



# An Assessment of Environmental Literacy Among Oklahoma Public High School Students and the Factors Affecting Students' Environmental Literacy

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An Assessment of Environmental Literacy among Oklahoma Public High School  
Students and the Factors Affecting Students' Environmental Literacy

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A Thesis in the Field of Sustainability and Environmental Management  
for the Degree of Master of Liberal Arts in Extension Studies

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## Abstract

The purpose of this study was to assess the environmental literacy of Oklahoma public high school students. The Oklahoma Environmental Literacy Assessment Tool (OELAT), an instrument designed to ascertain environmental literacy among high school students, was used to address research questions concerning student subpopulations including: gender, grade level, residence and participation in elective courses. There were 980 respondents to the OELAT representing a wide variety of elective interests.

Since the data reflected behaviors that were self-reported by students and not actually observed, the quality of students' responses may have been compromised and thus considered a limitation. Data were analyzed using descriptive and inferential statistics including: mean, median, mode, standard deviation, minimum and maximum, t-test, MANOVA analysis and Tukey HSD statistics.

Using a two-tailed t-test, in the gender subpopulation analysis no statistical significant difference was found in overall environmental literacy or in the attitude domain. Females exhibited significantly higher behavior scores than males ( $p=0.036$ ), while males exhibited significantly higher knowledge scores than females ( $p=0.007$ ). Thus, a portion of the hypothesis was substantiated. At the  $\alpha=.05$  level, there was a significant difference in behaviors, knowledge and overall environmental literacy. Seniors exhibited statistically significant positive behaviors toward the environment compared to sophomores and juniors, but there was not a statistical difference between the sophomores and juniors. Further, seniors exhibited statistically significant positive

environmental knowledge compared to freshman, sophomores and juniors, but there was not a statistical difference between freshman, sophomores or juniors. Finally, sophomores, juniors and seniors exhibited positive overall environmental literacy scores over freshman. Thus, the hypothesis was partially supported in the grade level analysis. Contradictory to the hypothesis in the residential analysis, there was a significant difference in the behaviors, knowledge and overall environmental literacy scores between rural and suburban schools ( $p < 0.05$ ), and between rural and urban schools ( $p < 0.05$ ), but not between urban and suburban schools ( $p=0.99$ ), ( $p=0.70$ ), ( $p=0.86$ ), respectively, where urban and suburban schools exhibited higher scores than rural students. Counter to the hypothesis there were no differences in composite environmental literacy scores compared to elective course participation ( $p=0.39$ ).

The study provided baseline data in the region where few studies exist to date. It is recommended that a statewide environmental literacy plan be implemented and that an environmental education component be added to the required state curriculum. Further, local school districts ought to establish a two-tiered environmental program with mandatory in-service training.

Although this study focused on comparing the types of electives, it may be advisable to develop a qualitative follow-up study to evaluate the top performing schools in this study. Interviews of participating principals and teachers may provide insights as to why these students performed well on this environmental literacy study. Also, it would be interesting to address a correlation between AP science courses and environmental literacy. School districts in Oklahoma with established AP environmental science programs would be good candidates for this study.

## Dedication

I would like to dedicate this thesis to Peggy Worden, whose passion for teaching has been an inspiration to myself and a lifetime of students. She has challenged me for many years and I cherish her counsel and friendship.

## Acknowledgements

This thesis would not have been possible without the help of so many people. First, I would like to thank Dr. Mary Hitchcock, my thesis director and mentor, for being patient with me, for sharing her knowledge and passion about the field of curriculum study and for challenging and encouraging me from start to finish. Dr. Mark Leighton, my research advisor, for helping me develop the research study. Dr. Case and Phyllis Rustin for their invaluable input as reading advisors.

To the administrators who welcomed me into their school districts and helped coordinate the administration of the assessment, without their belief that improving environmental literacy is important to our student's achievement, this project would not have been possible. Thank you to the teachers who opened their classrooms to me and took time out of their busy schedules to allow for the administration of the assessment. A special thanks to the students who volunteered to take the assessment. I am grateful beyond measure for your generosity and honesty.

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## Definitions

Curriculum: The entire range of experiences, both undirected and directed, concerned in unfolding the abilities of the individual; or the series of consciously directed training experiences that schools use for completing and perfecting the unfoldment.

Eco-Schools: School systems who model environmentally sound practices, provide support for greening the curriculum and enhance science and academic achievement through environmental education. The key priorities of eco-schools are to efficiently use resources, establish a healthy environment, have an ecological curriculum, provide nutritious food and have sustainable community practices.

Environmental curriculum: any information presented to the students regarding energy sources, pollution control, waste reduction, habitat conservation and/or problems solving in the form of activities, lecture, discussion or reading.

Environmental Education: “a learning process that increases people’s knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action (UNESCO, 1978).”

Environmental Literacy: “an understanding of the environmental, social and economic dimensions of human-environment interactions, and the skills and ethics to translate this understanding into life choices that promote the sustainable flourishing of diverse human communities and the ecological systems which they are embedded (Reynolds, H., Brondizio, E., Meta, J., 2010)”

Knowledge: a familiarity, awareness or understanding of the environment through experience or study. For this research study, it is specifically defined as the mean score on the 10-item Knowledge sub scale of the Oklahoma Environmental Literacy Assessment Tool (OELAT).

Responsible environmental behavior: refers to any behavior that aims at either preventing environmental problems or solving environmental issues.

Rural student: Any student who lives in a community with a population size less than 25,000.

Suburban student: Any student who lives in a community surrounding Oklahoma City or Tulsa with a population between 25,000 and 100,000.

Urban student: Any student who lives in a community with a population size greater than 100,000.

## Chapter I

### Introduction

“In the end, we will conserve what we love, we will love what we understand, and we will understand what we are taught (Dioum, 1968).”

The goal of environmental education is to increase students’ environmental literacy by improving their knowledge, cognitive skills, attitudes and behaviors. The development of each component is critical to achieve a citizenry equipped to tackle current and emerging environmental concerns worldwide. According to the North American Association for Environmental Education (2014), Oklahoma is one of thirty-seven states that does not have an implemented State Environmental Literacy Plan. Further, to my knowledge there has not been an environmental literacy baseline study conducted in the state of Oklahoma.

