3. **In citizen science programs, students assist in answering scientific questions developed within the scientific community. *Guidelines 2, 3, 4, 5, 6, 8, 18, & 21***
4. **In citizen science programs, student-collected data are valid and reliable if following rigorous protocols or verified by experts. *Guidelines 2, 4, & 21***
5. **In citizen science programs, students are in the out-of-doors learning about natural resources. *Guidelines 2, 3, 10, & 21***
6. **Citizen science programs also involve students in an in-door setting to learn about natural resources, i.e. energy audits. *Guidelines 2, 3, & 21***
7. **In citizen science programs, students can develop their own scientific protocol following previous experiences. *Guidelines 1 & 6***
8. **In citizen science programs, students interpret data. *Guidelines 4, 5, 6, 9, 11, & 18***

Framework Sample

Strand Title, Theme & Description: Subsequent Guidelines Address Strand

Individual Environmental Literacy Guideline

Example Performance Guidelines

Enduring Understanding: Strand 1

Strand 1: Guidelines for Questioning, Analysis, and Interpretation Skills: Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Citizen science provides learners with opportunities to develop some of the skills and knowledge of environmental literacy through first-hand participation. Learners participating in citizen science gain familiarity with inquiry, become skilled in fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.

Guideline 1:

Students are able to develop, focus and explain questions that help them learn about the environment and do environmental investigations.

How well is this guideline addressed?

1 – Very Well Addressed ☐
2 – Partly Addressed ☐
3 – Not At All ☐

Comments:

Example Performance Guidelines:

Identify environmental questions based on personal experiences both in and outside school, newspaper and magazine articles, television or radio news, or videos.

Pose clear questions and ideas to test (hypotheses), reforming them when necessary.

Clarify their own beliefs about the environment and discuss how those beliefs are reflected in the questions they ask.

Standards Addressed: Geography, Math & Science (*EV* page 13)

Enduring CRS: 1, 2, 3, 4, 5, & 7; Important CRS: 1, 2 & 7

Curriculum Evaluation Tool

Citizen Science Program Characteristics (CRS) Addressed by Guideline

Standards Addressed by the Guideline & Cross Reference Location in *Extended Version*

Enduring Understanding: Strand 1

Strand 1: Guidelines for Questioning, Analysis, and Interpretation Skills: Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Citizen science provides learners with opportunities to develop some of the skills and knowledge of environmental literacy through first-hand participation. Learners participating in citizen science gain familiarity with inquiry, become skilled in fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.

Guideline 1: Students are able to develop, focus and explain questions that help them learn about the environment and do environmental investigations. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Identify environmental questions based on personal experiences both in and outside school, newspaper and magazine articles, television or radio news, or videos. Pose clear questions and ideas to test (hypotheses), reforming them when necessary. Clarify their own beliefs about the environment and discuss how those beliefs are reflected in the questions they ask. **Standards Addressed: Geography, Math & Science (*EV* page 13)** **Enduring CRS: 1, 2, 3, 4, 5, & 7; Important CRS: 1, 2 & 7**
Guideline 2: Students are able to locate and collect reliable information about the environment or environmental topics using a variety of methods and sources. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Observe systematically, measure accurately, and keep thorough and accurate records. Understand and use various systems of measurement and derived measurements. Assess, choose, and synthesize materials from resources such as aerial photographs, topographic maps, and satellite images; library and museum collections, historical documents, and eyewitness accounts; computerized databases and spreadsheets; the internet; and government records. Collect firsthand information about their own community using field study skills. **Standards Addressed: Arts, ELA, History, Math, Science & Social Studies (*EV* page 14)** **Enduring CRS: 1, 3, 4, 5, 6, & 7; Important CRS: 1, 2, 3, 4, 5, & 6**

Important to Know & Do: Strand 1	
Guideline 3: Students are able to design environmental investigations to answer particular questions – often their own questions**.** **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Select types of inquiry appropriate to their questions. Define the scope of their inquiry, identifying the main variables and phenomena to be studied. Select appropriate systems of measurement and observation. Select tools that are appropriate for their environmental investigations based on the questions asked and the type of information sought. **Standards Addressed: Math & Science (*EV* page 15)** **Enduring CRS: 1, 3, 4, & 6; Important CRS: 1, 2, 3, 5, & 6**
Guideline 4: Students are able to assess the strengths and weaknesses of the information they are using. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Identify and evaluate vague claims they hear on television or through other media. Identify factors that affect the credibility of information, including assumptions and procedures used to create it; the social, political, and economic context in which the information was created; and potential bias due to omission, suppression, or invention of factual information. Examine evidence, identify faulty reasoning, and apply other basic logic and reasoning skills in evaluating information sources. Identify gaps in information that indicate a need for further discovery or inquiry. Evaluate data and evidence for accuracy, relevance, significance, appropriateness**,** and clarity. **Standards Addressed: History, Math & Science (*EV* page 16)** **Enduring CRS: 1, 3, 4, 6 & 7; Important CRS: 1, 2, 3, 4, & 8**

Guideline 5: Students are able to classify and order data, and organize and display information in ways that help analysis and interpretation. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Present environmental data in a variety of formats including charts, tables, plots, graphs, maps, and flow charts. Explain why they chose specific ways of ordering and displaying information. Consider factors such as the question being answered, the type of information, and the purpose of the display. Present environmental data in ways that demonstrate possible relationships between sets of information such as population census counts of bird species and the prevalence of certain tree species or habitat types. **Standards Addressed: Arts, ELA, Geography, Math & Science (*EV* page 17)** **Enduring CRS: 1, 3 & 7; Important CRS: 1, 2, 3, & 8**
Guideline 6: Students are able to synthesize their observations into coherent explanations. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Distinguish between description and explanation and give examples of each based on their own environmental investigations. Consider the possible relationships among two or more variables. Propose explanations based on what they observed or learned through research, selecting which evidence to use and accounting for discrepancies. Synthesize and interpret information from a range of sources. List strengths and weaknesses of proposed explanations. Discuss how the proposed explanation could be rejected or its reliability improved. Use proposed explanations to form new questions and suggest new avenues of inquiry. **Standards Addressed: ELA, Geography, History, Math & Science (*EV* page 18)** **Enduring CRS: 1, 3 & 7; Important CRS: 1, 3, 7, & 8**

Enduring Understanding: Strand 2

Strand 2 – Guidelines for Knowledge of Environmental Processes & Systems: Gaining an understanding of the processes and systems that comprise the environment, including human social systems and influences is an important component of environmental literacy. That understanding is based on knowledge synthesized from across traditional disciplines. Environmental processes and systems addressed by citizen science are dependent on the types of projects learners are involved in.

Guideline 7 – The Living Environment: Students understand that biotic communities are made up of plants and animals that are uniquely adapted to live in particular environments. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Define and give examples to illustrate the concepts of species, population, community, and ecosystem. Trace and give examples of connections among organisms at those levels of organization. Link features of internal and external anatomy with the ability of organisms to make or find food and reproduce in particular environments. Understand that some animals and plant s have adapted to extreme environmental conditions. Give examples that are behavioral (e.g., the migration of Canada geese and other birds) and physical (e.g., physical structures that enable desert animals and plants to exist on minimal amounts of water). Describe how organisms differ in how they use energy. For example, identify organisms that use energy quickly for growth and metabolism, and therefore must replace it quickly (e.g., a hummingbird) and others that use energy more slowly and therefore need to replace it less frequently (e.g., a python). Predict the habitat needs of these different types of organisms. **Standards Addressed: Geography & Science (*EV* page 20)** **Enduring CRS: 1; Important CRS: 1**
Guideline 8 – Environment & Society: Students are able to explain that human-caused changes have consequences for the immediate environment as well as for other places and future times. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Describe intended and unintended environmental and social consequences associated with the changing use of technologies. Consider consequences that may be positive as well as negative. Explain how human-caused environmental changes cause changes in other places on human and natural environments. Describe the effects of a local environmental restoration effort, such as wetlands creation. Predict the long-term consequences of such efforts, or a particular restoration project. **Standards Addressed: Geography & Science (*EV* page 21)** **Enduring CRS: 1, 2, 3, & 7; Important CRS: 1 & 3**

Important to Know & Do: Strand 2

Guideline	Example Performance Guidelines
Guideline 9 – The Earth As a Physical System: Students are able to relate the differences in physical patterns to their causes, e.g. how seasonal change is affected by the Earth/sun relationship. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Analyze physical patterns such as climate, areas or geothermal activity, soil types, and arid regions, suggesting reasons for these patterns. Explain these patterns in terms of abrupt forces (such as earthquakes or major storms) and long-term processes (such as erosion and rock formation), as well as those that are human-caused (such as suburban development or agricultural practices). Predict the consequences of specific physical phenomena such as a hurricane in a coastal area or heavy grazing in an arid region. Relate physical processes and patterns (such as climate, weather phenomena, and seasonal change) to the Earth/sun relationship. **Standards Addressed: Science (*EV* page 22)** **Enduring CRS: 1 & 7; Important CRS: 1 & 8**
Guideline 10 – The Living Environment: Students recognize and describe the importance of genetic variation in species and possible implications of species extinction. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Describe some ways in which variation among individuals of the same species can sometimes give certain individuals an advantage within a specific environment. Describe in general terms the theory of natural selection for particular traits and how that process can result in descendants that are quite different from their ancestors. Define extinction, cite evidence of extinction, and identify some of its causes. Discuss the possible implications of permanent loss of a species and how it affects interdependence within an ecosystem. **Standards Addressed: Science (*EV* page 23)** **Enduring CRS: 1 & 7; Important CRS: 1 & 5**

Guideline 11 – The Living Environment: Students identify and describe major kinds of interactions among organisms or populations of organisms. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Describe and give examples of producer/consumer, predator/prey, and parasite/host relationships. Identify organisms that are scavengers or decomposers. Describe the roles they play within particular systems focusing on their relationship to other organisms and physical elements of the system. Summarize how abiotic and biotic components combine to influence the structure of an ecosystem. For example, create a map for the local region that shows average temperature and rainfall correlated with local forest, grassland or desert ecosystems. Or discuss the process of soil formation in terms of the interaction of climate, geology, and living organisms. **Standards Addressed: Geography & Science (*EV* page 24)** **Enduring CRS: 1 & 6; Important CRS: 1, 2 & 8**
Guideline 12 – The Living Environment: Students describe how energy and matter flow among the biotic and abiotic components of the environment. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Trace the flow of energy through food webs that identify relationships among organisms in natural systems. Explain how matter is transferred among organisms and between organisms and their environment in these food webs. Describe how energy, which enters ecosystems as sunlight, changes form and is transferred in the exchanges (production, consumption, and decomposition) that comprise food webs. **Standards Addressed: Science (*EV* page 25)** **Enduring CRS: 1; Important CRS: 1 & 2**

Guideline 13 – Humans & Their Societies: Students identify and explain ways in which the world's environmental, societal, economic, cultural, and political systems are linked. Environmental justice would be an appropriate example. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Explain international trade in terms of uneven distribution of resources. Describe ways in which the global environment is affected by individual and group actions, as well as by government policies and actions having to do with energy use and other forms of consumption, waste disposal, resource management, industry, and population. Explain how an environmental change in one part of the world can have consequences for other places. Identify a variety of global links, including transportation and communication systems, treaties, multi-national corporations, and international organizations. **Standards Addressed: Civics & Government, Geography, Science & Social Studies (*EV* page 26)** **Enduring CRS: 1, 5 & 7; Important CRS: 1**
Guideline 14 – Humans & Their Societies: Students explain and analyze that human social systems change over time and that conflicts sometimes arise over differing viewpoints about the environment. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Describe patterns of change within and across cultures, communities, and other groups. Consider the rapidity of change, mechanisms that helped spread change, and what motivated change. Explain how change affects individuals and groups differently and give examples of the trade-offs involved in decisions and actions ranging from the individual to the societal levels. For example, discuss how a decision about where to site a landfill, build a chemical plant, or locate a new highway might affect different neighborhoods, businesses, workers, people of varying socio-economic status, and others. Role-play their reactions. Describe and analyze examples of tensions between individual rights and benefits and the societal good. Identify some of the formal and informal ways that groups (including governments) attempt to anticipate, avoid, or resolve conflicts related to the environment. **Standards Addressed: Science & Social Studies (*EV* page 27)** **Enduring CRS: 1 & 7; Important CRS: 1**

Guideline 15 – Environment & Society: Students explore differences in perceptions and importance of places close to home and around the world. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Analyze physical and human characteristics of places and make inferences about how and why these characteristics have developed and changed over time. For example, use maps and satellite photographs to examine how cities change in response to natural disasters such as floods, hurricanes, or earthquakes. Identify ways in which personal perceptions, culture, and technology influence people's perceptions of places. Discuss the importance of some places (such as Yellowstone National Park or the Mississippi River) as cultural symbols. Identify regions based on different criteria such as watershed boundaries, sales and service areas for different businesses, or the area from which sports teams draw fans or symphony orchestras attract audiences. **Standards Addressed: Arts, Geography & Social Studies (*EV* page 28)** **Enduring CRS: 1; Important CRS: 1**
Guideline 16 – Environment & Society: Students are able to discuss and explain why uneven distribution of resources around the world influences the use of these resources and their perceived value. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Map and discuss distribution and consumption patterns for specific resources, such as metals, fresh water, or certain types of forests. Note resources that are being rapidly depleted. Explain why certain resources (such as oil, coal, or natural gas) are important to development of human societies, and identify resources that were critical to development at different times in history. Explain conflicts between individuals, states, regions, or nations noting factors such as differing attitudes about the use of specific resources and scarcity of natural resources. Illustrate with local or regional examples such as conflicts over water rights and use of habitat for local endangered species. **Standards Addressed: Economics, Geography, History & Science (*EV* page 29)** **Enduring CRS: 1 & 7; Important CRS: 1**

Guideline 17 – Environment & Society: Students relate to and discuss how people in other places around the world experience environmental issues similar to the ones they are concerned about locally. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Identify other places, either contemporary or historical, experiencing issues similar to those in the learner's community or region. Explain how issues arise because of conflicting points of view about a specific proposal, event, or condition in the environment. For example, discuss conflicting perspectives about past and present proposals to build large-scale dams such as the Three Gorges project in China, the Hetch-Hetchy dam in the U.S., or a similar project in the learner's region. Discuss how disagreements at the heart of environmental issues make them difficult to resolve. Consider the role of understanding, creativity, or compromise in finding solutions. **Standards Addressed: Geography (*EV* page 30)** **Enduring CRS: 1 & 7; Important CRS: 1**

Enduring Understanding: Strand 3

Strand 3 – Guidelines for Skills for Understanding & Addressing Environmental Issues: Skills and knowledge are refined and applied in the context of environmental issues. These environmental issues are real-life dramas where differing viewpoints about environmental problems and their potential solutions are played out. Environmental literacy includes the abilities to define, learn about, evaluate, and act on environmental issues, and they are valuable goals to include in citizen science curricula.

Guideline 18 – Skills for Analyzing & Investigating Environmental Issues: Students apply their knowledge of ecological and human processes and systems to identify the consequences of specific environmental issues. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Describe the effects of human actions on specific elements, systems, and processes of the environment. Analyze issues by looking at trade-offs that have been made. For example, consider where various human activities (such as landfills, highways, chemical factories, or hazardous waste incinerators) are located and their effects on different places and different segments of the population. Speculate about the effects of a proposed state or local environmental regulation. For example, consider effects on different sectors of the economy, neighborhoods, public health, particular plant and animal species and communities, and overall environmental quality. Predict the consequences of inaction or failure to resolve particular issues. **Standards Addressed: Geography & Social Studies (*EV* page 32)** **Enduring CRS: 1 & 7; Important CRS: 1, 3 & 8**
Guideline 19 – Skills for Analyzing & Investigating Environmental Issues: Students identify and develop action strategies for addressing particular issue such as environmental stewardship. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Identify different proposals for resolving an environmental issue. Recognize and explain the perspectives on the issue that is embedded in those views. Explain why various strategies may be effective in different situations. Consider their likely effects on society and the environment. Independently and in groups, develop original strategies to address issues. Discern similarities and differences in problem situations which might affect their ability to apply strategies that were successful in other places and times. **Standards Addressed: ELA, History & Social Studies (*EV* page 33)** **Enduring CRS: 1, 3, 5, & 7; Important CRS: 1**

Guideline 20 – Decision-Making & Citizenship Skills: Students begin to see themselves as citizens taking active roles in their communities. They plan for and engage in citizen action at levels appropriate to their maturity and preparation. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Develop action plans they can carry out individually, in small groups, or with a class, club, or larger organization. Include clear reasons and goals for action. Base these plans on knowledge of a range of citizen action strategies and the results of their environmental issue investigations. Set realistic goals for action and include measures of success consistent with learners' abilities and an understanding of the complexity of the issue. Decide whether their plan should be implemented immediately or at another time, changed, or abandoned; and carry through with action when appropriate. **Standards Addressed: Civics & Government & Social Studies (*EV* page 34)** **Enduring CRS: 1, 3 & 7; Important CRS: 1**

Important to Know & Do: Stand 3

Guideline 21 – Skills for Analyzing & Investigating Environmental Issues: Students use primary and secondary sources of information, and apply their growing research and analytical skills to investigate environmental issues, beginning with those in their own community. Primary sources of information are based on first-hand student experiences while secondary sources are gathered from books/literature, community members, teachers, etc.	**Example Performance Guidelines:** Clearly articulate and define environmental issues. For example, describe the history and origins of the issue, actions that have been taken to address the issue, the apparent effects of these actions, and the current situation. Identify key individuals and groups involved, their view points, and the types of action they support. Describe areas of conflict and agreement. Investigate the issue using secondary sources and original research where needed. Examine how others have analyzed and understood the issue, identifying their approaches and the assumptions behind them. Compare the issue with similar issues from other places and times. **Standards Addressed: Geography, History & Social Studies (*EV* page 35)** **Enduring CRS : 1, 3, 4, 5, 6, & 7; Important CRS: 1, 2, 3, 4, 5, & 6**

How well is this guideline addressed? **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	
Guideline 22 – Skills for Analyzing & Investigating Environmental Issues: Students consider the assumptions and interpretations that influence the conclusions they and others draw about environmental issues. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Explain how the interplay of ideas and perspectives strengthens the process of inquiry and the societal ability to address issues. Receive questions and alternative explanations that others offer in discussions as well as in readings. Explain why it is not always possible to select one correct explanation or a single best approach to addressing an issue. **Standards Addressed: Arts, ELA, Geography, Science, & Social Studies (*EV* page 36)** **Enduring CRS: 1 & 2; Important CRS: 1**
Guideline 23 – Decision-Making & Citizenship Skills: Students identify, justify, and clarify their views on environmental issues and alternative ways to address them. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Discuss personal perspectives with classmates, remaining open to new ideas and information. Justify their views based on information from a variety of sources, and clear reasoning. Discuss their own beliefs and values regarding the environment and relate their personal view of environmental issues to these. Identify ways in which others' views correspond or differ with their own views. **Standards Addressed: Arts, Geography, History & Social Studies (*EV* page 37)** **Enduring CRS: 1, 2 & 3; Important CRS: 1**

Guideline 24 – Decision-Making & Citizenship Skills: Students evaluate whether they believe action is needed in particular situations, and decide whether they should be involved. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Discuss whether action is warranted. Account for factors such as the scale of the problem; legal, social, economic, and ecological consequences; and alternatives to citizen action. Identify different forms of action that citizens can take in the economic, political, and legal spheres, as well as actions aimed at directly improving or maintaining some part of the environment or persuading others to take action. Speculate about the likely effects of specific actions on society and the environment, and the likelihood these actions will resolve a specific environmental issue. Point out advantages and disadvantages of their personal involvement, considering factors such as their own skills, resources, knowledge, and commitment. **Standards Addressed: Social Studies (*EV* page 38)** **Enduring CRS: 1 & 3; Important CRS: 1**
Guideline 25 – Decision-Making & Citizenship Skills: Students evaluate the effects of their own actions and actions taken by other individuals and groups. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Analyze the effects of decisions, policies, and actions taken by individuals and groups on a particular issue. Analyze their own actions, explaining apparent effects and discussing them in light of students' goals and reasons for acting. Describe some of the reasons why analyzing the results of actions may be difficult, including the scale of the issue, the time required to see effects, and the influence of other actions and factors. **Standards Addressed: History & Social Studies (*EV* page 39)** **Enduring CRS: 1 & 2; Important CRS: 1**

Important to Know & Do: Strand 4

Strand 4 – Guidelines for Personal & Civic Responsibility: Environmentally literate citizens are willing and able to act on their own conclusions about what should be done to ensure environmental quality. As learners develop and apply concept-based learning and skills for inquiry, analysis, and action, they also understand that what they do individually and in groups can make a difference. Citizen science curricula should be developed with learners in mind in order to meet the following personal and civic responsibilities.

Guideline 26: Students identify and describe the rights and responsibilities of citizenship and their importance in promoting the resolution of environmental issues. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Identify rights and responsibilities associated with citizenship, including personal and civic responsibilities. Describe ways in which commonly accepted rights and responsibilities of citizenship motivate people to help resolve environmental issues. Consider rights and responsibilities such as acquiring, using and selling property; the right to vote; freedom of speech and assembly; accepting responsibility for the consequences of one's actions; obeying the law; and respecting the rights and interests of others. **Standards Addressed: Civics & Government & Social Studies (*EV* page 41)** **Enduring CRS: 1; Important CRS: 1**
Guideline 27: Students possess a realistic self-confidence in their effectiveness as citizens. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	**Example Performance Guidelines:** Explain the ways in which citizen action and public opinion influence environmental policy decisions. Describe how individuals and groups act within society to create change, meet individual needs and promote the common good. Illustrate with examples from environmental issues. Describe ways in which their actions have made a difference. Use examples that begin in the classroom and the home, and extend beyond to encompass the broader communities in which students begin to see possibilities for action. **Standards Addressed: Civics & Government & Social Studies (*EV* page 42)** **Enduring CRS: 1 & 3; Important CRS: 1**

Guideline 28:	Example Performance Guidelines:
Students understand that their actions can have broad consequences and that they are responsible for those consequences. **How well is this guideline addressed?** **1 – Very Well Addressed** ☐ **2 – Partly Addressed** ☐ **3 – Not At All** ☐ **Comments:**	Analyze some of the effects that their actions (and the actions of their families, social groups, and communities) have on the environment, other humans, and other living beings. Describe actions in terms of their effects that reach into the future. Describe their personal responsibilities, comparing their view of their responsibilities with commonly accepted societal views. Identify ways in which they feel responsible for helping resolve environmental issues within their community. **Standards Addressed: Civics & Government (*EV* page 43)** **Enduring CRS: 1, 2, & 3; Important CRS: 1**

Appendix X: Curriculum Framework – Extended Version

Field Inquiry through Citizen Science: A Framework for Environmental Literacy (5^{th}-8^{th} Grades) - Extended Version

Framework Acknowledgements

The framework was created as a partial requirement for a Master of Science in Natural Resources – Environmental Education by Scott Reilly of the University of Wisconsin, Stevens Point (UWSP) with the assistance of his graduate committee. Committee members included Drs. Dan Sivek and Dennis Yockers of the College of Natural Resources, and Dr. Perry Cook of the College of Professional Studies on the campus of UWSP.