Despite the immense need, integrating environmental education into schools across the United States has proven challenging (McBeth, Hungerford, Marcinkowski, Volk & Cifranick, 2011). The Oklahoma Academic Standards curriculum addresses a stand-alone environmental course for secondary students; however, this course is not mandatory for graduation. Instead, within many public schools a tendency has developed to meet environmental education goals by incorporating ecological principles into biology curriculum. The assumption is that ecological knowledge and environmental issues are closely associated and can be effectively taught within the biology course. Does this practice effectively influence students’ environmental literacy?

The No Child Left Behind Act limited the amount of time teachers spend on environmental education and science to focus more on testing standards (Braus et al., 2014). Furthermore, the lack of professional development opportunities for teachers, limited time and resources for field trips, outdoor activities and widespread cuts to education funding in general have hindered environmental education. These reasons indicate a clear need for an in-depth assessment of the factors affecting environmental literacy among Oklahoma public high school students. This research assessment will serve to inform state educators of current environmental literacy levels among students and will identify factors which contribute to higher environmental literacy in students.

#### Research Significance and Objectives

The National Environmental Education Advisory Council has requested environmental literacy studies be conducted to further the body of knowledge related to the factors which affect student literacy. This study is an ex post facto survey research where the purpose was to determine overall environmental literacy and describe the literacy characteristics of students in Oklahoma public high schools. I examined the relationships between students' knowledge, attitudes and behaviors related to their demographic factors, including grade level, gender and residence. The results of this study will be used to provide feedback to Oklahoma educators on the current level of environmental literacy among students and thereby improve the quality of environmental education in schools statewide. Moreover, this study seeks to discover if students' interests in elective courses affect environmental literacy. Finally, this study can inform methods to effectively create environmentally literate students based on their interests.

## Background

In the last century, it has become increasingly apparent the impact human activities have on the global ecosystem. Today, humanity faces a number of social, economic and environmental issues resulting from the interactions humans have with the global ecosystem. Urgent issues such as global climate change, loss of biodiversity, ozone depletion, pollution and food scarcity are highly complex and disputed both within society and the scientific community (Walsh et al., 2014). If there is any hope for the necessary societal changes to occur which would lower these impacts, then we must strive to adopt environmentally responsible behaviors. This can only be achieved by the development of an environmentally literate society. Environmental education presents a multi-faceted approach for bridging the gap between nature and society while developing environmentally literate citizens who have the knowledge and skills to meet today's challenges (Lloyd-Strovas, 2013).

Environmental education allows educators to teach students how to develop a better understanding of their relationship with the environment and thus begins to cultivate environmental literacy. The historical framework for assessing environmental literacy begins by defining environmental education, its goals and objectives. The Tbilisi Declaration, from the world's first intergovernmental conference on environmental education, defines environmental education as "a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action (UNESCO,

1978).” This definition remains the standard many environmental educators use today (UNESCO, 2012). The conference established three goals:

1. To foster clear awareness of, and concern about, economic, social, political and ecological interdependence in urban and rural areas.
2. To provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment.
3. To create new patterns of behavior of individuals, groups and society as a whole towards the environment (UNESCO, 1978).

Finally, the conference established five categories of objectives for environmental education:

1. Awareness—create a greater sensitivity and awareness of the environment in general and of its problems.
2. Knowledge—establishes a basic comprehension of the environment in its totality, its associated problems and humanity’s critically responsible presence and role in it.
3. Attitudes—build social values and a deep interest in the environment that may drive students to actively participate in its protection and improvement.
4. Skills—develop the skills needed to identify and solve environmental problems.
5. Participation—development in students sense of responsibility and participation in activities that lead to the resolution of environmental challenges (UNESCO, 1978).

These objectives will serve to prepare society to be able to understand and address the complex issues society is facing resulting from human impacts on the global ecosystem (Holloweg et al., 2011). In the 2012 report from the Intergovernmental Conference on Environmental Education for Sustainable Development, the committee

recognized the historical significance of the 1977 Tbilisi Declaration stating the crucial role it has played in framing education around environmental protection and sustainable development. Further, the report reaffirmed the objectives outlined in the original declaration are still valid today; however, it noted that the main goals of aligning human behaviors, actions, practices and social conditions towards a sustainable future has yet to be achieved.

Environmental education is an integrated process involving experience, investigation, and problem solving in natural and man-made surroundings. The intent is to help individuals become capable of responsible judgement. It cannot be learned from books alone. Instead, it requires innovative teaching methods with “hands-on” activities, subject matter that is relevant to everyday life, and topics that engage students allowing them to become active participants in their own education. It is through effective environmental education that environmental literacy is achieved.

Although there is no single definition for environmental literacy, collaborations between environmental literacy experts have refined the definition. In its essence, environmental literacy requires the understanding of basic scientific principles related to the functioning of nature, the roles humans play in nature and the importance of maintaining a habitat “fit for life” (Bruyere, 2008). Further, individuals with high environmental literacy have the knowledge and skills required to analyze issues enabling them to act in a responsible manner. Reynolds., Brondizio, and Meta. (2010) provides a more definitive definition:

as an understanding of the environmental, social and economic dimensions of human-environment interactions, and the skills and ethics to translate this understanding into life choices that promote the sustainable flourishing of diverse human communities and the ecological systems which they are embedded.

Most recently, researchers have explored the components of environmental literacy and attempted to define the characteristics of an environmentally literate person. A central question in much of the research is: what factors affect environmental literacy? This question and the evolution of the concept of environmental literacy formed the basis for this study. In order to assess environmental literacy, one must explore the history of environmental education, including the policy documents that provide the foundation upon which environmental literacy is defined.

### Environmental Education Pedagogy

The history and cultural impacts of environmental crises have greatly impacted the United States and its approach to environmental education. Widespread land degradation began when European colonists began settling in the United States territories in the 15th century. Unlike the Native Americans who lived sustainably, the colonists exploited and polluted the plentiful resources of “The Land of Milk and Honey,” and set a precedent of overconsumption which continues today (Cronon, 1983). Degradation only worsened in the nineteenth and early twentieth century as the Industrial Revolution began in the United States (Gillaspy, 2016). The Industrial Revolution was a major turning point in earth’s ecology, and in the relationship between humans and the environment. The invention of the steam engine caused a dramatic increase in energy use from the burning of fossil fuels. This led to increased air pollution, water pollution, climate change, acid rain, deforestation and habitat destruction.

By the 1800s, such problems indicated both philosophical and political transformations needed to be made in the United States. Naturalists such as John Muir

(1838-1914), Enos Mills, (1870-1922), Robert Marshall (1901-1939) and Aldo Leopold (1887-1948) started teaching about resource conservation and habitat preservation. The most famous writings from naturalists in this time period include that of Ralph Waldo Emerson's *Nature* (1836) and Henry David Thoreau's *Walden* (1854). These classic writings are still taught in many literature classes today. On a political front, President Roosevelt, after witnessing the effects of loss of habitat and species would write:

We have become great because of the lavish use of our resources. But the time has come to inquire seriously what will happen when our forests are gone, when the coal, the iron, the oil, and the gas are exhausted, when the soils have still further impoverished and washed into the streams, polluting the rivers, denuding the fields and obstructing navigation (Roosevelt, 1908).

In an effort to preserve natural resources President Roosevelt dedicated 230 million acres of land in the United States to national parks, monuments, forests and preserves, and established of the National Park Service, the National Conservation Commission and the Forest Service (later to become the Department of Agriculture) (Owens, 2012). The combined effort from philosophical and political leaders would lead to the origination of three educational movements that would influence modern environmental education.

Present day environmental education was preceded by the Nature Study movement in the 1890's, the Outdoor Education movement in the 1920's and Conservation Education movement in the 1930's. Wilbur Jackman's *Nature Study in the Common Schools* is credited with the start of the nature study. The Nature Study movement was concerned with increasing student's awareness and appreciation of nature by using discovery learning techniques and spending time outdoors. The premise of the philosophy is that being in nature will improve student's affect for the environment. In the *Handbook of Nature Study* (1911) the purpose is described as "to cultivate in children

powers of accurate observation and to build up within them understanding.” The Nature Study ended because it was viewed as lacking order and discipline by educators. It was followed by the Outdoor Education movement which occurred in response to increased concern that children living in urban areas were not having the same kind of contact with nature that their parents had enjoyed as children. The philosophies of the Outdoor Movement can be traced to John Amos Comenius (1592-1670). The main emphasis was teaching various subjects outdoors where students could have the opportunity to experience the environment. Soon thereafter, the Conservation Education movement emerged in response to the Great Depression and “Dust Bowl” of the 1930’s. As the name suggests the emphasis was on conservation curricula. The movement was sponsored by state and federal natural resource agencies as well as many non-government organizations. The curricula extended the ideas of nature study while emphasizing the need to conserve natural resources. *A Sand County Almanac* by Aldo Leopold is the book most cited for conservation education (Owens, 2012). John Dewey was also championing the progressive education movement in the 1930s which promoted a holistic approach to education and emphasized learning by doing, lifelong learning, integrated and interdisciplinary efforts. Philosophies from the three movements remain important aspects of environmental education today.

Modern environmental education principles were the result of many events and legislation passed during the 1960’s and 1970’s. The publication of *Silent Spring* by Rachel Carson in 1962 is credited with renewing public interest in the environment in the United States (Owens, 2012). The book identifies the negative and widespread impacts of pesticide use by exemplifying DDT. Moreover, environmental catastrophes, such as the

Santa Barbra oil spill and the Cuyahoga River Fire, also contributed to public interest in environmental reform. Outcry for the environment led to very important legislation being passed. Major reform began with the implementation of the Clean Air Act of 1963. This act was followed by the implementation of the Wilderness Act of 1964, Solid Waste Disposal Act of 1965, the Species Conservation Act of 1966, and the Wild and Scenic River Act of 1968. One year later, the National Environmental Policy Act of 1969 which established a Council on Environmental Quality and was the first national policy with broad frameworks which sought to encourage productive and enjoyable harmony between man and the environment would pass. This act promoted efforts which prevented or eliminated damage to the environment and sought to enrich the understanding of the ecological systems and natural resources.

The 1970s were monumental for the environmental movement and education. In 1970, President Nixon established the Environmental Protection Agency (EPA) and he addressed Congress stating:

It is also vital that our entire society develop a new understanding and a new awareness of man's relation to his environment-what might be called "environmental literacy." This will require the development and teaching of environmental concepts at every point in the education process.

President Nixon's statements were critical to Congress passing the National Environmental Education Act of 1970 which authorized the creation of the Office of Environmental Education and established a national advisory council. The Act itself was only authorized a life span of five years and was given a limited amount of funding. The act provided the first government sponsored definition of environmental education as "the educational process dealing with man's relationship with his natural and manmade

surroundings, and including of population, pollution, resource allocation and depletion, conservation, transportation, technology, and urban and rural planning (United States Environmental Protection Agency, 2016).” On April 22, 1970, America celebrated the first Earth Day. Gaylord Nelson, a US Senator from Wisconsin, and Denis Hays, a Harvard law student, who witnessed the Santa Barbara Oil Spill, enlisted the aid of campus activists from across the United States for an environmental “teach-in” which became known as Earth Day (Owens, 2012). An estimated 20 million people participated in the event from nearly 1,500 college campuses. Environmental education was further strengthened with the establishment of the National Association for Environmental Education (NAAEE) in 1971.

Concern for the environment had become a global issue by the 1970s. In response to this concern, the United Nations (UN), through the United Nations Education, Scientific and Cultural Organization (UNESCO) and in conjunction with the UN Environmental Programme (UNEP) initiated a series of international conferences. The first conference, the United Nations Conference on the Human Environment, was held in Stockholm, Sweden in 1972. Its purpose was to discuss environmental issues on a global scale and to consider appropriate actions to address these problems, including educational initiatives. The conference formed the International Program in Environmental Education (IEEP). The next UNESCO conference held in Belgrade, Yugoslavia in 1975 discussed the objectives, goals, and guiding principles of environmental education. Finally, in 1977 the Intergovernmental Conference on Environmental Education was held in Tbilisi, Republic of Georgia. The principles adopted from this conference are still used by environmental educators today.