Finally, with much appreciation to the representatives of the following organizations who assisted in the framework development: University of Minnesota, Smithsonian Institute, GREEN/Earth Force, Washington Department of Fish & Wildlife, Cornell Lab of Ornithology, Great Smoky Mountains Institute at Tremont, University of MN, Duluth – Great Lakes Worm Watch, Sigurd Olson Environmental Institute – Northland College, Beaver Creek Reserve, Bronx River Alliance, Minnesota Odonata Survey Project, and Lake Erie-Allegheny Earth Force.

Table of contents:

The Need for a Citizen Science Framework

Citizen science reaches large and varied audiences from local communities and regions to the entire nation and beyond. There are many opportunities for educators to incorporate lessons and aspects of citizen science into their classrooms and programs. The development of age appropriate curriculum to meet state and national standards, while contributing to students' environmental literacy, can also promote citizen science objectives.

The *Field Inquiry through Citizen Science* framework was developed to assist teachers and program developers clarify the focus of their curriculum. The framework guidelines give desired outcomes for student participation in citizen science, and provide a starting point for curriculum development based on Wiggins & McTighe's "Understanding by Design". By developing curricula and programs that address the enclosed guidelines, educators and program developers can increase students' environmental literacy while meeting educational standards.

The framework is meant as a guide, a place to start to improve current curricula. Finally, while the framework addresses grades five through eight, it may serve as a guiding document for high school and primary school students.

Standards-Based Education

In the 1990s state and the national governments developed educational standards that have been widely adopted by school districts around the country. In order to meet the changing educational climate, the North American Association for Environmental Education (NAAEE) developed the *Excellence in Environmental Education- Guidelines for Learning (Pre K-12).* These guidelines set voluntary student expectations for environmental education curricula and programs in order to increase student's environmental literacy while meeting these new educational standards. The guidelines provide specific content expectations and examples of achievement, and can be applied successfully to developing citizen science curricula.

The *Field Inquiry through Citizen Science* framework aims to unify those guidelines specific to citizen science and how they can contribute to enhancing students' environmental literacy. The framework guidelines correlate with Wisconsin state and national educational standards. Also included are those contributing characteristics valuable in guiding curriculum development. The framework is meant to provide achievable goals for program developers, teachers, and students alike.

Citizen Science & Its Importance to Environmental Literacy

According to the Cornell Laboratory of Ornithology, citizen science is a form of environment-based learning in which students (and adults) are actively engaged in the scientific process by working with scientists to address "real-world questions." The active engagement in citizen science by students can have numerous benefits.

- Develops students' skills in leadership, critical thinking, & teamwork;
- Increases students' sense of ownership and empowerment in addressing environmental issues;
- Addresses state & national standards;
- Addresses multiple disciplines & intelligences;
- Contributes to students' environmental literacy;
- Promotes students' environmental stewardship;
- **Facilitates students' environmental literacy.**

Environmental literacy is seen as the ultimate goal of environmental education. Disinger and Roth defined environmental literacy as "the capacity of citizens to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems" (1992).
Environmental literacy depends in part on scientific literacy and is an important goal of citizen science programs and curricula. It is an *Enduring* concept that students need to understand.

Intended Framework Audience

- Educators who work with middle school students;
- Nature centers and environmental education stations that have a citizen science component, or wish to implement one;
- Non-Governmental Organizations;
- Curriculum & citizen science program developers.

Framework Organization

Unders tanding by Design:

The "Citizen Science Curriculum Framework" was developed using Wiggins and McTighe's curriculum development process entitled "Understanding by Design" and which consists of three steps.

- Step 1: Identify desired results and skills, i.e., content standards.

  What is worthy and requiring of understanding?
- Step 2: Determine acceptable evidence of learning, i.e, performance standards.

  What is evidence of understanding?
- Step 3: Plan learning experiences and instruction, i.e., curriculum material and lessons.

  What learning experiences and teaching promote understanding, interest, and excellence?

The framework provides desired results for citizen science curriculum (Step 1) and acceptable evidence as suggested by the NAAEE to meet the guidelines of environmental literacy (Step 2), as well as state and national standards. The planning of curriculum materials (Step 3) is to be completed by program developers once the necessary guidelines and assessments have been identified.

The framework includes:

1. Fifteen program characteristics of citizen science that contribute to environmental literacy:

    Citizen Science Program Characteristics (15 Characteristics): The development, implementation, and evaluation of citizen science curriculum relies on numerous factors. The following 15 characteristics provide goals and recommendations that offer guidance to successful program and curriculum development. They were identified by citizen science professionals and can contribute to students' environmental literacy. Their implementation may also assist in successfully meeting the 28 guidelines of environmental literacy and correlate with appropriate guidelines where applicable.

2. Four strand that address specific knowledge and skills addressed in the NAAEE *Guidelines*, with wording modifications that specifically focus on citizen science.

    1) **Strand 1: Questioning, Analysis, and Interpretation Skills (6 Guidelines)**: Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Citizen science provides learners with opportunities to develop some of the skills and knowledge of environmental literacy through first-hand participation. Learners participating in citizen science gain familiarity with inquiry, become skilled in fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.

    2) **Strand 2: Knowledge of Environmental Processes and Systems (11 Guidelines)**: Gaining an understanding of the processes and systems that comprise the environment, including human social systems and influences, is an important component of environmental literacy. That understanding is based on knowledge synthesized from across traditional disciplines. Environmental processes and systems addressed by citizen science are dependent on the types of projects learners are involved in.

    3) **Strand 3: Skills for Understanding and Addressing Environmental Issues (8 Guidelines)**: Skills and knowledge are refined and applied in the context of environmental issues. These environmental issues are real-life dramas where differing viewpoints about environmental problems and their potential solutions are played out. Environmental literacy includes the abilities to define, learn about, evaluate, and act on environmental issues, and are valuable targets to include in citizen science curricula.

    4) **Strand 4: Personal and Civic Responsibility (3 Guidelines)**: Environmentally literate citizens are willing and able to act on their own conclusions about what

should be done to ensure environmental quality. As learners develop and apply concept-based learning and skills for inquiry, analysis, and action, they also understand that what they do individually and in groups can make a difference. Citizen science curricula need to be developed with learners in mind in order to meet the following personal and civic responsibilities.

3. Individual guidelines from the above strands followed by example performance guidelines that provide suggestions for student assessment.

4. Cross references for individual guidelines with corresponding Wisconsin state standards in English Language Arts, Mathematics, Science, and Social Studies. Also included are national standards in the previous four subject areas, plus Arts, Civics & Government, Economics, Geography, and History. Appendices at the end of the framework show original Wisconsin state and national content standards and provide performance standards to measure student progress. The original source and page numbers for each standard are given as well.

5. The program characteristics and individual guidelines are broken into two categories.

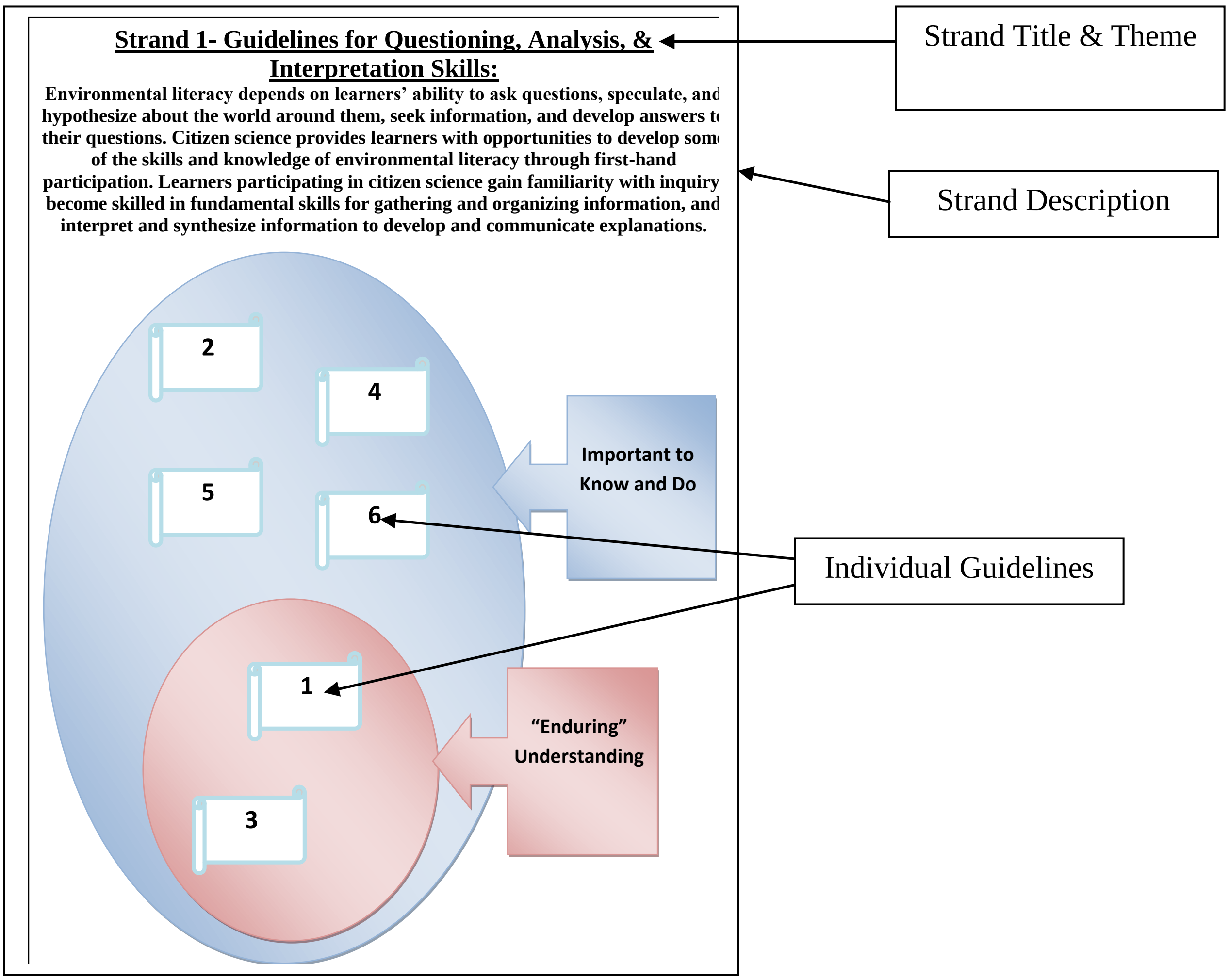
    Enduring Understanding/ Enduring Citizen Science Characteristics: Foundations, skills, knowledge, and characteristics seen as imperative for effective citizen science curriculum and/or programs. These guidelines refer to the "big ideas" and concepts that students should retain.

    Important to Know & Do/ Important Citizen Science Characteristics: Wiggins & McTighe describe these as "prerequisite knowledge and skills needed by students for them to successfully accomplish key performances". They can also be seen as less imperative at a particular time period but may become Enduring later.

6. Finally, individual guidelines are correlated with program characteristics.

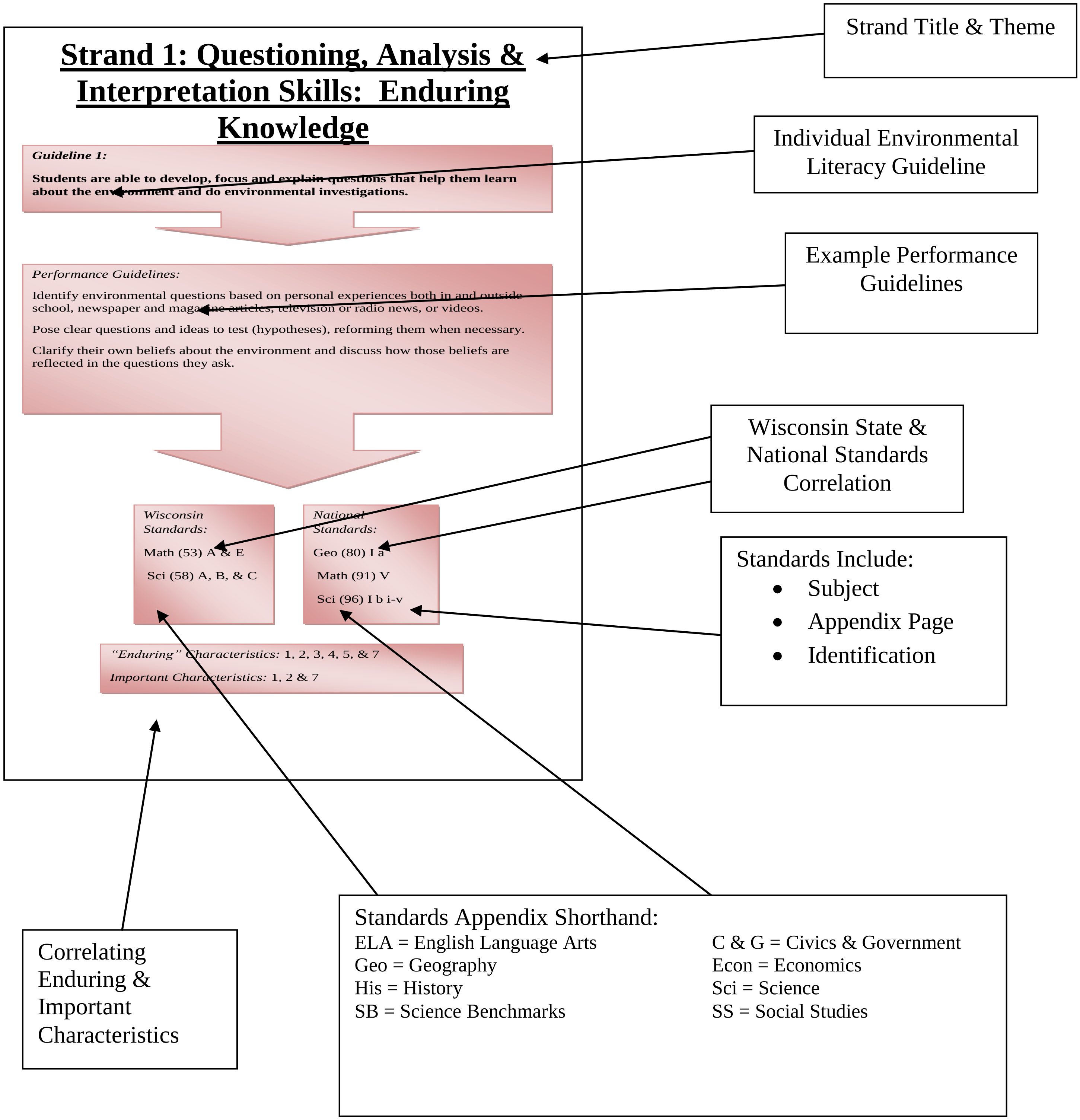
How to interpret the guidelines:

Each strand is laid out the same with a strand title, description, and guidelines that are "Important to Know and Do" or are "Enduring Understandings". All Enduring guidelines and characteristics are red, while blue indicates "Important".



Environmental Literacy Guidelines

Each guideline is laid out beginning with the strand title and importance, individual guideline, followed by example performance guidelines, state and national standards and program characteristic correlations.



<u>Citizen Science Program Characteristics</u>:

The development, implementation, and evaluation of citizen science curriculum rely on numerous factors. The following 15 characteristics, goals, and recommendations offer guidance to successful program and curriculum development. They were identified by citizen science professionals and can contribute to students' environmental literacy. Their implementation may also assist in successfully meeting the 28 guidelines of environmental literacy and correlate with appropriate guidelines where applicable

***The italicized "Guidelines" indicate correlations with NAAEE's* Guidelines for Learning (Pre K – 12) *(2004)*.**

The following are *Enduring* goals, characteristics, and recommendations for successful citizen science programs and curriculum.

8. **Citizen science programs are a multi-disciplinary educational approach that relies on many fields. *All Guidelines***

9. **In citizen science programs, students reflect on what they have done or learned. *Guidelines 1, 8, 22, 23, 25, & 28***

10. **In citizen science programs, students are empowered through increased personal responsibility for learning. *Guidelines 1, 2, 3, 4, 5, 6, 8, 19, 20, 21, 23, 24, 27, & 28***

11. **In citizen science programs, students conduct valuable research that assists in meeting research objectives. *Guidelines 1, 2, 3, 4, 11, & 21***

12. **Citizen science programs bring scientists and sponsoring organizations together with students. *Guidelines 1, 2, 13, 19, & 21***

13. **In citizen science programs, students are involved in the data collection process. *Guidelines 2, 3, 4, & 21***

14. **Student participation in citizen science develops a greater awareness of cause and effect relationships and its limitations to manipulation in citizen science programs. *Guidelines 1, 2, 4, 5, 6, 8, 9, 10, 13, 14, 16, 17, 18, 19, 20, & 21***

Citizen Science Program Characteristics:

The following are *Important* goals, characteristics, and recommendations for successful citizen science programs and curriculum.

1. **Citizen science programs are a component of curriculum to help meet state and national education standards.** ***All Guidelines***

2. **In citizen science programs, students learn about and apply scientific methodologies through first-hand experience.** ***Guidelines 1, 2, 3, 4, 5, 11, 13, & 21***

3. **In citizen science programs, students assist in answering scientific questions developed within the scientific community.** ***Guidelines 2, 3, 4, 5, 6, 8, 18, & 21***

4. **In citizen science programs, student-collected data are valid and reliable if following rigorous protocols or verified by experts.** ***Guidelines 2, 4, & 21***

5. **In citizen science programs, students are in the out-of-doors learning about natural resources.** ***Guidelines 2, 3, 10, & 21***

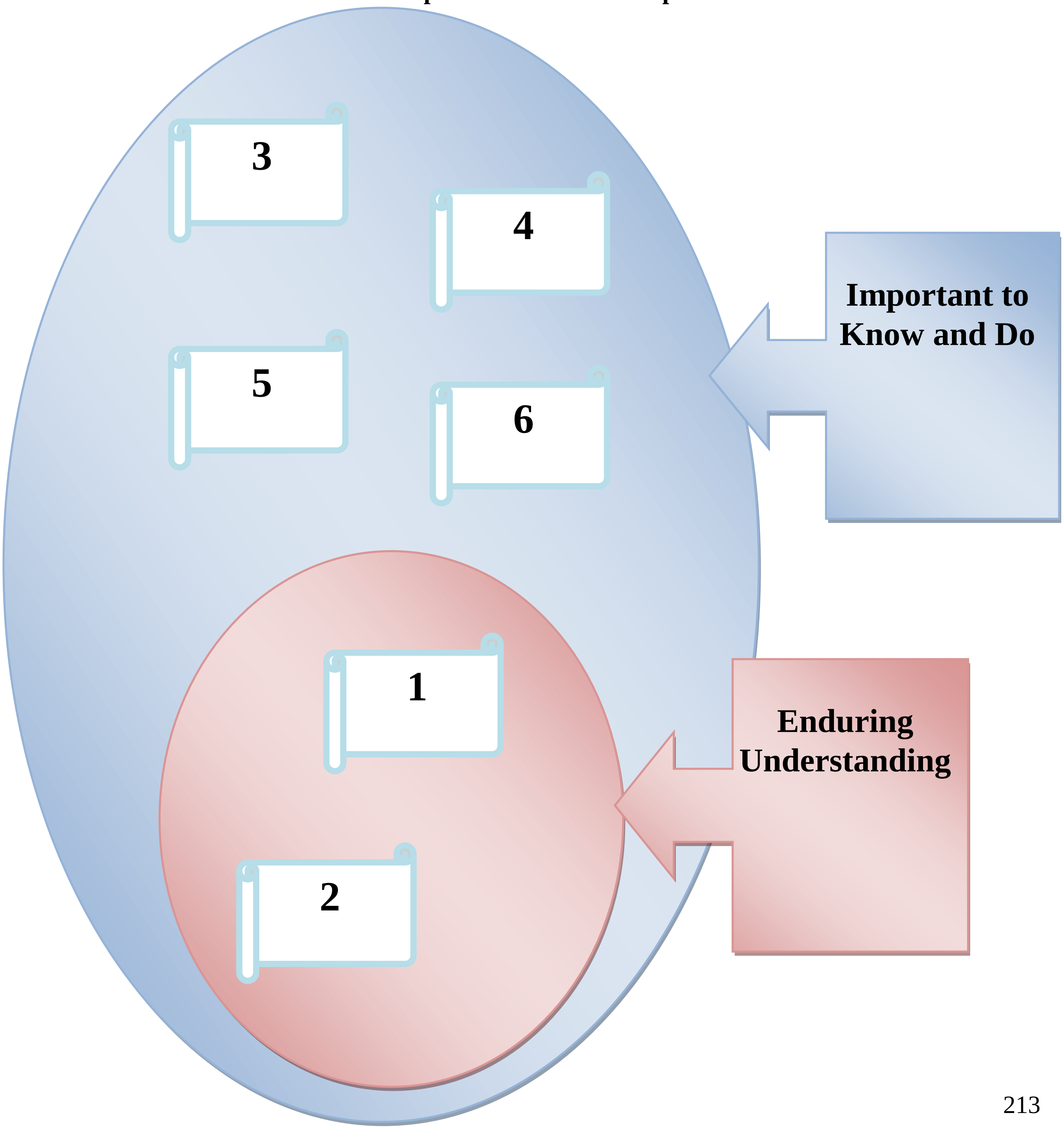
6. **Citizen science programs also involve students in an in-door setting to learn about natural resources, i.e. energy audits.** ***Guidelines 2, 3, & 21***

7. **In citizen science programs, students can develop their own scientific protocol following previous experiences.** ***Guidelines 1 & 6***

8. **In citizen science programs, students interpret data.** ***Guidelines 4, 5, 6, 9, 11, & 18***

Strand 1- Guidelines for Questioning, Analysis, & Interpretation Skills:

Environmental literacy depends on learners' ability to ask questions, speculate, and hypothesize about the world around them, seek information, and develop answers to their questions. Citizen science provides learners with opportunities to develop some of the skills and knowledge of environmental literacy through first-hand participation. Learners participating in citizen science gain familiarity with inquiry, become skilled in fundamental skills for gathering and organizing information, and interpret and synthesize information to develop and communicate explanations.



Strand 1- Questioning, Analysis, & Interpretation Skills: Enduring Understanding

Guideline 1:
Students are able to develop, focus and explain questions that help them learn about the environment and do environmental investigations.

Performance Guidelines:
Identify environmental questions based on personal experiences both in and outside school, newspaper and magazine articles, television or radio news, or videos.
Pose clear questions and ideas to test (hypotheses), reforming them when necessary.
Clarify their own beliefs about the environment and discuss how those beliefs are reflected in the questions they ask.

Wisconsin Standards:
Math (53) A & E
Sci (58) A, B, & C

National Standards:
Geo (80) I a
Math (91) V
Sci (96) I b i-v

Enduring Characteristics: 1, 2, 3, 4, 5, & 7
Important Characteristics: 1, 2 & 7

Strand 1- Questioning, Analysis, & Interpretation Skills: Enduring Understanding

Guideline 2:
Students are able to locate and collect reliable information about the environment or environmental topics using a variety of methods and sources.

Performance Guidelines:
Observe systematically, measure accurately, and keep thorough and accurate records.
Understand and use various systems of measurement and derived measurements.
Assess, choose, and synthesize materials from resources such as aerial photographs, topographic maps, and satellite images; library and museum collections, historical documents, and eyewitness accounts; computerized databases and spreadsheets; the internet; and government records.
Collect firsthand information about their own community using field study skills.

Wisconsin Standards:
ELA (45) A, E, & F
Math (53) B, C, D, & F
Sci (58) A, B, & C
SS (64) A

National Standards:
Arts (69) II
ELA (79) I, IV, & V
Geo (80) I b, & II
His (89) I a
Math (91) I – IV
SB (101) IV b
Sci (96) I b i-v
SS (106) III

Enduring Characteristics: 1, 3, 4, 5, 6, & 7
Important Characteristics: 1, 2, 3, 4, 5, & 6

Strand 1- Questioning, Analysis, & Interpretation Skills: Important to Know & Do

Guideline 3:
Students are able to design environmental investigations to answer particular questions – often their own questions.

Performance Guidelines:
Select types of inquiry appropriate to their questions.
Define the scope of their inquiry, identifying the main variables and phenomena to be studied.
Select appropriate systems of measurement and observation.
Select tools that are appropriate for their environmental investigations based on the questions asked and the type of information sought.

Wisconsin Standards:
Math (53) A & E
Sci (58) A, B, & C

National Standards:
Math (91) V
Sci (96) I b

Enduring Characteristics: 1, 3, 4, & 6
Important Characteristics: 1, 2, 3, 5, & 6

Strand 1- Questioning, Analysis, & Interpretation Skills: Important to Know & Do

Guideline 4:
Students are able to assess the strengths and weaknesses of the information they are using.

Performance Guidelines:
Identify and evaluate vague claims they hear on television or through other media. For example, examine the credibility of results of public opinion polling about environmental topics, considering such factors as sampling methods, logical conclusions, and appropriate analogies.
Identify factors that affect the credibility of information, including assumptions and procedures used to create it; the social, political, and economic context in which the information was created; and potential bias due to omission, suppression, or invention of factual information.
Examine evidence, identify faulty reasoning, and apply other basic logic and reasoning skills in evaluating information sources.
Identify gaps in information that indicate a need for further discovery or inquiry.
Evaluate data and evidence for accuracy, relevance, significance, appropriateness, and clarity.

Wisconsin Standards:
Math (53) B & E
Sci (58) A, B, & C

National Standards:
His (89) I a
Math (91) V & VI
Sci (96) I a & I b vi-ix

Enduring Characteristics: 1, 3, 4, 6, & 7
Important Characteristics: 1, 2, 3, 4, & 8

Strand 1- Questioning, Analysis, & Interpretation Skills: Important to Know & Do

Guideline 5:
Students are able to classify and order data, and organize and display information in ways that help analysis and interpretation.

Performance Guidelines:
Present environmental data in a variety of formats including charts, tables, plots, graphs, maps, and flow charts. For example, chart stream flows, create a map of local businesses that require air quality permits, or organize survey results into a table.
Explain why they chose specific ways of ordering and displaying information. Consider factors such as the question being answered, the type of information, and the purpose of the display.
Present environmental data in ways that demonstrate possible relationships between sets of information such as population census counts of bird species and the prevalence of certain tree species or habitat types.

Wisconsin Standards:
ELA (45) B
Math (53) A, E, & F
Sci (58) A, B, & C

National Standards:
Arts (69) III
ELA (79) III
Geo (80) I c & II
Math (91) II, V, VII, & VIII
Sci (96) I b i-v

Enduring Characteristics: 1, 3 & 7
Important Characteristics: 1, 2, 3, & 8

Strand 1- Questioning, Analysis, & Interpretation Skills: Important to Know & Do

Guideline 6:
Students are able to synthesize their observations into coherent explanations.

Performance Guidelines:
Distinguish between description and explanation and give examples of each based on their own environmental investigations.
Consider the possible relationships among two or more variables.
Propose explanations based on what they observed or learned through research, selecting which evidence to use and accounting for discrepancies. Synthesize and interpret information from a range of sources.
List strengths and weaknesses of proposed explanations. Discuss how the proposed explanation could be rejected or its reliability improved.
Use their proposed explanations to form new questions and suggest new avenues of inquiry.

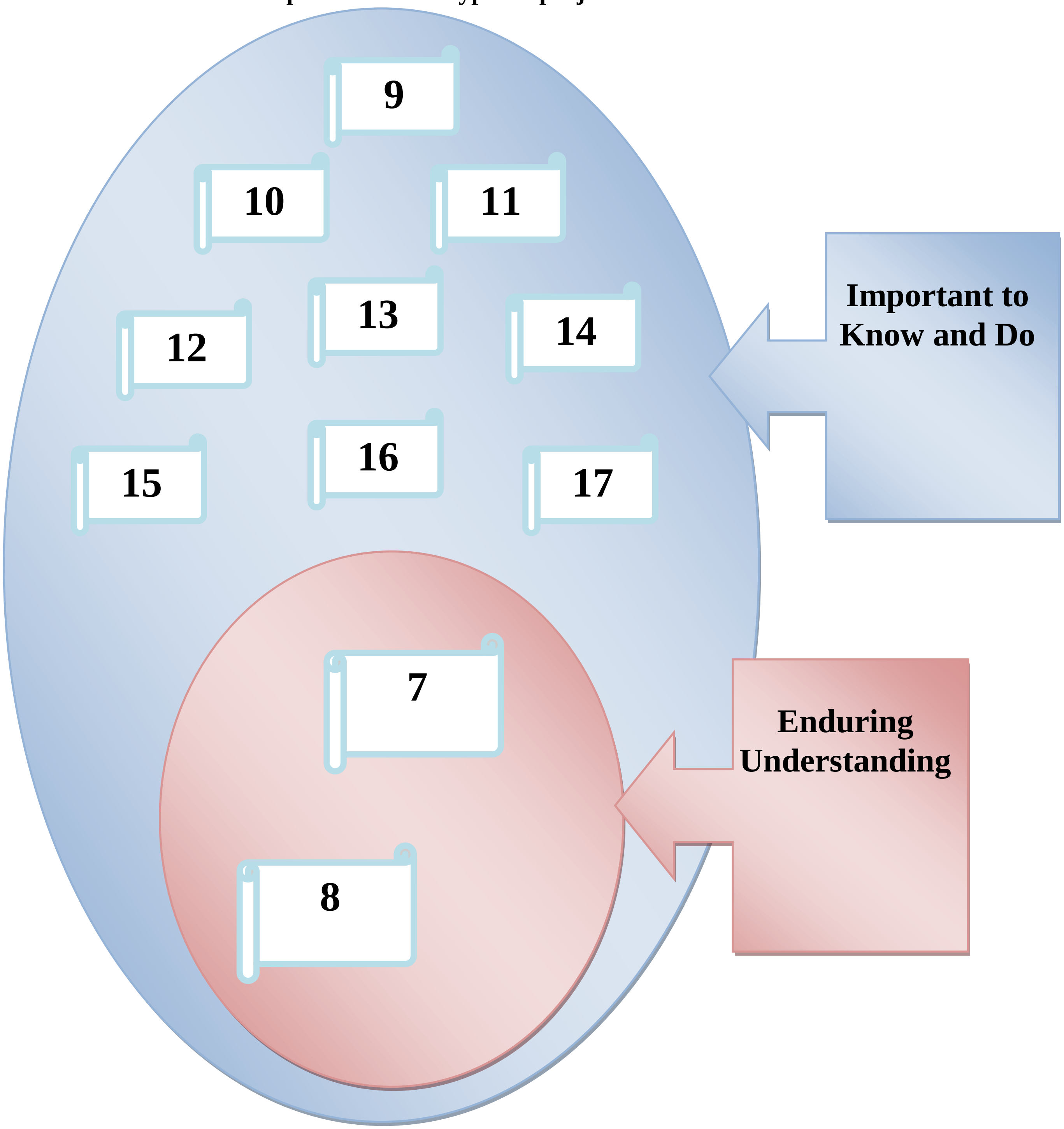
Wisconsin Standards:
ELA (45) E & F
Math (53) A, E, & F
Sci (58) A, B, & C

National Standards:
ELA (79) V
Geo (80) I d & I e
His (89) I b
Math (91) II, V, VII, & VIII
Sci (96) I b

Enduring Characteristics: 1, 3 & 7
Important Characteristics: 1, 3, 7, & 8

Strand 2 – Guidelines for Knowledge of Environmental Processes & Systems:

Gaining an understanding of the processes and systems that comprise the environment, including human social systems and influences is an important component of environmental literacy. That understanding is based on knowledge synthesized from across traditional disciplines. Environmental processes and systems addressed by citizen science are dependent on the types of projects learners are involved in.



Strand 2 - Knowledge of Environmental Processes & Systems: Enduring Understanding

Guideline 7 – The Living Environment:
Students understand that biotic communities are made up of plants and animals that are uniquely adapted to live in particular environments.

Performance Guidelines:
Define and give examples to illustrate the concepts of species, population, community, and ecosystem. Trace and give examples of connections among organisms at those levels of organization.
Link features of internal and external anatomy with the ability of organisms to make or find food and reproduce in particular environments.
Understand that some animals and plant s have adapted to extreme environmental conditions. Give examples that are behavioral (e.g., the migration of Canada geese and other birds) and physical (e.g., physical structures that enable desert animals and plants to exist on minimal amounts of water).
Describe how organisms differ in how they use energy. For example, identify organisms that use energy quickly for growth and metabolism, and therefore must replace it quickly (e.g., a hummingbird) and others that use energy more slowly and therefore need to replace it less frequently (e.g., a python). Predict the habitat needs of these different types of organisms.

Wisconsin Standards:
Sci (58) F 1-7

National Standards:
Geo (80) VI
SB (101) II a
Sci (96) III a, III b, & III c

Enduring Characteristics: 1
Important Characteristics: 1

Strand 2 - Knowledge of Environmental Processes & Systems: Enduring Understanding

Guideline 8 – Environment & Society:
Students are able to explain that human-caused changes have consequences for the immediate environment as well as for other places and future times.

Performance Guidelines:
Describe intended and unintended environmental and social consequences associated with the changing use of technologies. Consider consequences that may be positive as well as negative. For example, discuss particular irrigation methods, different ways of generating electrical power, or the use of synthetic pesticides.
Explain how human-caused environmental changes cause changes in other places. For example, discuss the effects of building a dam on downstream plant and animal communities as well as on human communities.
Describe the effects of a local environmental restoration effort, such as wetlands creation. Predict the long-term consequences of such efforts, or a particular restoration project.

Wisconsin Standards:
Sci (58) H

National Standards:
Geo (80) X
Sci (96) IV a, IV b, & IV c

Enduring Characteristics: 1, 2, 3, & 7
Important Characteristics: 1 & 3

Strand 2 - Knowledge of Environmental Processes & Systems: Important to Know & Do

Guideline 9 – The Earth as a Physical System:
Students are able to relate the differences in physical patterns to their causes, e.g. how seasonal change is affected by the Earth/sun relationship.

Performance Guidelines:
Analyze physical patterns such as climate, areas or geothermal activity, soil types, and arid regions, suggesting reasons for these patterns. Explain these patterns in terms of abrupt forces (such as earthquakes or major storms) and long-term processes (such as erosion and rock formation), as well as those that are human-caused (such as suburban development or agricultural practices).
Predict the consequences of specific physical phenomena such as a hurricane in a coastal area or heavy grazing in an arid region.
Relate physical processes and patterns (such as climate, weather phenomena, and seasonal change) to the Earth/sun relationship. For example, create a model that shows how seasonal change is affected by the Earth/sun relationship.

Wisconsin Standards:
Sci (58) D 1-7

National Standards:
SB (101) I a
Sci (96) II a & II b

Enduring Characteristics: 1 & 7
Important Characteristics: 1 & 8

Strand 2 - Knowledge of Environmental Processes & Systems: Important to Know & Do

Guideline 10 – The Living Environment:
Students recognize and describe the importance of genetic variation in species and possible implications of species extinction.

Performance Guidelines:
Describe some ways in which variation among individuals of the same species can sometimes give certain individuals an advantage within a specific environment.
Describe in general terms the theory of natural selection for particular traits and how that process can result in descendants that are quite different from their ancestors.
Define extinction, cite evidence of extinction, and identify some of its causes.
Discuss the possible implications of permanent loss of a species and how it affects interdependence within an ecosystem.

Wisconsin Standards:
Sci (58) F 4-8

National Standards:
SB (101) II b & II e
Sci (96) III b, III c, & III d

Enduring Characteristics: 1 & 7
Important Characteristics: 1 & 5

Strand 2 - Knowledge of Environmental Processes & Systems: Important to Know & Do

Guideline 11 – The Living Environment:
Students identify and describe major kinds of interactions among organisms or populations of organisms.

Performance Guidelines:
Describe and give examples of producer/consumer, predator/prey, and parasite/host relationships.
Identify organisms that are scavengers or decomposers. Describe the roles they play within particular systems focusing on their relationship to other organisms and physical elements of the system.
Summarize how abiotic and biotic components in combination influence the structure of an ecosystem. For example, create a map for the local region that shows average temperature and rainfall correlated with local forest, grassland or desert ecosystems. Or discuss the process of soil formation in terms of the interaction of climate, geology, and living organisms.

Wisconsin Standards:
Sci (58) F 6-8

National Standards:
Geo (80) VI
SB (101) II c
Sci (96) III c & III d

Enduring Characteristics: 1 & 6
Important Characteristics: 1, 2, & 8

Strand 2 - Knowledge of Environmental Processes & Systems: Important to Know & Do

Guideline 12 – The Living Environment:
Students describe how energy and matter flow among the biotic and abiotic components of the environment.

Performance Guidelines:
Trace the flow of energy through food webs that identify relationships among organisms in natural systems.
Explain how matter is transferred among organisms and between organisms and their environment in these food webs.
Describe how energy, which enters ecosystems as sunlight, changes form and is transferred in the exchanges (production, consumption, and decomposition) that comprise food webs**.**

Wisconsin Standards:
Sci (58) F 9-10

National Standards:
SB (101) II d
Sci (96) III e

Enduring Characteristics: 1
Important Characteristics: 1 & 2

Strand 2 - Knowledge of Environmental Processes & Systems: Important to Know & Do

Guideline 13 – Humans & Their Societies:
Students identify and explain ways in which the world's environmental, societal, economic, cultural, and political systems are linked. Environmental justice would be an appropriate example.

Performance Guidelines:
Explain international trade in terms of uneven distribution of resources.
Describe ways in which the global environment is affected by individual and group actions, as well as by government policies and actions having to do with energy use and other forms of consumption, waste disposal, resource management, industry, and population.
Explain how an environmental change in one part of the world can have consequences for other places. For example, develop a map or another visual presentation that shows the effects of acid rain or nuclear fallout in places distant from the source of the pollution.
Identify a variety of global links, including transportation and communication systems, treaties, multi-national corporations, and international organizations.

Wisconsin Standards:
Sci (58) G
SS (64) D

National Standards:
C & G (70) II a & II b
Geo (80) VII & IX
SB (101) III d
SS (106) VII

Enduring Characteristics: 1, 5, & 7
Important Characteristics: 1

Strand 2 - Knowledge of Environmental Processes & Systems: Important to Know & Do

Guideline 14 – Humans & Their Societies:
Students explain and analyze that human social systems change over time and that conflicts sometimes arise over differing viewpoints about the environment.

Performance Guidelines:
Describe patterns of change within and across cultures, communities, and other groups. Consider the rapidity of change, mechanisms that helped spread change, and what motivated change. For example, discuss how and why wastewater treatment became a common practice in the United States.
Explain how change affects individuals and groups differently and give examples of the trade-offs involved in decisions and actions ranging from the individual to the societal levels. For example, discuss how a decision about where to site a landfill, build a chemical plant, or locate a new highway might affect different neighborhoods, businesses, workers, people of varying socio-economic status, and others. Role play their reactions.
Describe and analyze examples of tensions between individual rights and benefits and the societal good. Illustrate with examples from the local community, possibly including disagreements over zoning, controversial proposals to raise taxes to pay for the purchase of open space or sewer system upgrades, or tradeoffs between commuting to work individually in a car or taking public transportation.
Identify some of the formal and informal ways that groups (including governments) attempt to anticipate, avoid, or resolve conflicts related to the environment.

Wisconsin Standards:
SS (64) B & D

National Standards:
SB (101) III a, III b, & III c
SS (106) II & V

Enduring Characteristics: 1 & 7
Important Characteristics: 1

Strand 2 - Knowledge of Environmental Processes & Systems: Important to Know & Do

Guideline 15 – Environment & Society:
Students explore differences in perceptions and importance of places close to home and around the world.

Performance Guidelines:
Analyze physical and human characteristics of places and make inferences about how and why these characteristics have developed and changed over time. For example, use maps and satellite photographs to examine how cities change in response to natural disasters such as floods, hurricanes, or earthquakes.
Identify ways in which personal perceptions, culture, and technology influence people's perceptions of places. Discuss the importance of some places (such as Yellowstone National Park or the Mississippi River) as cultural symbols.
Identify regions based on different criteria such as watershed boundaries, sales and service areas for different businesses, or the area from which sports teams draw fans or symphony orchestras attract audiences.

Wisconsin Standards:
SS (64) A

National Standards:
Arts (69) III
Geo (80) III, IV, & V
SS (106) III & VI

Enduring Characteristics: 1
Important Characteristics: 1

Strand 2 - Knowledge of Environmental Processes & Systems: Important to Know & Do

Guideline 16 – Environment & Society:
Students are able to discuss and explain why uneven distribution of resources around the world influences the use of these resources and their perceived value.

Performance Guidelines:
Map and discuss distribution and consumption patterns for specific resources, such as metals, fresh water, or certain types of forests. Note resources that are being rapidly depleted.
Explain why certain resources (such as oil, coal, or natural gas) are key to development of human societies, and identify resources that were critical to development at different times in history.
Explain conflicts between individuals, states, regions, or nations noting factors such as differing attitudes about the use of specific resources and scarcity of natural resources. Illustrate with local or regional examples such as conflicts over water rights and use of habitat for local endangered species.

Wisconsin Standards:
Sci (58) H

National Standards:
Econ (78) I
Geo (80) XI
His (89) I a
Sci (96) IV a

Enduring Characteristics: 1 & 7
Important Characteristics: 1

Strand 2 - Knowledge of Environmental Processes & Systems: Important to Know & Do

Guideline 17 – Environment & Society:
Students relate to and discuss how people in other places around the world experience environmental issues similar to the ones they are concerned about locally.

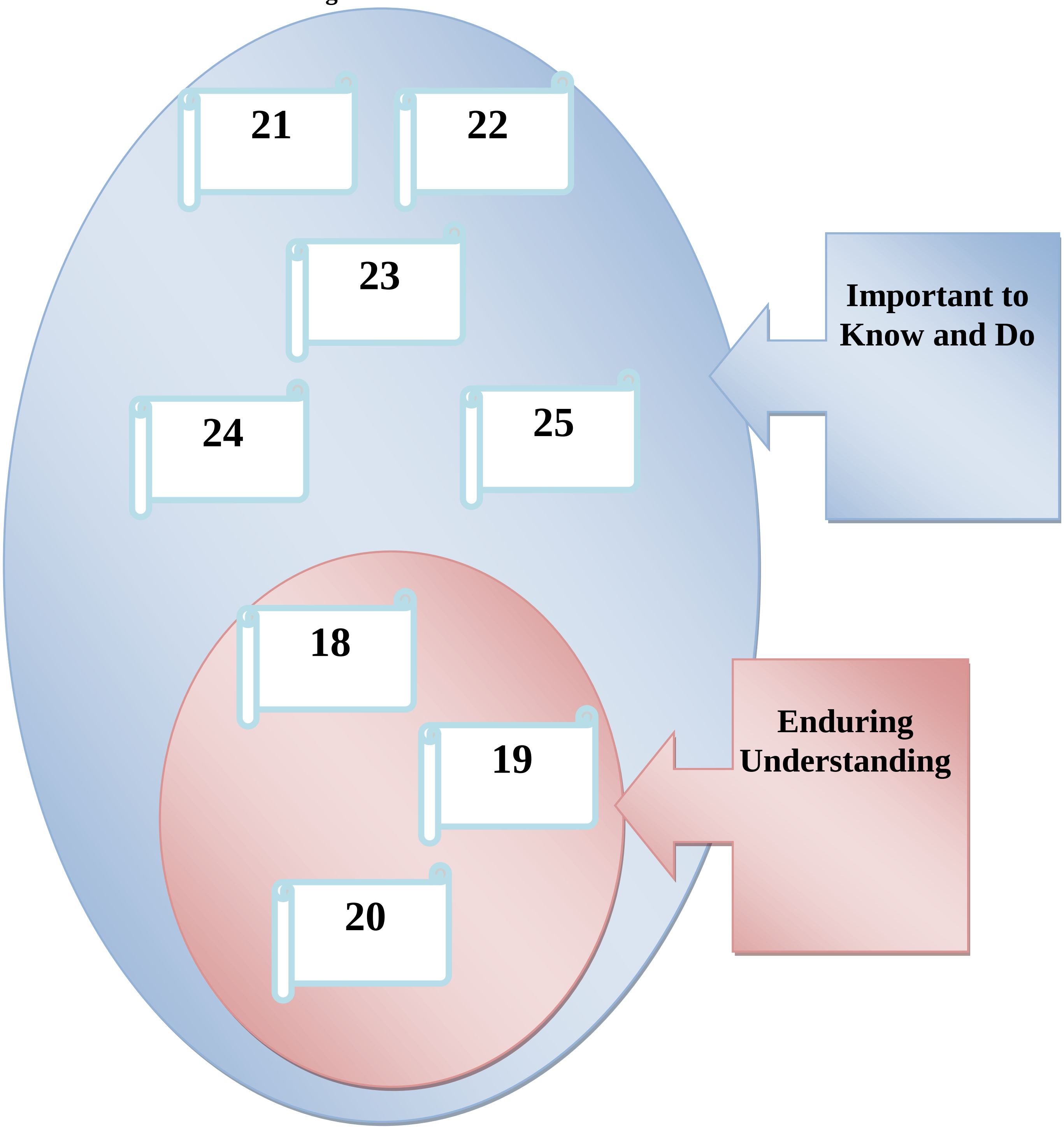
Performance Guidelines:
Identify other places, either contemporary or historical, experiencing issues similar to those in the learner's community or region.
Explain how issues arise because of conflicting points of view about a specific proposal, event, or condition in the environment. For example, discuss conflicting perspectives about past and present proposals to build large-scale dams such as the Three Gorges project in China, the Hetch-Hetchy dam in the U.S., or a similar project in the learner's region.
Discuss how disagreements at the heart of environmental issues make them difficult to resolve. Consider the role of understanding, creativity, or compromise in finding solutions.