The environmental education movement experienced major setbacks in the 1980s due to political agendas. A pro-development ideology was adopted during President Reagan's administration. The Office of Environmental Education was disbanded in 1981 and between 1980 and 1983, the EPA lost one-third of its budget and one-fifth of its staff. In spite of the environmental agenda, the American public still overwhelmingly supported environmental goals. This was evidenced by support for environmental organizations such as the Sierra Club and Wilderness Society, and passing legislation such as the Resource Conservation and Recovery Act Amendments of 1984, the Safe Drinking Water Act Amendments of 1986, and the Superfund Amendments and Reauthorization Act of 1986. A positive environmental education program that began in the 1980s was Project WILD which sponsors conservation and environmental education programs with a focus on wildlife for students in grades k-12.

In 1990, the United States environmental education movement regained momentum. First, Congress passed the National Environmental Education Act of 1990. This act established the Office of Environmental Education in the EPA, which has gone on to co-sponsor the two national environmental literacy assessments to date. Then in 1993, the North American Association for Environmental Education initiated the National Project for Excellence in Environmental Education. This program provided guidelines to integrate environmental education into school curricula.

From 2000 to the present, environmental education has been on a rollercoaster in the political arena. In 2001, the No Child Left Behind Act was reauthorized (it has since been renamed the Elementary and Secondary Education Act). According to a 2008 Center on Education Policy report on the No Child Left Behind Act, this has caused

teachers to spend more time preparing students for content found on the mandated standardized tests. The report found teachers had increased study time in reading and math by 43% on average, and decreased instruction time in other subjects by 32%. Cuts were found in social studies, science, art, music, physical education, recess or lunch (NEEF, 2015). In response to the need for more support for environmental education, leaders in the field launched the No Child Left Inside initiative. The movement was spearheaded by the Chesapeake Bay Foundation, a nonprofit coalition, dedicated to the cleanup and protection of the Chesapeake Bay. The initiative supported the No Child Left Inside Act of 2008. The Act was designed to help ensure every student achieves basic environmental literacy as part of their education. The act passed the House of Representatives, but never passed the Senate. It was reintroduced in 2015 and has been assigned to a congressional committee. Some verbiage from the No Child Left Inside Act was adopted when President Obama signed the Every Student Succeeds Act which reauthorized the Elementary and Secondary Education Act. For the first time this allowed environmental education to be eligible for federal funding through grants to states. “Programs and activities that support access to a well-rounded education,” including environmental literacy programs are now eligible for funding. Additionally, the inclusion of Title IV funds for hands-on, field-based, or service learning to enhance the understanding of STEM subjects provides a potential boost for environmental science education programs.” It is too soon to tell the effectiveness of this act; however, it is promising and a positive step forward for environmental education.

Environmental education is best applied using constructivism learning theory. Constructivism “is the philosophy, or belief, that learners create their own knowledge

based on interactions with their environment including their interactions with other people (Draper, 2002).” Historically influenced by Bruner (1966), Dewey (1933) and Vygotsky (1978), constructivism equates learning with creating meaning from experience. In this theory both the learner and learning environment are critical factors, as it is the specific interaction between these two variables that creates knowledge. Learning must be an interpretive, recursive, building process by active learners interrelating with both the physical and social world. Behavior is thus situationally determined because understanding is gained by experience. The impact of this is the authenticity of the experience becomes critical to the individual’s ability to use ideas. In other words, this teaching theory is motivational to students by engaging them in activities that have real-life applications.

Environmental education aims to help the learner perceive and understand ecological principles and problems, enables the learner to identify and evaluate possible alternative solutions to these problems, and assess the benefits and risks of the solutions proposed. The Tbilisi Declaration (1978) adopted the guiding principles of environmental education to assist learners in this mission. It states environmental education should:

1. Consider the environment in its totality-natural and built, technological and social (economic, political, cultural, historical, moral, aesthetic);
2. Be a continuous lifelong process, beginning at the preschool level and continuing through all formal and conforal stages;
3. Be interdisciplinary in its approach, drawing on the specific content of each discipline in making possible a holistic and balanced perspective;

4. Examine major environmental issues from local, national, regional and international points of view so that students receive insights into environmental conditions in other geographic areas;
5. Focus on current and potential environmental situations, while taking into account the historical perspective;
6. Promote the value and necessity of local, national and international cooperation in the prevention and solution of environmental problems;
7. Explicitly consider environmental aspects in plans for development and growth;
8. Enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences;
9. Relate environmental sensitivity, knowledge, problem solving skills, and values clarification to every age, but with special emphasis on environmental sensitivity to the learner's own community in early years;
10. Help learners discover the symptoms and real causes of environmental problems;
11. Emphasize the complexity of environmental problems and thus the need to develop critical thinking and problem solving skills;
12. Utilize diverse learning environments and a broad array of educational approaches to teaching, learning about and from the environment, with due stress on practical activities and first-hand experience.

Together, these principles help ensure that each child receives a high-quality, challenging education designed to maximize potential, an education that reflects and stretches his or her abilities and interests, and that promotes environmental stewardship. The principles are the foundation of effective environmental education methods.

Understanding of the goals, objectives and guiding principles outlined in the Tbilisi Declaration is a good theoretical starting point for thinking about what an ideal program should include. However, as the Intergovernmental Conference on Environmental Education for Sustainable Development 2012 report explains, the goals of environmental education have yet to be achieved. This is attributed to the implementation of environmental education programs remaining a challenge for a majority of school systems (McBeth, Hungerford, Marcinkowski, Volk and Cifranick, 2011). Many schools face obstacles ranging from lack of vision or awareness to lack of funding or policies (Marcinkowski and Weiss, 2010). Still environmental education can take many forms (Iacob, 2013). In some school systems, environmental education is carefully integrated throughout the curriculum. These schools rely on a guiding scope and sequence that ensures objectives are met throughout a student's school years. Other school systems may integrate environmental education fragmentarily, with portions of environmental education curriculum popping up in different classes and grade levels. Often these schools do not have a cohesive scope and sequence. Some schools offer individual courses that specifically address the environment. These courses may be a semester or year long, and should include topics such as environmental issues, environmental problems, resource management, etc. Few school systems offer both an integrated curriculum and individual environmental courses. Finally, some school systems do not integrate environmental education throughout the curriculum or try to add individual courses. Instead, these schools rely on motivated teachers to incorporate environmental education into their classrooms.