National Standards:
Geo (80) XIII

Enduring Characteristics: 1 & 7
Important Characteristics: 1

Strand 3 –Guidelines for Skills for Understanding & Addressing Environmental Issues:

Skills and knowledge are refined and applied in the context of environmental issues. These environmental issues are real-life dramas where differing viewpoints about environmental problems and their potential solutions are played out. Environmental literacy includes the abilities to define, learn about, evaluate, and act on environmental issues, and are valuable goals to include in citizen science curricula.



Strand 3 - Skills for Understanding & Addressing Environmental Issues: Enduring Understanding

Guideline 18 – Skills for Analyzing & Investigating Environmental Issues:
Students apply their knowledge of ecological and human processes and systems to identify the consequences of specific environmental issues.

Performance Guidelines:
Describe the effects of human actions on specific elements, systems, and processes of the environment.
Analyze issues by looking at trade-offs that have been made. For example, consider where various human activities (such as landfills, highways, chemical factories, or hazardous waste incinerators) are located and their effects on different places and different segments of the population.
Speculate about the effects of a proposed state or local environmental regulation. For example, consider effects on different sectors of the economy, neighborhoods, public health, particular plant and animal species and communities, and overall environmental quality.
Predict the consequences of inaction or failure to resolve particular issues.

Wisconsin Standards:
SS (64) B

National Standards:
Geo (80) IX
SS (106) II

Enduring Characteristics: 1 & 7
Important Characteristics: 1, 3, & 8

Strand 3 - Skills for Understanding & Addressing Environmental Issues: Enduring Understanding

Guideline 19 – Skills for Analyzing & Investigating Environmental Issues:
Students identify and develop action strategies for addressing particular issue such as environmental stewardship.

Performance Guidelines:
Identify different proposals for resolving an environmental issue. Recognize and explain the perspectives on the issue that are embedded in those views.
Explain why various strategies may be effective in different situations. Consider their likely effects on society and the environment.
Independently and in groups, develop original strategies to address issues.
Discern similarities and differences in problem situations which might affect their ability to apply strategies that were successful in other places and times.

Wisconsin Standards:
ELA (45) D
SS (64) D

National Standards:
ELA (79) VI
His (89) I b
SS (106) VIII

Enduring Characteristics: 1, 3, 5, & 7
Important Characteristics: 1

Strand 3 - Skills for Understanding & Addressing Environmental Issues: Enduring Understanding

Guideline 20 – Decision-Making & Citizenship Skills:
Students begin to see themselves as citizens taking active roles in their communities. They plan for and engage in citizen action at levels appropriate to their maturity and preparation.

Performance Guidelines:
Develop action plans they can carry out individually, in small groups, or with a class, club, or larger organization. Include clear reasons and goals for action. Base these plans on knowledge of a range of citizen action strategies and the results of their environmental issue investigations.
Set realistic goals for action and include measures of success consistent with learners' abilities and an understanding of the complexity of the issue.
Decide whether their plan should be implemented immediately or at another time, changed, or abandoned; and carry through with action when appropriate.

Wisconsin Standards:
SS (64) C

National Standards:
C & G (70) I a
SS (106) VIII

Enduring Characteristics: 1, 3, & 7
Important Characteristics: 1

Strand 3 - Skills for Understanding & Addressing Environmental Issues: Important to Know & Do

Guideline 21 – Skills for Analyzing & Investigating Environmental Issues:
Students use primary and secondary sources of information, and apply their growing research and analytical skills to investigate environmental issues, beginning with those in their own community. Primary sources of information are based on first-hand student experiences while secondary sources are gathered from books/literature, community members, teachers, etc.

Performance Guidelines:
Clearly articulate and define environmental issues. For example, describe the history and origins of the issue, actions that have been taken to address the issue, the apparent effects of these actions, and the current situation.
Identify key individuals and groups involved, their view points, and the types of action they support. Describe areas of conflict and agreement.
Investigate the issue using secondary sources and original research where needed.
Examine how others have analyzed and understood the issue, identifying their approaches and the assumptions behind them.
Compare the issue with similar issues from other places and times.

Wisconsin Standards:
SS (64) A, B, & D

National Standards:
Geo (80) VII, VIII, & XII
His (89) I b
SS (106) I, II, III, IV, V, & VIII

Enduring Characteristics: 1, 3, 4, 5, 6, & 7
Important Characteristics: 1, 2, 3, 4, 5, & 6

Strand 3 - Skills for Understanding & Addressing Environmental Issues: Important to Know & Do

Guideline 22 –Skills for Analyzing & Investigating Environmental Issues:
Students consider the assumptions and interpretations that influence the conclusions they and others draw about environmental issues.

Performance Guidelines:
Explain how the interplay of ideas and perspectives strengthens the process of inquiry and the societal ability to address issues.
Receive questions and alternative explanations that others offer in discussions as well as in readings.
Explain why it is not always possible to select one correct explanation or a single best approach to addressing an issue.

Wisconsin Standards:
ELA (45) A, C, & D
Sci (58) B
SS (64) D

National Standards:
Arts (69) IV
ELA (79) II, VI, & VII
Geo (80) XIII
SB (101) IV a
Sci (96) I b vi-ix
SS (106) IV

Enduring Characteristics: 1 & 2
Important Characteristics: 1

Strand 3 - Skills for Understanding & Addressing Environmental Issues: Important to Know & Do

Guideline 23 – Decision-Making & Citizenship Skills:
Students identify, justify, and clarify their views on environmental issues and alternative ways to address them.

Performance Guidelines:
Discuss personal perspectives with classmates, remaining open to new ideas and information.
Justify their views based on information from a variety of sources, and clear reasoning.
Discuss their own beliefs and values regarding the environment and relate their personal view of environmental issues to these.
Identify ways in which others' views correspond or differ with their own views.

Wisconsin Standards:
SS (64) D

National Standards:
Arts (69) I
Geo (80) XII & XIII
His (89) I b
SS (106) IV

Enduring Characteristics: 1, 2, & 3
Important Characteristics: 1

Strand 3 - Skills for Understanding & Addressing Environmental Issues: Important to Know & Do

Guideline 24 – Decision-Making & Citizenship Skills:
Students evaluate whether they believe action is needed in particular situations, and decide whether they should be involved.

Performance Guidelines:
Discuss whether action is warranted. Account for factors such as the scale of the problem; legal, social, economic, and ecological consequences; and alternatives to citizen action.
Identify different forms of action that citizens can take in the economic, political, and legal spheres, as well as actions aimed at directly improving or maintaining some part of the environment or persuading others to take action.
Speculate about the likely effects of specific actions on society and the environment, and the likelihood these actions will resolve a specific environmental issue.
Point out advantages and disadvantages of their personal involvement, considering factors such as their own skills, resources, knowledge, and commitment.

Wisconsin Standards:
SS (64) C

National Standards:
SS (106) VIII

Enduring Characteristics: 1 & 3
Important Characteristics: 1

Strand 3 - Skills for Understanding & Addressing Environmental Issues: Important to Know & Do

Guideline 25 – Decision-Making & Citizenship Skills:
Students evaluate the effects of their own actions and actions taken by other individuals and groups.

Performance Guidelines:
Analyze the effects of decisions, policies, and actions taken by individuals and groups on a particular issue.
Analyze their own actions, explaining apparent effects and discussing them in light of students' goals and reasons for acting.
Describe some of the reasons why analyzing the results of actions may be difficult, including the scale of the issue, the time required to see effects, and the influence of other actions and factors.

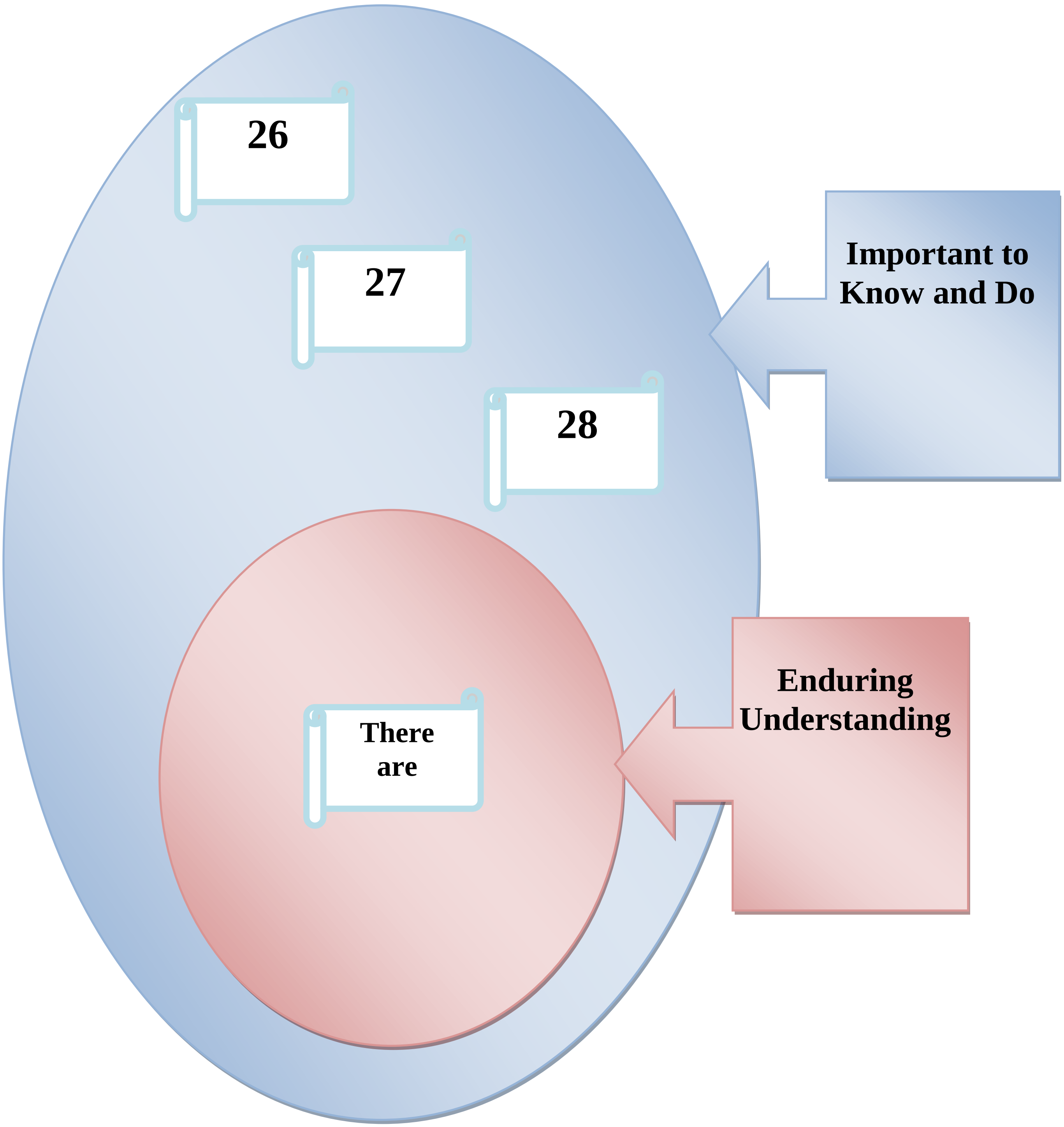
Wisconsin Standards:
SS (64) C

National Standards:
His (89) I b
SS (106) VIII

Enduring Characteristics: 1 & 2
Important Characteristics: 1

Strand 4 – Guidelines for Personal & Civic Responsibility:

Personal & Civic Responsibility: Environmentally literate citizens are willing and able to act on their own conclusions about what should be done to ensure environmental quality. As learners develop and apply concept-based learning and skills for inquiry, analysis, and action, they also understand that what they do individually and in groups can make a difference. Citizen science curricula should be developed with learners in mind in order to meet the following personal and civic responsibilities.



Strand 4 - Personal & Civic Responsibility: Important to Know & Do

Guideline 26:
Students identify and describe the rights and responsibilities of citizenship and their importance in promoting the resolution of environmental issues.

Performance Guidelines:
Identify rights and responsibilities associated with citizenship, including personal and civic responsibilities.
Describe ways in which commonly accepted rights and responsibilities of citizenship motivate people to help resolve environmental issues. Consider rights and responsibilities such as acquiring, using and selling property; the right to vote; freedom of speech and assembly; accepting responsibility for the consequences of one's actions; obeying the law; and respecting the rights and interests of others.

Wisconsin Standards:
SS (64) C

National Standards:
C & G (70) III a, III b, & III c
SS (106) VIII

Enduring Characteristics: 1
Important Characteristics: 1

Strand 4 - Personal & Civic Responsibility: Important to Know & Do

Guideline 27:
Students possess a realistic self-confidence in their effectiveness as citizens.

Performance Guidelines:
Explain the ways in which citizen action and public opinion influence environmental policy decisions.
Describe how individuals and groups act within society to create change, meet individual needs and promote the common good. Illustrate with examples from environmental issues.
Describe ways in which their actions have made a difference. Use examples that begin in the classroom and the home, and extend beyond to encompass the broader communities in which students begin to see possibilities for action.

Wisconsin Standards:
SS (64) B & C

National Standards:
C & G (70) III e
SS (106) II & VIII

Enduring Characteristics: 1 & 3
Important Characteristics: 1

Strand 4 - Personal & Civic Responsibility: Important to Know & Do

Guideline 28:
Students understand that their actions can have broad consequences and that they are responsible for those consequences.

Performance Guidelines:
Analyze some of the effects that their actions (and the actions of their families, social groups, and communities) have on the environment, other humans, and other living beings.
Describe actions in terms of their effects that reach into the future.
Describe their personal responsibilities, comparing their view of their responsibilities with commonly accepted societal views.
Identify ways in which they feel responsible for helping resolve environmental issues within their community.

National Standards:
C & G (70) III d

Enduring Characteristics: 1, 2, & 3
Important Characteristics

Appendices for State & National Standards

Appendix of Wisconsin State Standards: English Language Arts

The following state standards are taken from *Wisconsin's Model Academic Standards for English Language Arts* for 5th through 8th grades and correlate with the learning guidelines for citizen science. Included are the theme, specific content and performance standards, and the page numbers they are found in the original text.

A. Reading & Literature (pps. 2-5)

Content Standard:

i. Students in Wisconsin will read and respond to a wide range of writing to build an understanding of written materials, of themselves, and of others.

Performance Standards:

1. Use effective reading strategies to achieve their purposes in reading:
    a. Use knowledge of sentence and word structure, word origins, visual images, and context clues to understand unfamiliar words and clarify passages of text;
    b. Use knowledge of the visual features of texts, such as headings and bold face print, and structures of texts, such as chronology and cause-and-effect, as aids to comprehension;
    c. Establish purposeful reading and writing habits by using texts to find information, gain understanding of diverse viewpoints, make decisions, and enjoy the experience of reading;
    d. Select, summarize, paraphrase, analyze, and evaluate, orally and in writing, passages of texts chosen for specific purposes.

2. Read, interpret, and critically analyze literature:
    a. Identify the defining features and structure of literary texts, such as conflict, representation of character, and point of view;
    b. Analyze the effect of characters, plot, setting, language, topic, style, purpose, and point of view on the overall impact of literature;
    c. Draw on a broad base of knowledge about the genres of literature, such as the structure and conventions of essays, epics, fables, myths, plays, poems, short stories, and novels, when interpreting the meaning of a literary work;
    d. Develop criteria to evaluate literary merit and explain critical opinions about a text, either informally in

conversation or formally in a well-organized speech or essay.

3. Read and discuss literary and non-literary texts in order to understand human experience:

    a. Provide interpretive responses, orally and in writing, to literary and non-literary texts representing the diversity of American cultural heritage and cultures of the world;
    b. Identify common historical, social, and cultural themes and issues in literary works and selected passages;
    c. Draw on a broad base of knowledge about the themes, ideas, and insights found in classical literature while reading, interpreting, and reflecting on contemporary texts;
    d. Evaluate the themes and main ideas of a work considering its audience and purpose.

4. Read to acquire information:

    a. Interpret and use technical resources such as charts, tables, travel schedules, timelines, and manuals;
    b. Compare, contrast, and evaluate the relative accuracy and usefulness of information from different sources;
    c. Identify and explain information, main ideas, and organization found in a variety of informational passages;
    d. Distinguish between the facts found in documents, narratives, charts, maps, tables, and other sources and the generalizations and interpretations that are drawn from them.

B. Writing (pps. 6-9)

Content Standard:

i. Students in Wisconsin will write clearly and effectively to share information and knowledge, to influence and persuade, to create and entertain.

Performance Standards:

1. Create or produce writing to communicate with different audiences for a variety of purposes:
    a. Write a coherent and complete expository piece, with sufficient detail to fulfill its purpose, sufficient evidence to support its assertions, language appropriate for its intended

audience, and organization achieved through clear coordination and subordination of ideas;

b. Write a persuasive piece (such as a letter to a specific person or a script promoting a particular product) that includes a clear position, a discernible tone, and a coherent argument with reliable evidence;
c. Write a narrative based on experience that uses descriptive language and detail effectively, presents a sequence of events, and reveals a theme;
d. Write clear and pertinent responses to verbal or visual material that communicate, explain, and interpret the reading or viewing experience to a specific audience;
e. Write creative fiction that includes major and minor characters, a coherent plot, effective imagery, descriptive language, and concrete detail;
f. Write in a variety of situations (during an exam, in a computer lab) and adapt strategies, such as revision, technology, and the use of reference materials, to the situation;
g. Use a variety of writing technologies including pen and paper as well as computers;
h. Write for a variety of readers, including peers, teachers, and other adults, adapting content, style, and structure to audience and situation.

2. Plan, revise, edit, and publish clear and effective writing:
    a. Produce multiple drafts, including finished pieces, that demonstrate the capacity to generate, focus, and organize ideas and to revise the language, organization, content, and tone of successive drafts in order to fulfill a specific purpose for communicating with a specific audience;
    b. Identify questions and strategies for improving drafts in writing conferences with a teacher;
    c. Given a writing assignment to be completed in a limited amount of time, produce a well developed, well organized, and effective response in correct English and an appropriate voice.

3. Understand the function of various forms, structures, and punctuation marks of standard American English and use them appropriately in written communications:

    a. Understand the function of words, phrases, and clauses in a sentence and use them effectively, including coordinate and subordinate conjunctions, relative pronouns, and comparative adjectives;

b. Use correct tenses to indicate the relative order of events;
c. Understand and employ principles of agreement, including subject-verb, pronoun-noun, and preposition-pronoun;
d. Punctuate compound, complex, and compound-complex sentences correctly;
e. Employ the conventions of capitalization;
f. Spell frequently use words correctly and use effective strategies for spelling unfamiliar words.

C. Oral Language (pps. 10-13)

Content Standard:

i. Students in Wisconsin will listen to understand and will speak clearly and effectively for diverse purposes.

Performance Standards:

1. Orally communicate information, opinions, and ideas effectively to different audiences for a variety of purposes:

a. Share brief impromptu remarks about topics of interest to oneself and others;
b. Speaking from notes or an outline, relate an experience in descriptive detail, with a sense of timing and decorum appropriate to the occasion;
c. Perform expressive oral readings of prose, poetry, and drama;
d. Prepare and conduct interviews;
e. Present a coherent, comprehensive report on differing viewpoints on an issue, evaluating the content of the material presented, and organizing the presentation in a manner appropriate to the audience;
f. Differentiate between formal and informal contexts and employ an appropriate style of speaking, adjusting language, gestures, rate, and volume according to audience and purpose;
g. Observe the appropriate etiquette when expressing thanks and receiving praise.

2. Listen to and comprehend oral communications:

a. Summarize and explain the information conveyed in an oral communication, accounting for the key ideas, structure, and relationship of parts to the whole;

b. Distinguish among purposes for listening, such as gaining information or being entertained, and take notes as appropriate;
c. Recall significant details and sequence accurately;
d. Follow a speaker's argument and represent it in notes;
e. Evaluate the reliability of information in a communication, using criteria based on prior knowledge of the speaker, the topic, and the context and on analysis of logic, evidence, propaganda devices, and language.

3. Participate effectively in discussion:

a. Participate in discussion by listening attentively, demonstrating respect for the opinions of others, and responding responsibly and courteously to the remarks of others;
b. Explain and advance opinions by citing evidence and referring to sources;
c. Evaluate the stated ideas and opinions of others, seeking clarification through questions;
d. Invite ideas and opinions of others into the discussion, responding clearly and tactfully to questions and comments;
e. Accept and use helpful criticism;
f. Establish and maintain an open mind when listening to others' ideas and opinions;
g. Summarize the main points of a discussion, orally and in writing, specifying areas of agreement and disagreement and paraphrasing contributions;
h. Attend to the content of discussion rather than the speaker;
i. Participate in discussion without dominating;
j. Distinguish between supported and unsupported statements.

D. Language (pps. 14-15)

Content Standard:

i. Students in Wisconsin will apply their knowledge of the nature, grammar, and variations of American English.

Performance Standards:

1. Develop their vocabulary and ability to use words, phrases, idioms, and various grammatical structures as a means of improving communication:

a. Consult dictionaries, thesauruses, handbooks, and grammar texts when choosing words, phrases, and expressions for use in oral and written presentations;
b. Explain how writers and speakers choose words and use figurative language such as similes, metaphors, personification, hyperbole, and allusion to achieve specific effects;
c. Choose words purposefully and evaluate the use of words in communications designed to inform, explain, and persuade.

2. Recognize and interpret various uses and adaptations of language in social, cultural, regional, and professional situations, and learn to be flexible and responsive in their use of English:

a. Describe how American English is used in various public and private contexts, such as school, home and work;
b. Make appropriate choices when speaking and writing, such as formal or informal language, considering the purpose and context of the communication;
c. Evaluate how audience and context affect the selection and use of words and phrases, including technical terms, slang, and jargon.

E. Media & Technology (pps. 16-17)

Content Standard:

i. Students in Wisconsin will use media and technology critically and creatively to obtain, organize, prepare and share information; to influence and persuade; and to entertain and be entertained.

Performance Standards:

1. Use computers to acquire, organize, analyze, and communicate information:

a. Demonstrate efficient word-processing skills;
b. Construct and use simple databases;
c. Use manuals and on-screen help in connection with computer applications;
d. Perform basic computer operations on various platforms;
e. Collect information from various on-line sources, such as web pages, news groups, and listservs.

2. Make informed judgments about media and products:

a. Recognize common structural features found in print and broad cast advertising;
b. Identify and explain the use of stereotypes and biases evident in various media;
c. Compare the effect of particular symbols and images seen in various media;
d. Develop criteria for selecting or avoiding specific broadcast programs and periodicals.

3. Create media products appropriate to audience and purpose:

    a. Write informational articles that target audiences of a variety of publications;
    b. Use desktop publishing to produce products such as brochures and newsletters designed for particular organizations and audiences;
    c. Create videotapes and audiotapes designed for particular audiences.

4. Demonstrate a working knowledge of media production and distribution:

    a. Plan a promotion or campaign that involves broadcast and print media production and distribution;
    b. Analyze how messages may be affected by financial factors such as sponsorship;
    c. Identify advertising strategies and techniques aimed at teenagers.

5. Analyze and edit media work as appropriate to audience and purpose:

    a. Revise media productions by adding, deleting, and adjusting the sequence and arrangement of information, images, or other content as necessary to improve focus, clarity, or effect;
    b. Develop criteria for comprehensive feedback on the quality of media work and use it during production.

F. Research & Inquiry (pps. 18-19)

Content Standard:

i. Students in Wisconsin will locate, use, and communicate information from a variety of print and non-print materials.

Performance Standards:

1. Conduct research and inquiry on self-selected or assigned topics, issues, or problems and use an appropriate form to communicate their findings:

    a. Formulate research questions and focus investigation on relevant and accessible sources of information;
    b. Use multiple sources to identify and locate information pertinent to research including encyclopedias, almanacs, dictionaries, library catalogs, indexes to periodicals, and various electronic search engines;
    c. Conduct interviews, field studies, and experiments and use specialized resources (such as almanacs, fact books, pamphlets, and technical manuals) when appropriate to an investigation;
    d. Compile, organize, and evaluate information, take notes that record and summarize what has been learned and extending the investigation to other sources;
    e. Review and evaluate the usefulness of information gathered in an investigation;
    f. Produce an organized written and oral report that presents and reflects on findings, draws sound conclusions, adheres to the conventions for preparing a manuscript, and gives proper credit to sources.

Appendix of Wisconsin State Standards: Mathematics

The following state standards are taken from *Wisconsin's Model Academic Standards for Mathematics* for 5th through 8th grades and correlate with the learning guidelines for citizen science. Included are the theme, specific content and performance standards, and the page numbers they are found in the original text.

A. Mathematical Processes (pps. 4-5)

Content Standard:

i. Students in Wisconsin will draw on a broad body of mathematical knowledge and apply a variety of mathematical skills and strategies, including reasoning, oral and written communication, and the use of appropriate technology, when solving mathematical, real-world and non-routine problems.

Performance Standards:

1. Use reasoning abilities to evaluate information, perceive patterns identify relationships, formulate questions for further exploration, evaluate strategies, justify statements, test reasonableness of results, and defend work;
2. Communicate logical arguments clearly to show why a result makes sense;
3. Analyze non-routine problems by modeling, illustrating, guessing, simplifying, generalizing, shifting to another point of view, etc.;
4. Develop effective oral and written presentations that include: appropriate use of technology, the conventions of mathematical discourse (e.g., symbols, definitions, labeled drawings), mathematical language, clear organization of ideas and procedures, and understanding of purpose and audience;
5. Explain mathematical concepts, procedures, and ideas to others who may not be familiar with them;
6. Read and understand mathematical texts and other instructional materials and recognize mathematical ideas as they appear in other contexts.

B. Number Operations & Relationships (pps. 6-7)

Content Standard:

i. Students in Wisconsin will use numbers effectively for various purposes, such as counting, measuring, estimating, and problem solving.

Performance Standards:

1. Read, represent, and interpret various rational numbers (whole numbers, integers, decimals, fractions, and percents) with verbal

descriptions, geometric models, and mathematical notation (e.g., expanded, scientific, exponential);
2. Perform and explain operations on rational numbers (add, subtract, multiply, divide, raise to a power, extract a root, take opposites and reciprocals, determine absolute value);
3. Generate and explain equivalencies among fractions, decimals, and percents;
4. Express order relationships among rational numbers using appropriate symbols (<, >, =, etc.);
5. Apply proportional thinking in a variety of problem situations that include, but are not limited to: ratios and proportions (e.g., rates, scale drawings, similarity) and percents, including those greater than 100 and less than one (e.g., discounts, rate of increase or decrease, sales tax);
6. Model and solve problems involving number-theory concepts such as: prime and composite numbers, divisibility and remainders, greatest common factors, and least common multiples;
7. In problem-solving situations, select and use appropriate computational procedures with rational numbers such as: calculating mentally, estimating, and creating, using, and explaining algorithms using technology (e.g., scientific calculators, spreadsheets).

C. Geometry (pps. 8-9)

Content Standard:

i. Students in Wisconsin will be able to use geometric concepts, relationships and procedures to interpret, represent, and solve problems.

Performance Standards:

1. Describe special and complex two- and three- dimensional figures (e.g., rhombus, polyhedron, cylinder) and their component parts (e.g., base, altitude, and slant height) by: naming, defining, and giving examples, comparing, sorting, and classifying them, identifying and contrasting their properties (e.g., symmetrical, isosceles, regular), drawing and constructing physical models to specifications, and explaining how these figures are related to objects in the environment;
2. Identify and use relationships among the component parts of special and complex two- and three- dimensional figures (e.g., parallel sides, congruent faces);
3. Identify three-dimensional shapes from two-dimensional sketches of three-dimensional objects preserving their significant features;

4. Perform transformations on two-dimensional figures and describe and analyze the effects of the transformations on the figures;
5. Locate objects using the rectangular coordinate system.

D. Measurement (pps. 10-11)

Content Standard:

i. Students in Wisconsin will select and use appropriate tools (including technology) and techniques to measure things to a specified degree of accuracy. They will use measurements in problem-solving situations.

Performance Standards:

1. Identify and describe attributes in situations where they are not directly or easily measurable (e.g., distance, area of an irregular figure, likelihood of occurrence);
2. Demonstrate understanding of basic measurement facts, principles, and techniques including the following: approximate comparisons between metric and US Customary units (e.g., a liter and a quart are about eh same; a kilometer is about six-tenths of a mile), knowledge that direct measurement produces approximate, not exact, measures, and the use of smaller unites to produce more precise measure;
3. Determine measurement directly using standard units (metric and US Customary) with these suggested degrees of accuracy: lengths to the nearest mm or 1/16 of an inch, weight (mass) to the nearest 0.1 g or 0.5 ounce, liquid capacity to the nearest milliliter, angles to the nearest degree, temperature to the nearest C or F, and elapsed time to the nearest second;
4. Determine measurements indirectly using: estimation, conversion of units within a system (e.g., quarts to cups, millimeters to centimeters), ratio and proportion (e.g., similarity, scale drawings), geometric formulas to derive lengths, areas, volumes of common figures (e.g., perimeter, circumference, surface area), the Pythagorean relationship, and geometric relationships and properties for angle size (e.g., parallel lines and transversals; sum of angles of a triangle; vertical angles).

E. Statistics & Probability (pps. 12-13)

Content Standard:

i. Students in Wisconsin will use data collection and analysis, statistics and probability in problem-solving situations, employing technology where appropriate.

Performance Standards:

1. Work with data in the context of real-world situations by: formulating questions that lead to data collection and analysis, designing and conducting a statistical investigation, and using technology to generate displays, summary statistics, and presentations;
2. Organize and display data from statistical investigations using: appropriate tables, graphs, and/or charts (e.g., circle, bar, or line for multiple sets of data), and appropriate plots (e.g., line, stem-and-leaf, box, scatter);
3. Extract, interpret, and analyze information from organized and displayed data by using: frequency and distribution, including mode and range, central tendencies of data (mean and median), indicators of dispersion (e.g., outliers);
4. Use the results of data analysis to: make predictions, develop convincing arguments, and draw conclusions;
5. Compare several sets of data to generate, test, and, as the data dictate, confirm or deny hypotheses;
6. Evaluate presentations and statistical analyses from a variety of sources for: credibility of the source, techniques of collection, organization, and presentation of data, missing or incorrect data, inferences, and possible sources of bias;
7. Determine the likelihood of occurrence of simple events by: using a variety of strategies to identify possible outcomes (e.g., lists, tables, tree diagrams), conducting an experiment, designing and conducting simulations, applying theoretical notions of probability (e.g., that four equally likely events have a 25 % chance of happening).

F. Algebraic Relationships (pps. 14-15)

Content Standard:

i. Students in Wisconsin will discover, describe, and generalize simple and complex patterns and relationships. In the context of real-world problem situations, the student will use algebraic techniques to define and describe the problem to determine and justify appropriate solutions.

Performance Standards:

1. Work with algebraic expressions in a variety of ways including: using appropriate symbolism, including exponents and variables, evaluating expressions through numerical substitution, generating equivalent expressions, and adding and subtracting expressions;

2. Work with linear and nonlinear patterns and relationships in a variety of ways, including: representing them with tables, with graphs, and with algebraic expressions, equations, and inequalities, describing and interpreting their graphical representations (e.g., slope, rate of change, intercepts), using them as models of real-world phenomena, and describing a real-world phenomenon that a given graph might represent;
3. Recognize, describe, and analyze functional relationships by generalizing a rule that characterizes the pattern of change among variables. These functional relationships include exponential growth and decay (e.g., cell division, depreciation);
4. Use linear equations and inequalities in a variety of ways, including: writing them to represent problem situations and to express generalizations, solving them by different methods (e.g., informally, graphically, with formal properties, with technology), writing and evaluating formulas (including solving for a specified variable), and using them to record and describe solution strategies;
5. Recognize and use generalized properties and relations, including: additive and multiplicative property of equations and inequalities, commutativity and associativity of addition and multiplication, distributive property, inverses and identities for addition and multiplication, and transitive property.

Appendix of Wisconsin State Standards: Science

The following state standards are taken from *Wisconsin's Model Academic Standards for Science* for 5th through 8th grades and correlate with the learning guidelines for citizen science. Included are the theme, specific content and performance standards, and the page numbers they are found in the original text. Some of the performance standards are broken down further into sub-themes and only those applicable are included below.

A. Science Connections (pps. 4-5)

Content Standard:

Students in Wisconsin will understand that among the science disciplines there are unifying themes: systems, order, organization, and interactions; evidence, models, and explanations; constancy, change, and measurement; evolution, equilibrium, and energy; and form and function. These themes relate and interconnect the Wisconsin science standards to one another.

Performance Standards:

1. Develop their understanding of the science themes by using the themes to frame questions about science-related issues and problems;
2. Describe limitations of science systems and give reasons why specific science themes are included in or excluded from those systems;
3. Defend explanations and models by collecting and organizing evidence that supports them and critique explanations and models by collecting and organizing evidence that conflicts with them;
4. Collect evidence to show that models developed as explanations for events were (and are) based on the evidence available to scientists at the time;
5. Show how models and explanations, based on systems, were changed as new evidence accumulated (the effects of constancy, evolution, change, and measurement should all be part of these explanations);
6. Use models and explanations to predict actions and events in the natural world;
7. Design real or thought investigations to test the usefulness and limitations of a model;
8. Use the themes of evolution, equilibrium, and energy to predict future events or changes in the natural world.

B. Nature of Science (pps. 6-7)

Content Standard:

Students in Wisconsin will understand that science is ongoing and inventive, and that scientific understandings have changed over time as new evidence is found.

Performance Standards:

1. Describe how scientific knowledge and concepts have changed over time in the earth and space, life and environmental, and physical sciences;
2. Identify and describe major changes that have occurred over in conceptual models and explanations in the earth and space, life and environmental, and physical sciences and identify the people, cultures, and conditions that led to these developments;
3. Explain how the general rules of science apply to the development and use of evidence in science investigations, model-making, and applications;
4. Describe types of reasoning and evidence used outside of science to draw conclusions about the natural world;
5. Explain ways in which science knowledge is shared, checked, and extended, and show how these processes change over time;
6. Explain the ways in which scientific knowledge is useful and also limited when applied to social issues.

C. Science Inquiry (pps. 8-9)

Content Standard:

Students in Wisconsin will investigate questions using scientific methods and tools, revise their personal understanding to accommodate knowledge, and communicate these understandings to others.

Performance Standards:

1. Identify questions they can investigate using resources and equipment they have available;
2. Identify data and locate sources of information including their own records to answer the questions being investigated;
3. Design and safely conduct investigations that provide reliable quantitative or qualitative data, as appropriate, to answer their questions;
4. Use inferences to help decide possible results of their investigations, use observations to check their inferences;
5. Use accepted scientific knowledge, models, and theories to explain their results and to raise further questions about their investigations;

6. State what they have learned from investigations, relating their inferences to scientific knowledge and to data they have collected
7. Explain their data and conclusions in ways that allow an audience to understand the questions they selected for investigation and the answers they have developed;
8. Use computer software and other technologies to organize, process, and present their data;
9. Evaluate, explain, and defend the validity of questions, hypotheses, and conclusions to their investigations;
10. Discuss the importance of their results and implications of their work with peers, teachers, and other adults;
11. Raise further questions which still need to be answered.

D. Physical Science (pps. 10-11)

Content Standard:

Students in Wisconsin will demonstrate an understanding of the physical and chemical properties of matter, the forms and properties of energy, and the ways in which matter and energy interact.

Performance Standards:

<u>Properties & Changes of Properties in Matter</u>

1. Observe, describe, and measure physical and chemical properties of elements and other substances to identify and group them according to properties such as density, melting points, boiling points, conductivity, magnetic attraction, solubility, and reactions to common physical and chemical tests;
2. Use the major ideas of atomic theory and molecular theory to describe physical and chemical interactions among substances, including solids, liquids, and gases;
3. Understand how chemical interactions and behaviors lead to new substances with different properties;
4. While conducting investigations, use the science themes to develop explanations of physical and chemical interactions and energy exchanges.

<u>Motions & Forces:</u>

5. While conducting investigations, explain the motion of objects by describing the forces acting on them;
6. While conducting investigations, explain the motion of objects using concepts of speed, velocity, acceleration, friction, momentum, and changes over time, among others, and apply these

concepts and explanations to real-life situations outside the classroom;

7. While conducting investigations of common physical and chemical interactions occurring in the laboratory and the outside world, use commonly accepted definitions of energy and the idea of energy conservation.

E. Life & Environmental Science (pps. 14-15)

Content Standard:

Students in Wisconsin will demonstrate an understanding of the characteristics and structures of living things, the processes of life, and how living things interact with one another and their environment.

Performance Standards:

<u>Structure & Function in Living Things:</u>

1. Understand the structure and function of cells, organs, tissues, organ systems, and whole organisms;
2. Show how organisms have adapted structures to match their functions, providing means of encouraging individual and group survival within specific environments;
3. Differentiate between single-celled and multiple-celled organisms (humans) through investigation, comparing the cell functions of specialized cells for each type of organism.

<u>Reproduction & Heredity:</u>

4. Investigate and explain that heredity is comprised of the characteristic traits found in genes within the cell of an organism;
5. Show how different structures both reproduce and pass on characteristics of their group.

<u>Regulation & Behavior:</u>

6. Understand that an organism is regulated both internally and externally;
7. Understand that an organism's behavior evolves through adaptation to its environment.

<u>Populations & Ecosystems:</u>

8. Show through investigations how organisms both depend on and contribute to the balance or imbalance of populations and/or

ecosystems, which in turn contribute to the total system of life on the planet.

<u>Diversity & Adaptations of Organisms:</u>

9. Explain how some of the changes on the earth are contributing to changes in the balance of life and affecting the survival or population growth of certain species;
10. Project how current trends in human resource use and population growth will influence the natural environment, and show how current policies affect those trends.

F. Science Applications (pps. 16-17)

Content Standard:

Students in Wisconsin will demonstrate an understanding of the relationship between science and technology and the ways in which that relationship influences human activities.

Performance Standards:

1. Identify and investigate the skills people need for a career in science or technology and identify the academic courses that a person pursuing such a career would need;
2. Explain how current scientific and technological discoveries have an influence on the work people do and how some of these discoveries also lead to new careers;
3. Illustrate the impact that science and technology have had, both good and bad, on careers, systems, society, environment, and quality of life ;
4. Propose a design (or re-design) of an applied science model or a machine that will have an impact in the community or elsewhere in the world and show how the design (or re-design) might work, including potential side-effects;
5. Investigate a specific local problem to which there has been a scientific or technological solution, including proposals for alternative courses of action, the choices that were made, reasons for the choices, any new problems created, and subsequent community satisfaction;
6. Use current texts, encyclopedias, source books, computers, experts, the popular press, or other relevant sources to identify examples of how scientific discoveries have resulted in new technology;
7. Show evidence of how science and technology are interdependent, using some examples drawn from personally conducted investigations.

Appendix of Wisconsin State Standards: Science

G. Science in Social & Personal Perspectives (pps. 18-19)

Content Standard:

Students in Wisconsin will use scientific information and skills to make decisions about themselves, Wisconsin, and the world in which they live.

Performance Standards:

1. Evaluate the scientific evidence used in various media (for example, television, radio, Internet, popular press, and scientific journals) to address a social issue, using criteria of accuracy, logic, bias, relevance of data, and credibility of sources;
2. Present a scientific solution to a problem involving the earth and space, life and environmental, or physical sciences and participate in a consensus-building discussion to arrive at a group decision;
3. Understand the consequences of decisions affecting personal health and safety.

Appendix of Wisconsin State Standards: Social Studies

The following state standards are taken from *Wisconsin's Model Academic Standards for Social Studies* for 5th through 8th grades and correlate with the learning guidelines for citizen science. Included are the theme, specific content and performance standards, and the page numbers they are found in the original text.

A. Geography: People, Places, & Environments (pps. 2-3)

Content Standard:

Students in Wisconsin will learn about geography through the study of the relationships among people, places, and environments.

Performance Standards:

1. Use a variety of geographic representations, such as political, physical, and topographic maps, a globe, aerial photographs, and satellite images, to gather and compare information about a place;
2. Construct mental maps of selected locales, regions, states, and countries and draw maps from memory, representing relative location, direction, size, and shape;
3. Use an atlas to estimate distance, calculate scale, identify dominant patterns of climate and land use, and compute population density;
4. Conduct a historical study to analyze the use of the local environment in Wisconsin community and to explain the effect of this use on the environment;
5. Identify and compare the natural resource bases of different states and regions in the United States and elsewhere in the world, using a statistical atlas, aerial photographs, satellite images, and computer databases;
6. Describe and distinguish between the environmental effects on the earth of short-term physical changes, such as those caused by floods, droughts, and snowstorms, and long-term physical changes, such as those caused by plate tectonics, erosion, and glaciations;
7. Describe the movement of people, ideas, diseases, and products throughout the world;
8. Describe and analyze the ways in which people in different regions of the world interact with their physical environments through vocational and recreational activities;
9. Describe how buildings and their decoration reflect cultural values and ideas, providing examples such as cave paintings, pyramids, sacred cities, castles, and cathedrals;
10. Identify major discoveries in science and technology and describe their social and economic effects on the physical and human environment;

11. Give examples of the causes and consequences of current global issues, such as the expansion of global markets, the urbanization of the developing world, the consumption of natural resources, and the extinction of species, and suggest possible responses by various individuals, groups, and nations.

B. History: Time, Continuity, & Change (pps. 4-7)

Content Standard:

Students in Wisconsin will learn about the history of Wisconsin, the United States, and the world, examining change and continuity over time in order to develop historical perspective, explain historical relationships, and analyze issues that affect the present and the future.

Performance Standards:

1. Interpret the past using a variety of sources, such as biographies, diaries, journals, artifacts, eyewitness interviews, and other primary source materials, and evaluate the credibility of sources used;
2. Employ cause-and-effect arguments to demonstrate how significant events have influenced the past and the present in United States and world history;
3. Describe the relationships between and among significant events, such as the causes and consequences of wars in United States and world history;
4. Explain how and why events may be interpreted differently depending upon the perspectives a participants, witnesses, reporters, and historians;
5. Use historical evidence to determine and support a position about important political values, such as freedom, democracy, equality, or justice, and express the position coherently;
6. Analyze important political values such as freedom, democracy, equality, and justice embodied in documents such as the Declaration of Independence, the United States Constitution, and the Bill of Rights;
7. Identify significant events and people in the major eras of United States and world history;
8. Identify major scientific discoveries and technological innovations and describe their social and economic effects on society;
9. Explain the need for laws and policies to regulate science and technology;
10. Analyze examples of conflict, cooperation, and interdependence among groups, societies, or nations;

11. Summarize major issues associated with the history, culture, tribal sovereignty, and current status of the American Indian tribes and bands in Wisconsin;
12. Describe how history can be organized and analyzed using various criteria to group people and events chronologically, geographically, thematically, topically, and by issues.

C. Political Science & Citizenship: Power, Authority, Governance, & Responsibility (pps.8-9)

Content Standard:

Students in Wisconsin will learn about political science and acquire the knowledge of political systems necessary for developing individual civic responsibility by studying the history and contemporary uses of power, authority, and governance.