The primary methods for integrating environmental education into the curriculum are separated into two models: embedding environmental education into the curriculum or adding a stand-alone course (Iacob, 2013). Embedding environmental education into existing school curriculum is a holistic philosophy. This model requires integrating the teaching and learning activities required by environmental education across the curriculum into existing courses without jeopardizing the integrity of the courses themselves. This method is recommended in the Tbilisi Declaration (1978) and by the NAAEE (2016). It is preferred because of its interdisciplinary nature. Researchers have found implementing an interdisciplinary curriculum has several benefits to learners including: helping students learn and apply new skills, promoting positive attitudes, providing more quality time for curriculum exploration, and encouraging depth and breadth in learning. Interdisciplinary curriculum also helps students have faster knowledge retrieval and a more integrated knowledge base (Appleby, 2015). Further, there is strong evidence of improved student achievement associated with learning that is interdisciplinary, collaborative, student-centered, and hands-on and that engages the student, each of which is indicative of the embedding method. Despite the many documented benefits of the embedding method, many schools have a hard time implementing it for several reasons. The biggest drawback to this method is that it requires a great deal of involvement from a large number of faculty members, and cooperation and coordination between them (Marcinkowski & Weiss, 2010). Without the support of the faculty this method cannot be successful. Additional challenges schools face when embedding environmental education into the curricula include a lack of skill, training and confidence from educators crossing subject boundaries. In order to combat

these challenges, schools must hold workshops, professional development programs and/or in-service courses to successfully train teachers to integrate environmental education into the curriculum (Marcinkowski & Weiss, 2010). The success of the embedding method is ultimately determined by the faculty's enthusiasm to participate in the program. Alternatively, the school may choose to create a stand-alone environmental course and add it to the curriculum. Metz, McMillian, Maxwell, and Tetrault (2010) argue adding a stand-alone course devotes more time for students to critically examine environmental issues as opposed to being integrated into science education. Although stand-alone courses do not usually affect other courses in a program, adding a course to an overcrowded curriculum can be a daunting task (Arsat, Holgarrrd, and Graaff, 2011). While Puk and Behm (2003) challenge the realistic fulfillment of embedding environmental education programs across the curriculum, Saylan and Blumstein (2011) argue of the two methods the most effective for improving environmental literacy are for schools to fully integrate environmental education into the curriculum.

North American Association for Environmental Education (NAAEE) is the leader for environmental education in the United States. The organization has produced several publications and recommendations to optimize the field. In 1993, NAAEE published the Guidelines for Excellence which aims to assist educators in the evaluation of environmental education materials. The Guidelines for Excellence provides direction to programs while allowing them the flexibility to shape content, technique, and other aspects of instruction. They are summarized as:

1. Materials should be fair and accurate in describing environmental problems, issues, and conditions, and in reflecting the diversity of perspectives on them.

2. Should foster awareness of the natural and built environment, an understanding of environmental concepts, conditions, and issues, and an awareness of the feelings, values, attitudes, and perceptions at the heart of environmental issues, as appropriate for different development levels.
3. Should build lifelong skills that enable learners to address environmental issues.
4. Should promote civic responsibility, encouraging learners to use their knowledge, personal skills and assessments of environmental problems and issues as a basis for environmental problem solving and action.
5. Should rely on instruction techniques that create an effective learning environment.
6. Should be well designed and easy to use.

Educators rely on these guidelines to incorporate the several methodologies of instruction (Table 1). The Guidelines for Excellence and methodologies of instruction have set up a medium for effective environmental education; however, without proper environmental education methods the program cannot be successful. These factors have led researchers to test the effectiveness of environmental education programs. Before we can discuss the research results, we must discuss: the Oklahoma curriculum framework, explain environmental literacy and how it is affected by environmental education.

Table 1. Teaching methodologies of environmental education.

| Teaching Methodologies           | Description                                                                                                                                                                                                  |
|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Action Research                  | A student led four-phase cyclical process of critical inquiry, plan formation, action/outcome, observation and reflection.                                                                                   |
| Citizen Science                  | Used to empower students so they may be recognized as valuable contributors to a larger goal or scientific effort.                                                                                           |
| Critical and Cultural Thinking   | Examines issues that considers the relationships between communities, school, workplaces, etc. and questions the motivations and interests of stakeholders.                                                  |
| Envisioning and Futures Thinking | Aims to motivate students to envision the future and think critically about how their actions affect the future.                                                                                             |
| Action Learning                  | Action learning is best defined as learning by doing. The purpose is to excite and engage students to allow for more meaningful experiences.                                                                 |
| Experiential Learning            | Experiential learning draws upon prior knowledge and experiences; then through reflection of the new ideas and skills, the learner is able to apply the new ideas and skills to new situations and problems. |
| Systems Approach                 | The goal of systems approach is to create an awareness of the complexity of the system and give students insight into actions and behaviors they ought to be taking.                                         |
| Values Clarification             | Helps the student understand their own worldview, why they value what they do and how they make decisions.                                                                                                   |
| Issues Analysis                  | Helps the student to identify major arguments related to a community problem; how to objectively evaluate these problems and prepares them to become productive citizens in society.                         |

## Oklahoma Curriculum Frameworks and Environmental Education

The Oklahoma Department of Education specifically addresses the curricula for a stand-alone environmental course for secondary students in the Oklahoma Academic Standards (2015). This course is not required for graduation in Oklahoma per Title 70 O.S. 11-103.6 and the State Board of Education Regulations. The expectations for this course are illustrated in Table 2. No data is available regarding the number of schools who have added a stand-alone course or have embedded environmental education across the curricula. Environmental concepts are also incorporated into earth science curricula and biology courses.

The Oklahoma Academic Standards K-8 science curriculum does not specifically address environmental education. However, many environmental concepts are introduced. Kindergarten students learn how plants and animals can change the environment to meet their needs. In fourth grade, students learn about renewable and non-renewable resources and how their uses affect the environment. Fifth grade students learn more explicit concepts related to how human activities impact Earth's resources and the environment, while sixth grade students begin to study ecosystems interactions, populations and behavioral adaptations. These are a few of the many examples within the Oklahoma Academic Standards Curriculum where science standards are interrelated with environmental education concepts.