Performance Standards:

1. Identify and explain democracy's basic principles, including individual rights, responsibility for the common good, equal opportunity, equal protection of the laws, freedom of speech, justice, and majority rule with protection for minority rights;
2. Identify, cite, and discuss important political documents, such as the Constitution, the Bill of Rights, and landmark decisions of the Supreme Court, and explain their function in the American political system;
3. Explain how laws are developed, how the purposes of government are established, and how the powers of government are acquired, maintained, justified, and sometimes abused;
4. Describe and explain how the federal system separates the powers of federal, state, and local governments in the United States, and how legislative, executive, and judicial powers are balanced at the federal level;
5. Explain how the federal system and the separation of powers in the Constitution work to sustain both majority rule and minority rights;
6. Explain the role of political parties and interest groups in American politics;
7. Locate, organize, and use relevant information to understand an issue of public concern, take a position, and advocate the position in a debate;
8. Identify ways in which advocates participate in public policy debates;

9. Describe the role of international organization such as military alliances and trade associations.

D. The Behavioral Sciences: Individuals, Institutions, & Society (pps. 12-13)

Content Standard:

Students in Wisconsin will learn about the behavioral sciences by exploring concepts from the discipline of sociology, the study of the interactions among individuals, groups, and institutions; the discipline of psychology, the study of factors that influence individual identity and learning; and the discipline of anthropology, the study of cultures in various times and settings.

Performance Standards:

1. Give examples to explain and illustrate the influence or prior knowledge, motivation, capabilities, personal interests, and other factors on individual learning;
2. Give examples to explain and illustrate how factors such as family, gender, and socioeconomic status contribute to individual identity and development;
3. Describe the ways in which local, regional, and ethnic cultures may influence the everyday lives of people;
4. Describe and explain the means by which individuals, groups, and institutions may contribute to social continuity and change within a community;
5. Describe and explain the means by which groups and institutions meet the needs of individuals and societies;
6. Describe and explain the influence of status, ethnic origin, race, gender, and age on the interactions of individuals;
7. Identify and explain examples of bias, prejudice, and stereotyping, and how they contribute to conflict in a society;
8. Give examples to show how the media may influence the behavior and decision-making of individuals and groups;
9. Give examples of the cultural contributions of racial and ethnic groups in Wisconsin, the United States, and the world;
10. Explain how language, art, music, beliefs, and other components of culture can further global understanding or cause misunderstanding;
11. Explain how beliefs and practices, such as ownership of property or status at birth, may lead to conflict among people of different regions or cultures and give examples of such conflicts that have and have not been resolved;
12. Describe conflict resolution and peer mediation strategies used in resolving differences and disputes;

13. Select examples of artistic expressions from several different cultures for the purpose of comparing and contrasting the beliefs expressed;
14. Describe cooperation and interdependence among individuals, groups and nations, such as helping others in times of crisis.

Appendix of National Standards: Arts

The following national standards are taken from *National Standards for Arts Education* for 5th through 8th grades and correlate with the learning guidelines for citizen science. Included are the specific art and content standards, as well as the page numbers they are found in the original text.

I. Dance (pp 40)

   Content Standards:

   i. Understanding dance as a way to create and communicate meaning

II. Theatre (pp. 47):

   Content Standards:

   i. Researching by using cultural and historical information to support improvised and scripted scenes

III. Visual Arts (pp. 50)

   Content Standards:

   i. Understanding and applying media, techniques, and processes

   ii. Choosing and evaluating a range of subject matter, symbols, and ideas

IV. Visual Arts (pp. 51)

   Content Standards:

   i. Reflecting upon and assessing the characteristics and merits of their work and the work of others

Appendix of National Standards: Civics & Government

The following national standards are taken from *National Standards for Civics and Government* for 5th through 8th grades and correlate with the learning guidelines for citizen science. Included are the aims, goals and specific content and performance standards, as well as the page numbers they are found in the original text.

I. How does the government established by the Constitution embody the purposes, values, and principles of American democracy? (pps. 68-70)

a. How does the American political system provide for choice and opportunities for participation?

Content and Performance Standards:

i. The Public Agenda: Students should be able to explain what is meant by the public agenda and how it is set.
1. Explain that the public agenda consists of those matters that occupy public attention at any particular time
2. Describe how the public agenda is shaped by political leaders, interest groups, the media, state and federal courts, individual citizens
3. Explain how individuals can help to shape the public agenda

ii. Political Communication: Students should be able to evaluate, take, and defend positions on the influence of the media on American political life.
1. Explain the importance of freedom of the press to informed participation in the political system
2. Evaluate the influence of television, radio, the press, newsletters, and emerging means of electronic communication on American politics
3. Explain how Congress, the president, the Supreme Court, and state and local public officials use the media to communicate with the citizenry
4. Explain how citizens can evaluate information and arguments received from various sources so that they can make reasonable choices on public issues and among candidates for political office
5. Evaluate opportunities the media provide for individuals to monitor actions of their government
6. Evaluate opportunities the media provide for individuals to communicate their concerns and positions on current issues

iii. Political Parties, Campaigns, and Elections: Students should be able to explain how political parties, campaigns, and elections provide opportunities for citizens to participate in the political process.
1. Describe the role of political parties
2. Describe various kinds of elections

3. Explain ways individuals can participate in political parties, campaigns, and elections

iv. Association and Groups: Students should be able to explain how interest groups, unions, and professional organizations provide opportunities for citizens to participate in the political process.
   1. Describe the historical roles of prominent associations and groups in local, state, or national politics
   2. Describe the contemporary roles of prominent associations and groups in local, state, or national politics
   3. Explain how and why Americans become members of associations and groups
   4. Explain how individuals can participate in the political process through membership in associations and groups

v. Forming and Carrying out Public Policy: Students should be able to explain how public policy is formed and carried out at local, state, and national levels and what roles individuals can play in the process.
   1. Define public policy and identify examples at local, state, and national levels
   2. Describe how public policies are formed and implemented
   3. Explain how citizens can monitor and influence the formation and implementation of public policies
   4. Explain why conflicts about values, principles, and interests may make agreement difficult or impossible on certain issues of public policy

II. What is the relationship of the United States to other nations and to world affairs? (pps. 71-73)

a. How is the world organized politically?

Content Standards:

i. Nation-states: Students should be able to explain how the world is organized politically.
   1. Describe how the world is divided into nation-states that claim sovereignty over a defined territory and jurisdiction over everyone within it
   2. Explain why where is no political organization at the international level with power comparable to that of the nation-state

ii. Interaction among Nation-states: Students should be able to explain how nation-states interact with each other.
   1. Describe the most important means nation-states use to interact with one another, e.g., trade, diplomacy, treaties and agreements,

humanitarian aid, economic incentives and sanctions, military force and the threat of force
2. Explain reasons for the breakdown of order among nation-states
3. Explain the consequences of the breakdown of order among nation-states
4. Explain why and how the breakdown of order among nation-states can affect their own lives

iii. United States' Relations with other Nation-states: Students should be able to explain how United States foreign policy is made and the means by which it is carried out.
1. Explain the most important powers the United States Constitution gives to the Congress, president, and federal judiciary in foreign affairs
2. Describe various means used to attain the ends of United States foreign policy
3. Identify important current foreign policy issues and evaluate the means the United States is using to deal with them

iv. International Organizations: Students should be able to explain the role of major international organizations in the world today.
1. Describe the purposes and functions of major governmental international organizations
2. Describe the purposes and functions of major nongovernmental international organizations

b. How has the United States influenced other nations and how have other nations influenced American politics and society?

Content Standards:

i. Impact of the American Concept of Democracy and Individual Rights on the World: Students should be able to describe the influence of American political ideas on other nations.
1. Describe the impact on other nations of the American Revolution and of the values and principles expressed in the Declaration of Independence and the United States Constitutions, including the Bill of Rights
2. Describe the influence American ideas about rights have had on other nations and international organizations
3. Describe the impact of other nations' ideas about rights on the United States

ii. Political, Demographic, and Environmental Developments: Students should be able to explain the effects of significant political, demographic, and environmental trends in the world.

1. Describe the impact of current political developments in the world on the United States
2. Describe the impact of major demographic trends on the United States
3. Describe environmental conditions that affect the United States

III. What are the roles of the citizen in American democracy? (pps. 74-83)

a. What is citizenship?

Content Standards:

i. The Meaning of Citizenship: Students should be able to explain the meaning of American citizenship.
   1. Explain the important characteristics of citizenship in the United States
   2. Explain that Americans are citizens of both their state and the United States

ii. Becoming a Citizen: Students should be able to explain how one becomes a citizen of the United States.
   1. Explain that anyone born in the United States is a U.S. citizen
   2. Explain the distinction between citizens and noncitizens (aliens)
   3. Describe the process by which noncitizens may become citizens
   4. Compare naturalization in the United States with that of other nations
   5. Evaluate the criteria established by law that are used for admission to citizenship in the United States

b. What are the rights of citizens?

Content Standards:

i. Personal Rights: Students should be able to evaluate, take, and defend positions on issues involving personal rights.
   1. Identify personal rights
   2. Identify the major documentary sources of personal rights
   3. Explain the importance to the individual and to society of such persona rights
   4. Identify and evaluate contemporary issues that involve personal rights

ii. Political Rights: Students should be able to evaluate, take, and defend positions on issues involving political rights.
   1. Identify political rights

2. Explain the meaning of political rights as distinguished from personal rights
3. Identify major statements of political rights in documents such as the Declaration of Independence, U. S. Constitution, Bill of Rights, civil rights legislation, and state constitutions
4. Explain the importance to the individual and society of such political rights as freedom of speech, press, assembly and petition, and right to vote and to seek public office
5. Identify and evaluate contemporary issues that involve political rights.

iii. Economic Rights: Students should be able to evaluate, take, and defend positions on issues involving economic rights.

1. Identify important economic rights, e.g., property, work, change employment
2. Identify statements of economic rights in the United States Constitution
3. Explain the importance to the individual and to society of such economic rights
4. Identify and evaluate contemporary issues regarding economic rights

iv. Scope and Limits of Rights: Students should be able to evaluate, take, and defend positions on issues regarding the proper scope and limits of rights.

1. Explain what is meant by the "scope and limits" of a right
2. Explain the argument that all rights have limits
3. Explain criteria commonly used in determining what limits should be placed on specific rights
4. Identify and evaluate positions on contemporary conflict between rights
5. Identify and evaluate positions on a contemporary conflict between rights and other social values and interests

c. What are the responsibilities of citizens?

Content Standards:

i. Personal Responsibilities: Students should be able to evaluate, take, and defend positions on the importance of personal responsibilities to the individual and to society.

1. Evaluate the importance of commonly held personal responsibilities
2. Identify and evaluate contemporary issues that involve personal responsibilities

ii. Civic Responsibilities: Students should be able to evaluate, take, and defend positions on the importance of civic responsibilities to the individual and society.
    1. Evaluate the importance of commonly held civic responsibilities
    2. Explain the meaning of civic responsibilities as distinguished from personal responsibilities
    3. Evaluate when their responsibilities as Americans require that their personal rights and interests be subordinated to the public good
    4. Evaluate the importance for the individual and society of fulfilling civic responsibilities
    5. Identify and evaluate contemporary issues that involve civic responsibilities

d. What dispositions or traits of character are important to the preservation and improvement of American Constitutional democracy?

Content Standards:

i. Dispositions that Enhance Citizen Effectiveness and Promote the Healthy Functioning of American Constitutional Democracy: Students should be able to evaluate, take, and defend positions on the importance of certain dispositions or traits of character to themselves and American constitutional democracy.
    1. Explain the importance to the individual and society of the following dispositions or traits of character: individual responsibility, self-discipline/self-governance, civility, courage, respect for the rights of other individuals, respect for law, honest, open mindedness, critical mindedness, negotiation and compromise, persistence, civic mindedness, compassion, and patriotism

e. How can citizens take part in civic life?

Content Standards:

i. Participations in Civic and Political Life and the Attainment of Individual and Public Goals: Students should be able to explain the relationship between participating in civic and political life and the attainment of individual and public goals.
    1. Identify examples of their own individual goals and explain how their participation in civic and political life can help to attain them
    2. Identify examples of public goals and explain how participation in civic and political life can help to attain them

ii. The Difference between Political and Social Participation: Students should be able to explain the difference between political and social participation.

1. Explain what distinguished political form social participation
2. Explain the importance of both political and social participation to American constitutional democracy
3. Identify opportunities in their own community for both political and social participation

iii. Forms of Political Participation: Students should be able to describe the means by which Americans can monitor and influence politics and government.
   1. Explain how Americans can use the following means to monitor and influence politics and government at local, state, and national levels: voting, informed about public issues, discussing public issues, communicating with public officials, joining political parties, attending meetings of governing bodies, working in campaigns, taking part in peaceful demonstration, circulating and signing petitions, and contributing money to political parties or causes
   2. Describe historical and current examples of citizen movements seeking to promote individual rights and the common good
   3. Explain what civil disobedience is, how it differs from other forms or protest, what its consequences might be, and circumstances under which it might be justified
   4. Explain why becoming knowledgeable about public affairs and the values of principles of American constitutional democracy and communicating that knowledge to others is a form or political participation

iv. Political Leadership and Public Service: Students should be able to explain the importance of political leadership and public service in a constitutional democracy.
   1. Describe personal qualities necessary for political leadership
   2. Explain the functions of political leadership and why leadership is a vital necessity in a constitutional democracy
   3. Explain and evaluate ethical dilemmas that might confront political leaders
   4. Identify opportunities for political leadership in their own school, community, state, and the nation
   5. Explain the importance of individuals working cooperatively with their elected leaders
   6. Evaluated the role of "the loyal opposition" in a constitutional democracy
   7. Explain the importance of public service in a constitutional democracy
   8. Identify opportunities for public service in their own school, community, state and the nation
   9. Identify career opportunities in public service

v. Knowledge and Participation: Students should be able to explain the importance of knowledge to competent and responsible participation in American democracy.
    1. Explain why becoming knowledgeable about public affairs and the values and principles of American constitutional democracy and communicating that knowledge to others is an important form of participation
    2. Explain how awareness of the nature of American constitutional democracy may give citizens the ability to reaffirm or change fundamental constitutional values
    3. Evaluate the claim that constitutional democracy requires the participation of an attentive, knowledgeable, and competent citizenry

Appendix of National Standards: Economics

The following national standards are taken from *Voluntary National Standards in Economics* for 5th through 8th grades and correlate with the learning guidelines for citizen science. Included are the content/performance standard, standard benchmarks, and the page numbers it is found in the original text.

I. Content/Performance Standard 1 (pps. 1-3)

   a. Students will understand that productive resources are limited. Therefore, people cannot have all the goods and services they want; as a result, they must choose some things and give up others.

      i. Students will be able to use this knowledge to identify what they gain and what they give up when they make choices.

         Performance Standard Benchmarks:

         1. Scarcity is the condition of not being able to have all the goods and services one wants. It exists because human wants for goods and services exceed the quantity of goods and services that can be produced using all available resources.
         2. Like individuals, governments and societies experience scarcity because human wants exceed what can be made from all available resources.
         3. Choices involve trading off the expected value of one opportunity against the expected value of its best alternative.
         4. The choices people make have both present and future consequences.
         5. The evaluation of choices and opportunity costs is subjective; such evaluations differ across individuals and societies.

Appendix of National Standards: English Language Arts

The following national standards are taken from *Standards for the English Language Arts* for 5th through 8th grades and correlate with the learning guidelines for citizen science. Included are the specific content standards and the page numbers they are found in the original text.

I. Students read a wide range of print and non-print texts to build an understanding of texts, of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classic and contemporary works. (pps. 27-28)

II. Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and of other texts, their word identification strategies, and their understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, graphics). (pps. 31-33)

III. Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes. (pps. 35-36)

IV. Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience. (pps. 38-39)

V. Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. (pps. 29-30)

VI. Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic groups, geographic regions, and social roles. (pps. 41-42)

VII. Students participate as knowledgeable, reflective, creative, and critical members of a variety of literacy communities. (pps. 44-45)

Appendix of National Standards: Geography

The following national standards are taken from *Geography for Life: National Geography Standards* for 5th through 8th grades and correlate with the learning guidelines for citizen science. The appendix is divided into geographic skill sets, and the themes, goals and specific content/performance standards. The page numbers where the information is found in the original text is also included.

I. Geographic Skills & Perspectives (pps. 49-52)

a. Asking Geographic Questions

Geographic Skill Set 1 with Specific Skills:

i. Identify geographic issues, define geographic problems, and pose geographic questions.
    1. Analyze newspaper and magazine articles and identify geographic issues and problems evident in the articles
    2. Develop geographic questions about issues in subjects other than geography (e.g., language arts, history, science)
    3. Ask questions about geographic problems in local issues relating to traffic, the environment, land use, housing, etc., and then summarize these problems by preparing written or oral statements, maps, and graphs

ii. Plan how to answer geographic questions.
    1. Develop questions to obtain information about a place, put the questions to likely informants, and then prepare a short description of their answers
    2. Identify and organize issues that should be considered in tackling a geographic problem (e.g., identify the factors involved in the location and design of a school playground)

b. Acquiring Geographic Information

Geographic Skill Set 2 with Specific Skills:

i. Use a variety of research skills to locate and collect geographic data.
    1. Enter and retrieve population information on a computer, using databases, spreadsheets, and other sources
    2. Know how to find as well as choose appropriate sources of information (e.g., periodicals, Census materials, databases, reference works, etc.)
    3. Conduct interviews and field surveys in the student's local community to collect geographic information

ii. Use maps to collect and/or compile geographic information.
    1. Use cartograms, such as one dealing with petroleum production to prepare a list of major producers

2. Read aerial photographs to recognize patterns apparent from the air and identify the patterns on a topographic map of the same area
3. Describe phenomena reported on a map

iii. Systematically observe the physical and human characteristics of places on the basis of field work.
1. Conduct field survey to be able to map information about land use
2. Take photographs and/or shoot videos or prepare sketches of human features and physical features of the landscape
3. View pictures and video images of a place to collect geographic information

c. Organizing Geographic Information

Geographic Skill Set 3 with Specific Skills:

i. Prepare various forms of maps as a means of organizing geographic information.
1. Use area data to create choropleth maps
2. Use maps to plot information contained in graphs
3. Use isolines to map information

ii. Prepare various forms of graphs to organize and display geographic information.
1. Use weather data to produce climagraphs
2. Use population data to produce population pyramids for a variety of countries
3. Use computer programs to graph data from geographic databases

iii. Prepare various forms of diagrams, tables, and charts to organize and display geographic information.
1. Create a table to compare data on a specific topic for different geographic regions
2. Use flowcharts and diagrams to illustrate inputs, outputs, elements, feedbacks, and other aspects of physical and human systems
3. Organize data in tables or diagrams to make decisions or draw conclusions

iv. Integrate various types of materials to organize geographic information.
1. Prepare overlays of different types of geographic information to create a geographic information system
2. Organize materials for a multimedia report

d. Analyzing Geographic Information

Geographic Skill Set 4 with Specific Skills:

i. Interpret information obtained from maps, aerial photographs, satellite-produced images and geographic information systems (GIS).
1. Draw inferences from information presented in maps

2. Use maps to recognize spatial associations and relationships between locations
3. Interpret information from map overlays to prepare a description of the geography of a region or place
4. Evaluate geographic information to identify the possibility of bias

ii. Use statistics and other quantitative techniques to evaluate geographic information.

1. Use data obtained from quantitative methods of analysis to identify trends and patterns in data
2. Produce summaries of geographic information
3. Cross-tabulate the occurrences of geographic variables to discover whether they co-vary spatially

iii. Interpret and synthesize information obtained from a variety of sources – e.g., graphs, charts, tables, diagrams, texts, photographs, documents, interviews.

1. Analyze and explain geographic themes in texts and documents
2. Prepare written and oral explanations of geographic relationships based on synthesis and analysis of information
3. Compare maps of voting patterns, ethnicity, and congressional districts to make inferences about distributions of political power in a U.S. state or region at different periods

e. Answering Geographic Questions:

Geographic Skill Set 5 with Specific Skills:

i. Develop and present combinations of geographic information to answer geographic questions.

1. Use data from a geographic database to suggest alternative locations for a new rods, a park, or a garbage dump
2. Develop and present a multimedia report on a geographic topic, making use of maps, graphs, diagrams, videos, and pictures
3. Draw sketch maps and graphs to illustrate written and oral summaries of geographic information

ii. Make generalizations and assess their validity.

1. Prepare a reasoned account about the best locations for a crop by comparing its requirements for moisture with maps of rainfall, temperature, and soil quality
2. Select appropriate locations for service industries by using population, transportation, and other kids of maps
3. Identify populations at risk for specific natural hazards by using a topographic map and a map of population distribution

II. The World in Spatial Terms (pps. 144-145)

a. How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.

Content Standards:

i. The characteristics, functions, and applications of maps, globes, aerial and other photographs, satellite-produced images, and models.
ii. How to make and use maps, globes, graphs, charts, models, and databases to analyze spatial distributions and patterns.
iii. The relative advantages and disadvantages of using maps, globes, aerial and other photographs, satellite-produced images, and models to solve geographical problems.

Performance Standards:

iv. Describe the essential characteristics and functions of maps and geographic representations, tools, and technologies.
v. Develop and use different kinds of maps, globes, graphs, charts, databases, and models.
vi. Evaluate the relative merits of maps and other geographic representations, tools, and technologies in terms of their value in solving geographic problems.
vii. Use geographic tools and technologies to pose and answer questions about spatial distributions and patterns of Earth.

III. Places & Regions (pps. 150-151)

a. The physical and human characteristics of places.

Content Standards:

i. How different physical processes shape places.
ii. How different human groups alter places in distinctive ways.
iii. The role of technology in shaping the characteristics of places.

Performance Standards:

iv. Analyze the physical characteristics of places.
v. Analyze the human characteristics of places.
vi. Identify and analyze how technology shapes the physical and human characteristics of places.

IV. Places & Regions (pps. 152-153)

a. That people create regions to interpret Earth's complexity.

Content Standards:

i. The elements and types of regions.
ii. How and why regions change.
iii. The connections among regions.
iv. The influences and effects of regional labels and images.

Performance Standards:

v. Identify the criteria used to define a region.
vi. Identify types of regions.
vii. Explain how regions change over space and time.
viii. Explain how regions are connected.
ix. Evaluate the influences and effects of regional labels and images.

V. Places & Regions (pps. 154-155)

a. How culture and experience influence people's perception of places and regions.

Content Standards:

i. How personal characteristics affect our perception of places and regions.
ii. How culture and technology affect perception of places and regions.
iii. How places and regions serve as cultural symbols.

Performance Standards:

iv. Evaluate the characteristics of places and regions from a variety of points of view.
v. Explain how technology affects the ways in which culture groups perceive and use places and regions.
vi. Identify ways culture influences people's perceptions of places and regions.
vii. Illustrate and explain how places and regions serve as cultural symbols.

VI. Physical Systems (pps. 158-159)

a. The characteristics and spatial distribution of ecosystems on Earth's surface.