Table 2. Oklahoma academic standards for environmental science.

|                                                                          |                                                                                                                                                                                                                                    |
|--------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Oklahoma<br>Academic<br>Standards for<br>Environmental<br>Science (2015) | Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.                                                                          |
|                                                                          | Use mathematical representations to support and revise explanation based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.                                                       |
|                                                                          | Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.                                                                                                  |
|                                                                          | Evaluate the claims evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. |
|                                                                          | Define, evaluate, and refine a solution for reducing the impacts of human activities on the environment biodiversity.                                                                                                              |
|                                                                          | Develop a model to illustrate how Earth's internal and surface processes operate at different spatio and temporal scale to form continental and ocean-floor features.                                                              |
|                                                                          | Analyze geoscience data to make the claim that one change to Earth's surface can create beds and interactions that cause changes to other Earth's systems.                                                                         |
|                                                                          | Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.                                                                                                                     |
|                                                                          | Analyze and interpret data to explore how variations in the flow of energy in and out of Earth's systems result in changes in atmosphere and climate.                                                                              |
|                                                                          | Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.                                                                                                             |
|                                                                          | Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.                                                                                                        |
|                                                                          | Construct and argument based on evidence about the simultaneous co-evolution of Earth's systems and life on Earth.                                                                                                                 |
|                                                                          | Construct and explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.                                                   |
|                                                                          | Evaluate competing design solutions for developing, managing and utilizing natural resources based on cost-benefit ratios.                                                                                                         |
|                                                                          | Create a computational simulation to illustrate the relationship among management of natural resources, the sustainability of human populations, and biodiversity.                                                                 |
|                                                                          | Evaluate or refine a technology solution that reduced the impacts of human activities on natural systems.                                                                                                                          |

## Environmental Literacy

The term environmental literacy was first used in a publication by Charles Roth in 1968 as he expressed: “How shall we know the environmentally literate citizen? (Roth, 1992).” Since 1968, multiple definitions of environmental literacy have been reviewed within the scientific community (e.g., Rockcastle, 1989; Gilbertson, 1990; Roth, 1992; Simmons, 1995; Morrone, Mancl, and Carr, 2001; Weiser, 2001; NAAEE, 2004; O’Brien, 2007; Bruyere, 2008; Reynolds, Brondizio, and Meta, 2010; Marcinkowski et al., 2011). Fundamentally, environmental literacy requires the understanding of scientific principles related to ecology, the roles humans play in the ecosystem and the importance of environmentally responsible behaviors (Bruyere, 2008).

The collective definitions aided the NAAEE in the development of seven major components of environmental literacy which further clarifies the specific knowledge, skills and abilities needed to be considered environmentally literate (Holloweg et al., 2011). These components include: affect, ecological knowledge, socio-political knowledge, knowledge of environmental issues, cognitive skills, environmentally responsible behaviors (ERB) and additional determinants of ERB (Holloweg et al., 2011). The first component, affect, considers an individual’s sensitivity and attitude toward environmental issues such as: pollution, technology, economics, conservation and environmental action. Affect also considers a willingness to recognize and choose between different value perspectives, and the courage to express the individual’s own values (McBride, 2011). The second component, ecological knowledge, is the ability to communicate and apply major ecological concepts; including understanding energy production and transfer, interdependence, niche adaptation, succession, homeostasis,

limiting factors and how social systems affect natural systems (McBride, 2011). The third component, socio-political knowledge, requires awareness of the economic, social, political and ecological interdependence in urban and rural areas from an ecological perspective. Socio-political knowledge also considers the relationships between beliefs, political structures and environmental values of cultures at local, regional and global levels (McBride, 2011). The fourth component, knowledge of environmental issues, is an individual's understanding of environmental problems and how they are influenced by political, educational, economic and governmental institutions. Knowledge of air quality, water quality, soil quality, land use and waste management are essential to fulfill this component (McBride, 2011). The fifth component, cognitive skills, considers an individual's ability to analyze and evaluate information about environmental issues. An individual should be able to select appropriate action strategies and create, evaluate and implement action plans. Further, an individual should be able to conduct scientific inquiry, basic risk analysis, think in terms of systems, think and plan ahead (McBride, 2011). The sixth component, ERB, requires the individual to demonstrate consistent active participation in environmentally responsible behaviors; including sound consumer purchasing, utilizing known conservation methods, helping enforce environmental regulations, encouraging others to use environmentally sound practices and supporting environmental policies (McBride, 2011). Finally, the seventh component, additional determinants of ERB, requires the person to assume a locus of control and perception that he or she has the ability to bring about change because of his or her behavior (McBride, 2011). An individual who is truly environmentally literate will exhibit strong skills in each of these components.

Many researchers recognize there is a spectrum of environmental literacy. Historically, Roth (1992) was the first to identify three degrees of environmental literacy. According to Roth the lowest degree is nominal environmental literacy. It implies an individual has basic cognitive awareness of the environment and a basic understanding of natural systems (Roth, 1992). The nominally literate individual can demonstrate some environmentally responsible behaviors and will show a familiarity with some major environmental organizations. Functional environmental literacy is the second degree. It implies an individual has the knowledge and skills to analyze, synthesize and evaluate information about environmental issues. The functionally literate individual will feel a sense of concern for the environment and will exhibit environmentally responsible behaviors based on the most current available knowledge and may participate in group actions. Operational environmental literacy is the highest degree. This implies an individual exhibits strong skills in each of the components identified by the NAAEE including, a strong locus of control. Nominal, functional and operational literacy are the terms historically used in literature to describe the varying degrees of environmental literacy; however, recently researchers have begun to reclassify the sub-levels of environmental literacy to make it easier for the public to understand the research findings. The International PISA 2006 Science Assessment classified sub-levels as “A” “B” “C” “D” and “Below D.” The justification for this change was because our society is more familiar with a letter grading system and the researchers sought to ease comprehension of the results (OECD, 2009). Most recently, McGinn (2014) used the terms low, basic, standard and high. Multiple assessments have been developed to measure environmental literacy in the past fifty years.