Content Standards:

i. The local and global patterns of ecosystems
ii. How ecosystems work.
iii. How physical processes produce change in ecosystems.
iv. How human activities influence changes in ecosystems.

Performance Standards:

v. Explain the distribution of ecosystems from local to global scales.
vi. Explain the functions and dynamics of ecosystems.
vii. Explain how physical processes influence ecosystems.
viii. Explain how human processes contribute to changes in ecosystems.

VII. Human Systems (pps. 164-166)

a. The patterns and networks of economic interdependence on Earth's surface.

Content Standards:

i. Ways to classify economic activity
ii. The basis for global interdependence
iii. Reasons for the spatial patterns of economic activities
iv. How changes in technology, transportation, and communication affect the location of economic activities

Performance Standards:

v. List and define the major terms used to describe economic activity in a geographic context.
vi. Explain the spatial aspects of systems designed to deliver goods and services.
vii. Analyze and evaluate issues related to the spatial distribution of economic activities.
viii. Identify and explain the primary geographic causes for world trade.

VIII. Human Systems (pps. 169-170)

a. How the forces of cooperation and conflict among people influence the division and control of Earth's surface

Content Standards:

i. The multiple territorial divisions of the student's own world
ii. How cooperation and conflict among people contribute to political divisions of Earth's surface
iii. How cooperation and conflict among people contribute to economic and social divisions of Earth's surface

Performance Standards:

iv. Identify and explain reasons for the different spatial divisions in which the student lives.

v. Explain why people cooperate but also engage in conflict to control Earth's surface.
vi. Describe the factors that affect the cohesiveness and integration of countries.
vii. Analyze divisions on Earth's surface at different scales (local to global).

IX. Environment & Society (pps. 171-172)

a. How human actions modify the physical environment

Content Standards:

i. The consequences of human modification of the physical environment
ii. How human modifications of the physical environment in one place often lead to changes in other places
iii. The role of technology in the human modification of the physical environment

Performance Standards:

iv. Analyze the environmental consequences of humans changing the physical environment.
v. Identify and explain the ways in which human-induced changes in the physical environment in one place can cause changes in other places.
vi. Evaluate the ways in which technology influences human capacity to modify the physical environment.

X. Environment & Society (pps. 173-175)

a. How physical systems affect human systems

Content Standards:

i. Human responses to variations in physical systems
ii. How the characteristics of different physical environments provide opportunities for or place constraints on human activities
iii. How natural hazards affect human activities

Performance Standards:

iv. Analyze ways in which human systems develop in response to conditions in the physical environment.
v. Explain how the characteristics of different physical environments affect human activities.
vi. Describe the effects of natural hazards on human systems.

Appendix of National Standards: Geography

XI. Environment & Society (pps. 176-178)

a. The changes that occur in the meaning, use, distribution, and importance of resources

Content Standards:

i. The worldwide distribution and use of resources
ii. Why people have different viewpoints regarding resource use
iii. How technology affects the definitions of, access to, and use of resources
iv. The fundamental role of energy resources in society

Performance Standards:

v. Describe and analyze world patterns of resource distribution and utilization.
vi. Describe the consequences of the use of resources in the contemporary world.
vii. Evaluate different viewpoints regarding resource use.
viii. Identify the role of technology in resource acquisition and use.
ix. Identify and develop plans for the management and use of renew able, nonrenewable, and flow resources.
x. Explain the critical importance of energy resources to the development of human societies.

XII. The Uses of Geography (pps. 179-180)

a. How to apply geography to interpret the past

Content Standards:

i. How the spatial organization of a society changes over time
ii. How people's differing perceptions of places, peoples, and resources have affected events and conditions in the past
iii. How geographic contexts have influenced events and conditions in the past

Performance Standards:

iv. Describe the ways in which the spatial organization of society changes over time.
v. Assess the roles that spatial and environmental perceptions played in past events.
vi. Analyze the effects of physical and human geographic factors on major historic events.

vii. List and describe significant physical features that have influenced historical events.

XIII. The Uses of Geography (pps. 181-182)

a. How to apply geography to interpret the present and plan for the future

Content Standards:

i. How the interaction of physical and human systems may shape present and future conditions on Earth
ii. How varying points of view on geographic context influence plans for change
iii. How to apply the geographic point of view to solve social and environmental problems by making geographically informed decisions

Performance Standards:

iv. Analyze the interaction between physical and human systems to understand possible causes and effects of current conditions on Earth and to speculate on future conditions.
v. Integrate multiple points of view to analyze and evaluate contemporary geographic issues.
vi. Demonstrate an understanding of the spatial organization of human activities and physical systems and be able to make informed decisions.

Appendix of National Standards: History

The following national standards are taken from *National Standards for History* for 5th through 8th grades and correlate with the learning guidelines for citizen science. Included are the theme, goal, and specific content/performance standards and the page numbers they are found in the original text.

I. Standards In Historical Thinking (pps. 67-70)

a. Historical Research Capabilities: The student conducts historical research.

Content/Performance Standards:

i. Formulate historical questions from encounters with historical documents, eyewitness accounts, letters, diaries, artifacts, photos, historical sites, art, architecture, and other records from the past.

ii. Obtain historical data from a variety of sources, including: library and museum collections, historic sites, historical photos, journals, diaries, eyewitness accounts, newspapers, and the like; documentary films, oral testimony from living witnesses, censuses, tax records, city directories, statistical compilations, and economic indicators.

iii. Interrogate historical data by uncovering the social, political, and economic context in which it was created; testing the data source for its credibility, authority, authenticity, internal consistency and completeness; and detecting and evaluating bias, distortion, and propaganda by omission, suppression, or inventions of facts.

iv. Identify the gaps in the available records and marshal contextual knowledge and perspectives of the time and place in order to elaborate imaginatively upon the evidence, fill in the gaps deductively, and construct a sound historical interpretation.

v. Employ quantitative analysis in order to explore such topics as changes in family size and composition, migration patterns, wealth distribution, and changes in the economy.

vi. Support interpretations with historical evidence in order to construct closely reasoned arguments rather than facile opinions.

b. Historical Issues-Analysis and Decision Making: The student engages in historical issues-analysis and decision-making.

Content/Performance Standards:

i. Identify issues and problems in the past and analyze the interests, values, perspectives, and points of view of those involved in the situation.

ii. Marshal evidence of antecedent circumstances and current factors contributing to contemporary problems and alternative courses of action.

iii. Identify relevant historical antecedents and differentiate from those that are inappropriate and irrelevant to contemporary issues.

iv. Evaluate alternative courses of action, keeping in mind the information available at the time, in terms of ethical considerations, the interests of those affected by the decision, and the long- and short-term consequences of each.

v. Formulate a position or course of action on an issue by identifying the nature of the problem, analyzing the underlying factors contributing to the problem, and choosing a plausible solution from a choice of carefully evaluated options.

vi. Evaluate the implementation of a decision by analyzing the interests it served; estimating the position, power, priority of each player involved; assessing the ethical dimensions of the decision; and evaluating its costs and benefits from a variety of perspectives.

Appendix of National Standards: Mathematics

The following national standards are taken from *Principles and Standards for School Mathematics* for 6th through 8th grades and correlate with the learning guidelines for citizen science. Included are themes, specific content and performance standards, and the page numbers they are found in the original text.

I. Number & Operations (pp. 214)

Content & Performance Standards:

i. Understand numbers, ways of representing numbers, relationships among numbers, and number systems.
   1. Work flexibly with fractions, decimals, and percents to solve problems;
   2. Compare and order fraction, decimals, and percents efficiently and find their approximate locations on a number line;
   3. Develop meaning for percents greater than 100 and less than 1;
   4. Understand and use ratios and proportions to represent quantitative relationships;
   5. Develop an understanding of large numbers and recognize and appropriately use exponential, scientific, and calculator notation;
   6. Use factors, multiples, prime factorization, and relatively prime numbers to solve problems;
   7. Develop meaning for integers and represent and compare quantities with them.

ii. Understand meanings of operations and how they relate to one another.
   1. Understand the meaning and effects of arithmetic operations with fractions, decimals, and integers;
   2. Use the associative and commutative properties of addition and multiplication and the distributive property of multiplication over addition to simplify computations with integers, fractions, and decimals;
   3. Understand and use the inverse relationships of addition and subtraction, multiplication and division, and squaring and finding square roots to simplify computations and solve problems.

iii. Compute fluently and make reasonable estimates.
   1. Select appropriate methods and tools for computing with fractions and decimals from among mental computation, estimation, calculators or computers, and paper and pencil, depending on the situation, and apply the selected methods;
   2. Develop and analyze algorithms for computing with fractions, decimals, and integers and develop fluency in their use;
   3. Develop and use strategies to estimate the results of rational-number computations and judge the reasonableness of the results;
   4. Develop, analyze, and explain methods for solving problems involving proportions, such as scaling and finding equivalent ratios.

II. Algebra (pp. 222)

Content & Performance Standards:

i. Understand patterns, relations, and functions.
   1. Represent, analyze, and generalize a variety of patterns with tables, graphs, words, and, when possible, symbolic rules;
   2. Relate and compare different forms of representation for a relationship;
   3. Identify functions as linear or nonlinear and contrast their properties from tables, graphs, or equations.

ii. Represent and analyze mathematical situations and structures using algebraic symbols.
   1. Develop an initial conceptual understanding of different uses of variables;
   2. Explore relationships between symbolic expressions and graphs of lines, paying particular attention to the meaning of intercept and slope;
   3. Use symbolic algebra to represent situations and to solve problems, especially those that involve linear relationships;
   4. Recognize and generate equivalent forms for simple algebraic expressions and solve linear equations.

iii. Use mathematical models to represent and understand quantitative relationships.
   1. Model and solve contextualized problems using various representations, such as graphs, tables, and equations.

iv. Analyze change in various contexts.
   1. Use graphs to analyze the nature of changes in quantities in linear relationships.

III. Geometry (pp. 232)

Content & Performance Standards:

i. Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships.
   1. Precisely describe, classify, and understand relationships among types of two- and three-dimensional objects using their defining properties;
   2. Understand relationships among the angles, side lengths, perimeters, areas, and volumes of similar objects;
   3. Create and critique inductive and deductive arguments concerning geometric ideas and relationships, such as congruence, similarity, and the Pythagorean relationship.

ii. Specify locations and describe spatial relationships using coordinate geometry and other representational systems.
    1. Use coordinate geometry to represent and examine the properties of geometric shapes;
    2. Use coordinate geometry to examine special geometric shapes, such as regular polygons or those with pairs of parallel or perpendicular sides.

iii. Apply transformations and use symmetry to analyze mathematical situations.
    1. Describe sizes, positions, and orientations of shapes under informal transformations such as flips, turn, slides, and scaling;
    2. Examine the congruence, similarity, and line or rotational symmetry of objects using transformations.

iv. Use visualization, spatial reasoning, and geometric modeling to solve problems.
    1. Draw geometric objects with specified properties, such as side lengths or angle measures;
    2. Use two-dimensional representations of three-dimensional objects to visualize and solve problems such as those involving surface are and volume;
    3. Use visual tools such as networks to represent and solve problems;
    4. Use geometric models to represent and explain numerical and algebraic relationships;
    5. Recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art science, and everyday life.

IV. Measurement (pp. 240)

Content & Performance Standards:

i. Understand measurable attributes of objects and the units, systems, and processes of measurement.
    1. Understand both metric and customary systems of measurement;
    2. Understand relationships among units and convert from one unit to another within the same system;
    3. Understand, select, and use units of appropriate size and type to measure angles, perimeter, area, surface area, and volume.

ii. Apply appropriate techniques, tools, and formulas to determine measurements.
    1. Use common benchmarks to select appropriate methods for estimating measurements;
    2. Select and apply techniques and tools to accurately find length, area, volume, and angle measures to appropriate levels of precision;

3. Develop and use formulas to determine the circumference of circles and the area of triangles, parallelograms, trapezoids, and circles and develop strategies to find the area of more-complex shapes;
4. Develop strategies to determine the surface area and volume of selected prisms, pyramids, and cylinders;
5. Solve problems involving scale factors, using ratio and proportions;
6. Solve simple problems involving rates and derived measurements for such attributes as velocity and density.

V. Data Analysis & Probability (pp. 248)

Content & Performance Standards:

i. Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.
   1. Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population;
   2. Select, create, and use appropriate graphical representations of data, including histograms, box plots, and scatter plots.

ii. Select and use appropriate statistical methods to analyze data.
   1. Find, use, and interpret measures of center and spread, including mean and inter-quartile range;
   2. Discuss and understand the correspondence between data sets and their graphical representations, especially histograms, stem-and-leaf plots, box plots, and scatter plots.

iii. Develop and evaluate inferences and predictions that are based on data.
   1. Use observations about differences between two or more samples to make conjectures about the populations from which the sample were taken;
   2. Make conjectures about possible relationships between two characteristics of a sample on the basis of scatter plots of the data and approximate lines of fit;
   3. Use conjectures to formulate new questions and plan new studies to answer them.

iv. Understand and apply basic concepts of probability.
   1. Understand and use appropriate terminology to describe complementary and mutually exclusive events;
   2. Use proportionality and a basic understanding of probability to make and test conjectures about eh results of experiments and simulations;
   3. Compute probabilities for simple compound events, using such methods as organized lists, tree diagrams, and area models.

Appendix of National Standards: Mathematics

VI. Problem Solving Standard (pp. 256)

Content Standards:

i. Build new mathematical knowledge through problem solving;
ii. Solve problems that arise in mathematics and in other contexts;
iii. Apply and adapt a variety of appropriate strategies to solve problems;
iv. Monitor and reflect on the process of mathematical problem solving.

VII. Connections (pp. 274)

Content Standards:

i. Recognize and use connections among mathematical ideas;
ii. Understand how mathematical ideas interconnect and build on one another to produce a coherent whole;
iii. Recognize and apply mathematics in contexts outside of mathematics.

VIII. Representation (pp.280)

Content Standards:

i. Create and use representations to organize, record, and communicate mathematical ideas;
ii. Select, apply, and translate among mathematical representations to solve problems;
iii. Use representations to model and interpret physical, social, and mathematical phenomena.

Appendix of National Standards: Science

The following national standards are taken from *National Science Education Standards* for 5th through 8th grades and correlate with the learning guidelines for citizen science. Included are the themes, goals and specific content/performance standards, as well as the page numbers they are found in the original text.

I. Science as Inquiry (pps. 143, 145, & 148)

  a. Developing Student Abilities to Do & Understanding about Scientific Inquiry

  Content/Performance Standards:

   i. Students should be provided opportunities to engage in full and partial inquiries through questions, investigation design, evidence gathering, formulating an answer, and communicating the process and results.
   ii. Students can begin to recognize the relationship between explanation and evidence through understanding background knowledge and investigative design theory, types of observations, data interpretation.

  b. Necessary Abilities to Do Scientific Inquiry

  Content/Performance Standards:

   i. Students identify questions that can be answered through scientific investigations.
   ii. Students design and conduct a scientific investigation.
   iii. Students use appropriate tools and techniques to gather, analyze, and interpret data.
   iv. Students develop descriptions, explanations, predictions, and models using evidence
   v. Students think critically and logically to make the relationships between evidence and explanations.
   vi. Students recognize and analyze alternative explanations and predictions.
   vii. Students communicate scientific procedures and explanations.
   viii. Students use mathematics in all aspects of scientific inquiry.
   ix. Students understand about scientific inquiry.

II. Physical Science (pp. 154)

  a. Properties and Changes of Properties in Matter

  Content/Performance Standards:

   i. Characteristic properties of substances and mixtures of substances, such as density, boiling point, and solubility, sample size independence, and the separation of mixtures through use of original substance characteristic properties.

ii. Substances react chemically in characteristic ways with other substances to form new substances or compounds with different characteristic properties.
iii. Chemical elements do not break down during normal laboratory reactions, involving treatments such as heat, exposure to electrical current, or reaction with acids.

b. Motions and Forces

Content/Performance Standards:

i. Motion of an object can be described by position, direction of motion, and speed, and can be measured and represented on a graph.
ii. An object not subjected to a force will continue to move at a constant speed and in a straight line.
iii. If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on direction and magnitude. Unbalanced forces will cause changed in the speed or direction of an object's motion.

III. Life Science (pps. 156-158)

a. Structure and Function in Living Systems

Content/Performance Standards:

i. Living systems at all levels of organization demonstrate the complementary nature of structure and function such as cells, organs, tissues, organ systems, whole organisms, and ecosystems.
ii. All organisms are composed of cells – fundamental unit of life. Most organisms are single cells; others are multi-cellular.
iii. Cells carry on the functions needed to sustain life. Growth, division, nutrient uptake, energy production, and cell or organism material manufacture necessary for cell life are example functions.
iv. Specialized cells perform specialized functions in multi-cellular organisms. Groups of specialized cells cooperate to form a tissue, such as a muscle. Different tissues are in turn grouped together to form larger functional units, called organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole.
v. Humans have systems for digestion, respiration, reproduction, circulation, excretion, movement, control, and coordination, and disease protection and interact with one another.
vi. Disease is a breakdown in structures or functions of an organism and can result from intrinsic failure or damage by infection by other organisms.

b. Reproduction and Heredity

Content/Performance Standards:

i. Reproduction is characteristic of all living systems and is essential for species continuation, and is done through sexual or asexual reproduction.
ii. The female of many species produce eggs and male's sperm, as well as plants reproduce sexually as egg and sperm are produced in flowers of flowering plants. An egg and sperm unite to begin development of a new individual. That new individual receives genetic information from the mother (egg) and father (sperm). Sexually produced offspring never are identical to either of their parents.
iii. Heredity is passage of instructions from one generation to next that specify its traits.
iv. Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.
v. The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited and others result from environmental interactions.

c. Regulation and Behavior

Content/Performance Standards:

i. All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a changing external environment.
ii. Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive.
iii. Behavior is one kind of response an organism can make to an internal or environmental stimulus. A behavioral response requires coordination and communication at many levels, including cells, organ systems, and whole organisms. Behavioral response is a set of actions determined in part by heredity and in part from experience.
iv. An organism's behavior evolves through adaptation to its environment. How a species moves, obtains food, reproduces, and responds to danger are based in the species' evolutionary history.

d. Populations and Ecosystems

Content/Performance Standards:

i. A population consists of all individuals of a species that occur together at a given place and time. All populations living together and the physical factors with which they interact compose an ecosystem.
ii. Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some microorganisms are producers – they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers of that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem.
iii. For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis and passes from organism to organism in food webs.
iv. The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations increase rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem.

e. Diversity and Adaptations of Organisms

Content/Performance Standards:

i. Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry.
ii. Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptations, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.
iii. Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on the earth no longer exist.

IV. Science in Personal and Social Perspectives (pps 168-169)

a. Populations, Resources, and Environments

Content/Performance Standards:

i. When an area becomes overpopulated, the environment will become degraded due to the increase use of resources.
ii. Causes of environmental degradation and resource depletion vary from region to region and from country to country.

b. Natural Hazards

Content/Performances Standards:

i. Internal and external processes of the earth system cause natural hazards, events that change or destroy human and wildlife habitats, damage property, and harm or kill humans. Natural hazards include earthquakes, landslides, wildfires, volcanic eruptions, floods, storms, and even possible impacts of asteroids.
ii. Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.
iii. Natural hazards can present personal and societal challenges because misidentifying the change or incorrectly estimating the rate and scale of change may result in either too little attention and significant human costs or too much cost for unneeded preventive measures.

c. Risks and Benefits

Content/Performances Standards:

i. Risk analysis considers the type of hazard and estimates the number of people that might be exposed and the number likely to suffer consequences. The results are used to determine the options for reducing or eliminating risks.
ii. Students should understand the risks with natural hazards (fires, floods, tornadoes, hurricanes, earthquakes, and volcanic eruptions), with chemical hazards (pollutants in air water, soil, and food), with biological hazards (pollen, viruses, bacterial, and parasites), social hazards (occupational safety and transportation), and with personal hazards (smoking, dieting, and drinking).
iii. Individuals can use a systematic approach to thinking critically about risks and benefits. Examples include applying probability estimates to risks and comparing them to estimated personal and social benefits.
iv. Important personal and social decisions are made based on perceptions of benefits and risks.

Appendix of National Standards: Science Benchmarks

The following national standards are taken from *Benchmarks for Science Literacy* for 6^{th} through 8^{th} grades and correlate with the learning guidelines for citizen science. Included are the specific themes and content/performance standards, as well as the page numbers they are found in the original text.

I. The Physical Setting (pps. 77-79)

a. The Structure of Matter

Content/Performance Standards:

i. All matter is made up of atoms, which are far too small to see directly through a microscope. The atoms of any element are alike but are different from atoms of other elements. Atoms may stick together in well-defined molecules or may be packed together in large arrays. Different arrangements of atoms into groups compose all substances.
ii. Equal volumes of different substances usually have different weights.
iii. Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. In solids, the atoms are closely locked in position and can only vibrate. In liquids, the atoms or molecules have higher energy of motion, are more loosely connected, and can slide past one another; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy of motion and are free of one another except during occasional collisions.
iv. The temperature and acidity of a solution influence reaction rates. Many substances dissolve in water, which may greatly facilitate reactions between them.
v. Scientific ideas about elements were borrowed from some Greek philosophers of 2,000 years earlier, who believed that everything was made from four basic substances: air, earth, fire, and water. It was the combination of these "elements" in different proportions that gave other substances their observable properties. The Greeks were wrong about those four, but now over 100 different elements have been identified, some rare and some plentiful, out of which everything is made. Because most elements tend to combine with others, few elements are found in their pure form.
vi. There are groups of elements that have similar properties, including highly reactive metals, less reactive metals, highly reactive non-metals (such as chlorine, fluorine, and oxygen), and some almost completely nonreactive gases (such as helium and neon). An especially important kind of reaction between substances involves combination of oxygen with something else – as in burning or rusting. Some elements don't fit into any to the categories; among them are carbon and hydrogen, essential elements of living matter.

vii. No matter how substances within a closed system interact with one another, or how they combine or break apart, the total weight of the system remains the same. The idea of atoms explains the conservation of matter: If the number of atoms stays the same no matter how they are rearranged, then their total mass stays the same.

II. The Living Environment (pps. 104, 108, 117, 120, 124)

a. Diversity of Life

Content/Performance Standards:

i. One of the most general distinctions among organisms is between plants, which use sunlight to make their own food, and animals, which consume energy-rich foods. Some kinds of organisms, many of them microscopic, cannot be neatly classified as either plants or animals.
ii. Animals and plants have a great variety of body plans and internal structures that contribute to their being able to make or find food and reproduce.
iii. Similarities among organisms are found in internal anatomical features, which can be used to infer the degree of relatedness among organisms. In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance.
iv. For sexually reproducing organisms, a species comprises all organisms that can mate with one another to produce fertile offspring.
v. All organisms, including the human species, are part of and depend on two main interconnected global food webs. One includes microscopic ocean plants, the animals that feed on them, and finally the animals that feed of those animals. The other web includes land plants, the animals that feed on them, and so forth. The cycles continue indefinitely because organisms decompose after death to return food material to the environment.

b. Heredity

Content/Performance Standards:

i. In some kinds of organism, all the genes come from a single parent, whereas in organisms that have sexes, typically half of the genes come from each parent.
ii. In sexual reproduction, a single specialized cell from a female merges with a specialized cell from a male. As the fertilized egg, carrying genetic information from each parent, multiplies to form the complete organism with about a trillion cells, the same genetic information is copied in each cell.
iii. New varieties of cultivated plants and domestic animals have resulted from selective breeding for particular traits.

c. Interdependence of Life

Content/Performance Standards:

i. In all environments – freshwater, marine, forest, desert, grassland, mountain, and others – organisms with similar needs may compete with one another for resources, including food, space, water, air, and shelter. In any particular environment, the growth and survival of organisms depend on the physical conditions.
ii. Two types of organisms may interact with one another in several ways: They may be in a producer/consumer, predator/prey, or parasite/host relationship. Or one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other.

d. Flow of Matter and Energy

Content/Performance Standards:

i. Food provides the fuel and the building material for all organisms. Plants use the energy from light to make sugars from carbon dioxide and water. This food can be used immediately or stored for later use. Organisms that eat plants break down the plant structures to produce the materials and energy they need to survive. Then they are consumed by other organisms.
ii. Over a long time, matter is transferred from one organism to another repeatedly and between organisms and their physical environment. As in all material systems, the total amount of matter remains constant, even though its form and location change.
iii. Energy can change from one form to another in living things. Animals get energy from oxidizing their food, releasing some of its energy as heat. Almost all food energy comes originally from sunlight.

e. Evolution of Life

Content/Performance Standards:

i. Small differences between parents and offspring can accumulate (through selective breeding) in successive generations so that descendants are very different from their ancestors.
ii. Individual organisms with certain traits are more likely than others to survive and have offspring. Changes in environmental conditions can affect the survival of individual organisms and entire species.
iii. Many thousands of layers of sedimentary rock provide evidence for the long history of the earth and for the long history of changing life forms

whose remains are found in the rocks. More recently deposited rock layers are more likely to contain fossils resembling existing species.

III. Human Society (pps. 163, 166, 173, & 177)

a. Social Change

Content/Performance Standards:

i. Some aspects of family and community life are the same now as they were a generation ago, but some aspects are very different. What is taught in school and school policies toward student behavior have changed over the years in response to family and community pressures.
ii. By the way they depict the ideas and customs of one culture, communications media may stimulate changes in others.
iii. Migration, conquest, and natural disasters have been major factors in causing social and cultural change.

b. Social Trade-offs

Content/Performance Standards:

i. There are trade-offs that each person must consider in making choices – about personal popularity, health, family relations, and education for example – that often have life-long consequences.
ii. One common aspect of all social trade-offs pits personal benefit and the rights of the individual, on one side, against the social good and the rights of society, on the other.
iii. Trade-offs are not always between desirable possibilities. Sometimes social and personal trade-offs require accepting an unwanted outcome to avoid some other unwanted one.

c. Social Conflict

Content/Performance Standards:

i. Being a member of a group can increase an individual's social power or hostile actions against other groups or individuals. It may also subject that person to the hostility of people who are outside the group.
ii. Most groups have formal or informal procedures for arbitrating disputes among their members.

d. Global Interdependence

Content/Performance Standards:

i. Trade between nations occurs when natural resources are unevenly distributed and the costs of production are very different in different countries. A nation has a trade opportunity whenever it can create more of a product or service at a lower cost than another.

ii. The major ways to promote economic health are to encourage technological development, to increase the quantity or quality of a nation's productive resources – more or better-trained workers, better equipment and methods – and to engage in trade with other nations.

iii. The purpose of treaties being negotiated directly between individual countries or by international organizations is to bring cooperation among countries.

iv. Scientists are linked to other scientists worldwide both personally and through international scientific organizations.

v. The global environment is affected by national policies and practices relating to energy use, waste disposal, ecological management, manufacturing, and population.

IV. Habits of Mind (pps. 286-287, 294)

a. Values and Attitudes

Content/Performance Standards:

i. Know why it is important in science to keep honest, clear, and accurate records.

ii. Know that hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations.

iii. Know that often different explanations can be given for the same evidence, and it is not always possible to tell which one is correct.

b. Manipulation and Observation

Content/Performance Standards:

i. Use calculators to compare amounts proportionally.

ii. Use computers to store and retrieve information in topical, alphabetical, numerical, and key-word files, and create simple files of their own devising.

iii. Read analog and digital meters on instruments used to make direct measurements of length, volume, weight, elapsed time, rate, and temperature, and choose appropriate units for reporting various magnitudes.

iv. Use cameras and tape recorders for capturing information.

v. Inspect, disassemble, and reassemble simple mechanical devices and describe what the various parts are for; estimate what the effect that making a change in one part of a system is likely to have on the system as a whole.

Appendix of National Standards: Science Benchmarks

The following national standards are taken from *Expectations of Excellence: Curriculum Standards for Social Studies* for 5th through 8th grades and correlate with the learning guidelines for citizen science. Included are the themes, goals and specific content/performance standards, as well as the page numbers they are found in the original text.

I. Culture (pps. 79-81)

  a. Social studies programs should include experiences that provide for the study of culture and cultural diversity, so that the learner can:

     Content/Performance Standards:

     i. Compare similarities and differences in the ways groups, societies, and cultures meet human needs and concerns;

     ii. Explain how information and experiences may be interpreted by people from diverse cultural perspectives and frames of reference;

     iii. Explain and give examples of how language, literature, the arts, architecture, other artifacts, traditions, beliefs, values, and behaviors contribute to the development and transmission of culture;

     iv. Explain why individuals and groups respond differently to their physical and social environments and/or changes to them on the basis of shared assumptions, values, and beliefs;

     v. Articulate the implications of cultural diversity, as well as cohesion, within and across groups.

II. Time, Continuity, & Change (pps. 82-84)

  a. Social studies programs should include experiences that provide for the study of the ways human beings view themselves in and over time, so that the learner can:

     Content/Performance Standards:

     i. Demonstrate an understanding that different scholars may describe the same event or situation in different ways but must provide reasons or evidence for their views;

     ii. Identify and use key concepts such as chronology, causality, change, conflict, and complexity to explain, analyze, and show connections among patterns of historical change and continuity;

     iii. Identify and describe selected historical periods and patterns of change within and across cultures, such as the rise of civilizations, the development of transportations systems, the growth and breakdown of colonial systems, and other;

iv. Identify and use processes important to reconstructing and reinterpreting the pas, such as using a variety of sources, providing, validating, and weighing evidence for claims, checking credibility of sources, and searching for causality;

v. Develop critical sensitivities such as empathy and skepticism regarding attitudes, values, and behaviors of people in different historical contexts;

vi. Use knowledge of facts and concepts drawn from history, along with methods of historical inquiry, to inform decision-making about and action-taking on public issues.

III. People, Places, & Environment (pps. 85-87)

a. Social studies programs should include experiences that provide for the study of people, places, and environments, so that the learner can:

Content/Performance Standards:

i. Elaborate mental maps of locales, regions, and the world that demonstrate understanding of relative location, direction, size, and shape;

ii. Create, interpret, use, and distinguish various representations of the earth, such as maps, globes, and photographs;

iii. Use appropriate resources, data sources, and geographic tools such as aerial photographs, satellite images, geographic information systems (GIS), map projections, and cartography to generate, manipulate, and interpret information such as atlases, data bases, grid systems, charts, graphs, and maps;

iv. Estimate distance, calculate scale, and distinguish other geographic relationship such as population density and spatial distribution patterns;

v. Locate and describe varying landforms and geographic features, such as mountains, plateaus, islands, rain forests, deserts, and oceans, and explain their relationships within the ecosystem;

vi. Describe physical system changes such as seasons, climate and weather, and the water cycle and identify geographic patterns associated with them;

vii. Describe how people create places that reflect cultural values and ideals as they build neighborhoods, parks shopping centers, and the like;

viii. Examine, interpret, and analyze physical and cultural patterns and their interactions, such as land use, settlement patterns, cultural transmissions of customs and ideas, and ecosystem changes;

ix. Describe ways that historical events have been influenced by, and have influenced, physical and human geographic factors in local, regional, national, and global settings;

x. Observe and speculate about social and economic effects of environmental changes and crises resulting from phenomena such as floods, storms, and drought;

xi. Propose, compare, and evaluate alternative uses of land and resources in communities, regions, nations, and the world.

IV. Individual Development & Identity (pps. 88-90)

a. Social studies programs should include experiences that provide for the study of individual development and identify, so that the learner can:

Content/Performance Standards:

i. Relate personal changes to social, cultural, and historical contexts;

ii. Describe personal connections to place – as associated with community, nation, and world;

iii. Describe the ways family, gender, ethnicity, nationality, and institutional affiliations contribute to personal identity;

iv. Relate such factors as physical endowment and capabilities, learning, motivation, personality, perception, and behavior to individual development;

v. Identify and describe ways regional, ethnic, and national cultures influence individuals' daily lives;

vi. Identify and describe the influence of perception, attitudes, values, and beliefs on personal identity;

vii. Identify and interpret examples of stereotyping, conformity, and altruism;

viii. Work independently and cooperatively to accomplish goals.

V. Individuals, Groups, & Institutions (pps. 91-93)

a. Social studies programs should include experiences that provide for the study of interactions among individuals, groups, and institutions, so that the learner can:

Content/Performance Standards:

i. Demonstrate an understanding of concepts such as role, status, and social class in describing the interactions of individuals and social groups;

ii. Analyze group and institutional influences on people, events, and elements of culture;

iii. Describe the various forms institutions take and the interactions of people with institutions;

iv. Indentify and analyze examples of tensions between expressions of individuality and group or institutional efforts to promote social conformity;

v. Identify and describe examples of tensions between belief systems and government policies and laws;

vi. Describe the role institutions in furthering both continuity and change;

vii. Apply knowledge of how groups and institutions work to meet individual needs and promote the common good.

VI. Science, Technology, & Society (pps. 99-101)

a. Social studies programs should include experiences that provide for the study of relationships among science, technology, and society, so that the learner can:

Content/Performance Standards:

i. Examine and describe the influence of culture on scientific and technological choices and advancement, such as in transportations, medicine, and warfare;

ii. Show through specific examples how science and technology have changed people's perceptions of the social and natural world, such as in their relationship to the land, animal life, family life, and economic needs, wants, and security;

iii. Describe examples in which values, beliefs, and attitudes have been influenced by new scientific and technological knowledge, such as the invention of the printing press, conceptions of the universe, applications of atomic energy, and genetic discoveries;

iv. Explain the need for laws and policies to govern scientific and technological applications, such as in the safety and well-being of workers and consumers and the regulations of utilities, radio, and television;

v. Seek reasonable and ethical solutions to problems that arise when scientific advancements and social norms or values come into conflict.

VII. Global Connections (pps. 102-104)

a. Social studies programs should include experiences that provide for the study of global connections and interdependence, so that the learner can:

Content/Performance Standards:

i. Describe instances in which language, art, music, belief systems, and other cultural elements can facilitate global understanding or cause misunderstanding;

ii. Analyze examples of conflict, cooperation, and interdependence among groups, societies, and nations;

iii. Describe and analyze the effects of changing technologies on the global community;

iv. Explore the causes, consequences, and possible solutions to persistent, contemporary, and emerging global issues, such as health, security, resource allocation, economic development, and environmental quality;

v. Describe and explain the relationships and tensions between national sovereignty and global interests in such matters as territory, natural resources, trade, use of technology, and welfare of people;

vi. Demonstrate understanding of concerns, standards, issues, and conflicts related to universal human rights;

vii. Identify and describe the roles of international and multinational organizations.

VIII. Civic Ideals & Practices (pps. 105-107)

a. Social studies programs should include experiences that provide for the study of the ideals, principles, and practices of citizenship in a democratic republic, so that the learner can:

Content/Performance Standards:

i. Examine the origins and continuing influence of key ideals of the democratic republican form of government, such as individual human dignity, liberty, justice, equality, and the rule of law;

ii. Identify and interpret sources and examples of the rights and responsibilities of citizens;

iii. Locate, access, analyze, organize, and apply information about selected public issues – recognizing and explaining multiple points of view;

iv. Practice forms of civic discussions and participation consistent with the ideals of citizens in a democratic republic;

v. Explain and analyze various forms of citizen action that influence public policy decisions;

vi. Identify and explain the roles of formal and informal political actors in influencing and shaping public policy and decision-making;

vii. Analyze the effectiveness of selected public policies and citizens behaviors in realizing the stated ideals of a democratic republican form of government;

viii. Explain the relationship between policy statements and action plans used to address issues of public concern;

ix. Examine strategies designed to strengthen the “common good”, which consider a range of options for citizen action.

References & Additional Resources:

Additional Citizen Science Resources: Below you will find a brief list of citizen science opportunities in Wisconsin, and throughout the United States. Included is brief description of the program and where you can find more information.

Wisconsin Programs:

1. **Beaver Creek Reserve/ Wisconsin NatureMapping**: "The mission of the Citizen Science Center is to bring together community members, individuals, teachers, and students with environmental professionals and university researchers to carry out scientific research and promote environmental stewardship. The Wisconsin NatureMapping project, which documents the location of animals and plants throughout the state, is coordinated through Beaver Creek Reserve's Citizen Science Center." http://beavercreekreserve.org/CSC.htm

2. **Loon Watch**: "Loon Watch, a program of the Sigurd Olson Environmental Institute, protects common loons and their aquatic habitats through education, monitoring, and research. Though our primary focus is Wisconsin, our education and research activities extend to Upper Great Lakes region, such as Michigan and Minnesota. We also lend support to North American conservation efforts by working with loon conservation organizations across the United States and Canada." http://www.northland.edu/sigurd-olson-environmental-institute-loon-watch.htm

Additional State & Nationwide Programs:

1. **Appalachian Highlands Science Learning Center: "**Located at 5000 feet in Haywood County on the North Carolina side of Great Smoky Mountains National Park, the Appalachian Highlands Science Learning Center is part of a network of what will be 32 research learning centers supporting research and education about science in our national parks. The mission of the Appalachian Highlands Science Learning Center at Purchase Knob is to increase the amount and effectiveness of research in the Appalachian highlands network parks that meet management needs while increasing public access to and understanding and appreciation of these research activities." http://www.nps.gov/grsm/naturescience/pk-homepage.htm

2. **Bronx River Alliance: "**The mission of the Bronx River Alliance is to serve as a coordinated voice for the river and work in harmonious partnership to protect, improve and restore the Bronx River corridor and greenway so that they can be healthy ecological, recreational, educational and economic resources for the communities through which the river flows." http://www.bronxriver.org/?pg=home

3. **Cornell Lab of Ornithology:** “Who we are: We are a passionate, science-driven team that provides innovative and pioneering citizen science projects that anyone can do.

   OUR MISSION: Provide meaningful opportunities for anyone to participate in collaborative scientific research to track and improve the status of birds through collective observation and environmental stewardship.

   What we do: Help people learn about the birds in their own backyards and neighborhoods. Create projects to answer questions of real scientific interest that engage diverse audiences, cultivate awareness, and get people outdoors. Analyze the data you submit and publish the results in scientific journals and popular publications. Link to project publications pages Share results with land managers and inform conservation efforts.” http://www.birds.cornell.edu/netcommunity/citsci/about

4. **Earth Force: “**Earth Force engages young people as active citizens who improve the *environment* and their *communities* now and in the future.

   Now is the time to foster a scientifically capable and civically engaged populace. Through Earth Force young people get hands-on, real-world opportunities to practice civic skills, acquire and understand environmental knowledge, and develop the skills and motivation to become life-long leaders in addressing environmental issues.

   Earth Force achieves these results by training and supporting educators as they implement our unique six-step model for engaging young people. Thanks to 10 years of rigorous evaluation, we know that our model positions young people to use their creativity and passion to play a meaningful role in environmental decision-making.

   Earth Force knows that little can be accomplished by working alone. To meet our goals, Earth Force partners with businesses, schools, community-based organizations and civic leaders nationwide.” http://www.earthforce.org/

5. **Frogwatch USA: “**Frogwatch USA is a frog and toad monitoring program that gives YOU the opportunity to help scientists conserve amphibians! With as little as 20 minutes a week you can collect essential information to protect frogs and toads.

   This long-term amphibian study, managed by the National Wildlife Federation, will increase awareness of amphibian decline and will give you the opportunity to be directly involved in gathering information that can ultimately lead to practical and workable ways to help stop the decline of these important species.” http://www.nwf.org/frogwatchUSA/

6. **Globe:** “A worldwide community of students, teachers, scientists, and citizens working together to better understand, sustain, and improve Earth’s environment at local, regional, and global scales.” http://www.globe.gov/r

7. **Great Lakes Worm Watch: "**Great Lakes Worm Watch is committed to increasing scientific literacy and public understanding of the role of exotic species in ecosystems change.

   We provide the tools and resources for citizens to actively contribute to the development of a database documenting the distributions of exotic earthworms and their impacts across the region as well as training and resources for educators to help build understanding of the methods and results of scientific research about exotic earthworms and forest ecosystems ecology." http://www.nrri.umn.edu/worms/default.htm

8. **Great Smoky Mountain Institute: "**Great Smoky Mountains Institute at Tremont provides in-depth experiences through educational programs designed to nurture appreciation of Great Smoky Mountains National Park, celebrate diversity, and foster stewardship. *Connecting people and nature* summarizes our mission, which we accomplish through providing hands-on learning experiences with the National Park, focusing on developing in people a greater sense of place, a deepened appreciation and awe for the diversity of life and people, and an ethics of stewardship that follows them home." www.gsmit.org

9. **International Brant Monitoring Project: "**The International Brant Monitoring Project was developed to monitor the migration of a small sea goose, the Brant. Project participants gain a greater understanding of the importance of local ecosystems and global environmental health through the observation of brant and sharing of information between participants in three countries. Project participants include students, wildlife biologists, concerned citizens, National Estuarine Research Reserves, U.S. Fish and Wildlife Service and various others along the Pacific flyway. Students monitor through field observations and counting of the brant in their area and then share their findings with others via the Internet. In the classroom, students learn about brant from their teachers, environmental educators, biologists, and other local brant enthusiasts." http://www.padillabay.gov/brant/#Intro

10. **Journey North:** "Journey North engages students in a global study of wildlife migration and seasonal change. K-12 students share their own field observations with classmates across North America. They track the coming of spring through the migration patterns of monarch butterflies, robins, hummingbirds, whooping cranes, gray whales, bald eagles—and other birds and mammals; the budding of plants; changing sunlight; and other natural events. Find migration maps, pictures, standards-based lesson plans, activities and information to help students make local observations and fit them into a global context. Widely considered a best-practices model for education, Journey North is the nation's premiere "citizen science" project for children. The general public is welcome to participate." http://www.learner.org/jnorth/

11. **Long-Term Monitoring Program & Experiential Training for Students (LiMPETS): "**LiMPETS is an environmental monitoring and education program for students, educators, and volunteer groups. This hands-on program was developed to monitor the

ocean and coastal ecosystems of California's National Marine Sanctuaries to increase awareness and stewardship of these important areas." http://limpetsmonitoring.org/

12. **Monarch Watch: "**Monarch Watch is an educational outreach program based at the University of Kansas that engages citizen scientists in large-scale research projects. This program produces real data that relate to a serious conservation issue. Monarch Watch gets children of all ages involved in science. Our website provides a wealth of information on the biology and conservation of Monarch butterflies and many children use it as a resource for science fair projects or reports. Additionally, we encourage children to showcase their research or school projects on our website and we involve them in real science with the tagging program." http://www.monarchwatch.org/

13. **MN Frog & Toad Calling Survey: "**The DNR's Nongame Wildlife Program is sponsoring an ongoing state-wide study of Minnesota's frogs and toads. Since 1996, volunteers across Minnesota have collected data by listening to and identifying frog and toad species on specified 10-stop routes. The results of this ongoing study will provide information on where species are located throughout the state, and how their populations change in abundance and distribution."
http://www.dnr.state.mn.us/volunteering/frogtoad_survey/index.html

14. **MN Odonata Survey Project: "**The Minnesota Odonata Survey Project (MOSP) is a volunteer effort to determine the ranges and distributions of Minnesota's dragonfly and damselfly populations. Citizen-scientists (potentially, you!) will catch and identify dragonflies and damselflies in Minnesota and will report back to the MOSP with their findings. There are many species, some considered rare, in Minnesota whose ranges are not known. Finding a new county record is a common occurrence and there are many new state records to be found as well." http://www.mndragonfly.org/

15. **Ocean GLOBE: "**Ocean GLOBE is a beach research and outdoor environmental education program for upper elementary, middle and high school students. It is one component of a multi-faceted educational outreach program created by the UCLA Marine Science Center (MSC) and builds upon a pilot program funded by National Science Foundation. Students participating in Ocean GLOBE collect environmental and biological data from a beach site close to their school campus over an extended period of time. At the discretion of the participating teacher, students may organize, graph and analyze their data, which may lead to a variety of student-created, "real" science products. Another feature of Ocean GLOBE is the support material it provides teachers and students. We make available, here on this website, learning material in the form of PowerPoint presentations, as well as relatively inexpensive activities or labs that relate to each of the types of data collected during the field research done by students. So, for example, if students measure ocean temperatures, we provide a PowerPoint presentation

about ocean temperature and also temperature-related investigations."
http://www.msc.ucla.edu/oceanglobe/

16. **Smithsonian Institute – Biodiversity Monitoring Project: "**The Conservation and Research Center's Biodiversity Monitoring Project (BMP) is a school-scientist partnership designed to provide teachers with the skills and tools needed to teach the scientific principles of biodiversity monitoring using local forests, parkland or other natural areas as a living ecosystem laboratory. Students, teachers, and community partners experience their local environment first-hand, and become involved in projects that allow them to understand and relate their local experiences to their global environment."
http://nationalzoo.si.edu/Education/ClassroomPartnerships/BioDivMonPro/

17. **Washington NatureMapping: "**Citizens of all ages conducting meaningful science for the benefit of their local communities and biodiversity. "
http://depts.washington.edu/natmap/

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