Researchers first began conducting environmental literacy assessments in the late 1970's. Early assessments focused on environmental knowledge (Wood, 2013). As we now know, having environmental knowledge does not necessarily equate to being environmentally literate (Goldman, Yavetz, and Pe'er, 2014). Numerous studies have researched one or several components of environmental literacy. Guidance from Hollowg et al. (2011) proposes these components can be grouped into four domains: environmental knowledge, affect, cognitive skills and ERB. Below is a condensed list of the most influential historical assessments based on these domains:

1. Environmental knowledge or ecological knowledge (Maloney, Ward, & Braucht, 1975; Leeming, Dwyer, Porter, & Cobern, 1993; Bogan & Kromrey, 1996; Disinger, 1997; Marcinkowski, 1997/2013; Marshall, 1997; Bogner, 1999; Rovira, 2000; Swanepoel, Loubser, & Chacko, 2002.; Mony, 2003; Makki, Abd-El-Khalick, & Boujaoude, 2003; Shin et al., 2005; Walsh-Daneshmandi & MacLachlan, 2006; Chu et al., 2007; Alp, Ertepinar, Tekkaya, & Yilmaz, 2008; Negev, Sagy, Garb, Salzberg, & Tal, 2008; McBeth, Hungerford, Marcinkowski, Volk & Meyers, 2008; McBeth, Hungerford, Marcinkowski & Cifranick, 2011; Meyers, 2009; Ruiz-mallen, Barraze, Bodenhorn, de la Paz Ceja-Adame, & Garcia, 2010; OEDC, 2009),
2. Affect (Maloney, Ward, & Braucht, 1975; Disinger, 1997; Marcinkowski, 1997/2013; Alp, Ertepinar, Tekkaya, & Yilmaz, 2008; McBeth, Hungerford, Marcinkowski, Volk & Meyers, 2008; McBeth, Hungerford, Marcinkowski, Volk & Cifranick, 2011),
3. Cognitive skills (Disinger, 1997; Marchinkowski, 1997/2013; Marshall, 1997; Money 2003; Shin et al., 2005; Chu et al., 2007; McBeth, Hungerford, Marcinkowski, Volk &

Meyers, 2008; McBeth, Hungerford, Marcinkowski, Volk & Cifranick, 2011; Meyers, 2009; OEDC, 2009),

4. Environmentally responsible behaviors (Hines, Hungerford, & Tomera, 1986; Leeming, Dwyer, Porter, & Cobern, 1993; Bogan & Kromrey, 1996; Marcinkowski, 1997/2013; Disinger, 1997; Hsu, 2004; Chu et al., 2007; Alp, Ertepinar, Tekkaya, & Yilmaz, 2008; Negev, Sagy, Garb, Salzberg, & Tal, 2008; McBeth, Hungerford, Marcinkowski, Volk & Meyers, 2008; McBeth, Hungerford, Marcinkowski, Volk & Cifranick, 2011).

Numerous other research studies have expanded beyond these components which are necessary for determining environmental literacy. These studies and components are omitted from this list. Significant findings have been identified from national, international and small-scale assessments.

Presently, the United States has conducted two national environmental literacy assessments. Sponsored by the U.S Environmental Protection Agency (EPA) and the National Oceanic Administration (NOAA); the National Environmental Literacy Assessment Project (NELA) began Phase One in 2008 and Phase Two in 2011 (McBeth, Hungerford, Marcinkowski, Volk & Cifranick, 2011). The Middle School Environmental Literacy Instrument (MSELI) developed by McBeth, Hungerford, Bluhm and Volk (2008) was used in the research study. The MSELI evaluates knowledge, cognitive skills, affect, and behavioral components. The first phase of the NELA was a national baseline study of sixth and eighth graders from forty-eight schools (McBeth, Hungerford, Marcinkowski, Volk and Cifranick, 2011). The results of the study found students had higher ecological knowledge than cognitive skills and higher verbal commitment than

actual commitment. Overall, most students had low environmental sensitivity. Eighth graders scored higher on the knowledge section than sixth graders; however, sixth graders scored higher affectually than eighth graders. The study concluded attitudes change as a function of specific exposures and experiences, rather than as a result of increasing age. The second phase studied sixty-four schools with established environmental education programs. Once again, the study revealed knowledge and issue identification increased from sixth to eighth grade, but affect and environmental sensitivity decreased with age. Likewise, the students struggled to translate verbal commitment into actual commitment. Students in schools with environmental education components scored higher than students in the baseline study in all aspects of the MSEL except in the area of cognitive skills where both samples of students had similar results. Additional phases of the NELA are anticipated to further our understanding of the development of environmental literacy. Researchers in Korea, Turkey and Israel have also conducted national assessments similar to the NELA (e.g., Chu et al., 2007; Alp, Ertepinar, Tekkaya, and Yılmaz, 2008; Negev, Sagy, Garb, Salzberg, and Tal, 2008).

The Organization for Economic Cooperation and Development (OECD) sponsored the only international environmental literacy assessment (OECD, 2009). Thirty countries including the United States participated in the PISA 2006 Science Assessment (OECD, 2009). The research evaluated fifteen year olds from around the world using the components knowledge, cognitive skills and locus of control. The results of the study found only one in five students could consistently identify, explain and apply scientific concepts related to environmental topics. The highest-ranking countries were Canada, Finland and Japan where over 33% of students were ranked as having high

levels of environmental literacy (OECD, 2009). United States students scored below average in all components of the assessment and 19% of students tested “Below D” level (OECD, 2009). In the United States, there was no measurable difference between male and female students; however, the study did find a statistically significant difference in ethnicity where environmental literacy was positively associated with Caucasian and Asian students more so than with Hispanic and African American students. Each country exhibited different demographic results which indicates the multi-variant factors associated with environmental literacy (OECD, 2009). The study concluded most students acquire environmental information from school, although only a minority of students learn in stand-alone environmental science courses.

Small-scale environmental literacy assessments conducted for dissertation and thesis research have also explored interesting topics. In an ex-post facto study Monty (2002) investigated the impact 4-H after school programs in Florida had on student environmental literacy. 4-H is a national after school program which introduces Science, Technology, Engineering and Math (STEM) through hands-on activities and projects. The results of this study found students who participated in 4-H with incorporated environmental education curriculum scored higher in all sections of a modified MSEL than students who did not participate in 4-H, with the exception of the environmental action section (Monty, 2002). Research on middle school students in North Carolina found environmental education curricula and time outdoors positively affects environmental literacy components: knowledge, affect, cognitive skills and behavior (Stevenson, 2015). The study found limited positive associations between having a role model and time outdoors, and negative associations between watching nature television

and environmental knowledge (Stevenson, 2015). Small class sizes and high socioeconomic status was positively associated with environmental knowledge and overall environmental literacy (Stevenson, 2015). Other important small-scale studies have found that knowledge does not correlate to environmental stewardship (Morrone, Mancl, & Carr, 2001) and environmental attitudes do not correlate to ERB (Altantar, 2011).

Many universities have also been the subject of environmental literacy assessments. McGinn (2014) evaluated seven liberal arts colleges. The research study examined caring, knowledge and practical competency (ERB) components. The results of the study found 58% of students were literate, however, only 4% of students tested at a high level of literacy. The most students who were illiterate were so because of practical competency. A similar study by Nash (2015) measured attitude and behavioral components of undergraduates from a liberal arts university. The study assessed and compared student environmental literacy with the student's major. As expected, students who majored in environmental studies had the highest levels of environmental literacy. The results of the study ranked the majors: environmental studies, hard sciences, economics, arts/humanities and social sciences, respectively. Interestingly, hard science majors also received the lowest scores total. While many assessments reinforce previous findings, it is important to note there are some discrepancies. For example, the number of courses a college student takes does not improve student attitudes or behaviors (Altantar, 2011). Conversely, Hovarth (2013) found students who took three or more sustainability courses had significantly higher environmental literacy than students who take zero to two courses. These studies show that the factors affecting both environmental literacy and environmental education need further evaluation.

## Notable Environmental Education Research

Having discussed the principles of environmental literacy and how it is affected by environmental education has led to the discussion of what factors affect environmental education itself. Recent curriculum studies indicate environmental education programs in the United States need further evaluation. As found in the second national study conducted by McBeth, Hungerford, Marcinkowski, Volk and Cifranick (2011), students in middle schools with established environmental education programs scored higher than students in the baseline study in the domains of knowledge, affect and ERB of the MSEL. However, students in environmental education programs scored similarly in the cognitive skills domain as compared to students in the baseline study. Using the MSEL, Wood (2013), conducted a state-wide environmental literacy assessment of Arkansas 6th grade students. The results of the research indicated students had moderate knowledge in the domains of environmental knowledge, affect and ERB. Overall, student cognitive skills measured in the low range. Compared to the national survey, the Arkansas students scored significantly lower in all domains of the MSEL. The research also identified significant differences on physiographic and geographic regions of the state. Many of the teachers in this study indicated they received little-to-no training in environmental education during pre-service teacher preparation programs and little-to-no on-going professional development related to environmental education. Ruiz-mallen, Barraze, Bodenhorn, de la Paz Ceja-Adame and Garcia (2010) also found in a regional study in Mexico that environmental education curricula had to be tailored to the community. Students in urban and rural schools required different curriculum strategies in order to be effective. The impact of these research studies is that in order to improve overall

environmental education programs (and environmental literacy); schools need to implement environmental education programs tailored specifically to the community and ensure teachers have the content knowledge and strategies to effectively integrate environmental education across the curriculum.

Several educational factors and practices influence student environmental education goals. The exploration of gender and the teaching methods which best enhance learning was conducted by Carrier (2009). Research in this study showed boys who participated in outdoor environmental education strategies significantly had greater scores than groups of boys in a traditional classroom. The treatment did not significantly affect girl's scores. McBeth, Hungerford, Marcinkowski, Volk and Cifranick (2011) explored age as it relates to environmental literacy. The study found older students exhibited stronger environmental knowledge skills than younger students, but older students lacked in environmental sensitivity (affect) compared to younger students. Liefländer, Fröhlich, Bogner and Schultz (2013) examined the differences in a student's academic tracts. This research found university-track students had higher scores than students in the general curriculum. Another study, conducted by Taylor (2014) examined the difference between traditional and online teaching platforms. The study found student's general environmental knowledge, actual commitment to environmental issues and global environmental awareness were statistically the same; however, students' verbal and emotional commitment were found to be statistically different with students in traditional programs having higher scores. Research has shown eco-schools or green schools have improved reading literacy (Lieberman, 1998), improved math literacy (NEETF, 2000), improved science achievement and attitudes towards learning (Klemmer,

Waliczek, & Zajicek, 2005; Dirks & Orvis, 2005; Smith & Motsenbocker, 2005) improved critical thinking skills (Ernest & Monrow, 2004), and improved student behaviors and attitudes (Washington State Report Card, 2004) over traditional schools. Bruick (2009) clarifies that green schools did not affect student achievement on standardized tests or student attendance records. Research by Maltese (2013) found student gardens benefit students in a number of ways including: having an enriched science curriculum, cross-curricular lessons in authentic settings, developing a sense of school community, and showed positive shifts in attitudes toward nature. The impact of these research studies is to show that the factors affecting environmental education is both dynamic and complex.

A national survey of environmental education and sustainability among private independent schools in the United States found 57% of principals believe environmental education is extremely or very important in helping students achieve environmental literacy (Chapman, 2014). This same research found few principals indicate their school has achieved a high level of success in integrating environmental education into the curriculum; 17% indicated extremely successful/very successful implementation, while 29% indicated not very/not at all successful (Chapman, 2014). Thirty-five percent of the schools surveyed reported having tried to integrate environmental education into the curriculum, while 15% of schools reported having added an elective class and 12% added an Advanced Placement course (Chapman, 2014). Many schools reported including outdoor learning experiences (50%), service learning projects (41%), school gardens (40%), using the campus as a hands-on learning laboratory (38%) and civic engagement projects with environmental themes (36%) as informal efforts to incorporate EE. The

study found the main challenges of using informal EE in school were a lack of time, schedule constraints that make field trips difficult, limited funds and transportation issues (Chapman, 2014).

Many research studies have also noted the distinguishing characteristics of successful environmental education programs. Programs must be based on reputable facts and science. Goals should be explicitly outlined and a continual improvement process should be established. However, ecological knowledge alone does not lead to environmental literacy (Goldman, Yavetz, & Pe'er, 2014). Consequently, programs that are grounded in a real-world context that are specific to age, curriculum and place, and encourage a personal affinity with the earth through practical experience greatly enhance student environmental literacy. Programs which create exciting and enjoyable learning situations and integrate caring, knowledge and action components improve student environmental literacy. Research shows the most effective environmental education programs are learner-centered (Marcinkowski, 2013). Collaborative, experiential learning approaches have greater success fostering environmental literacy over traditional didactic approaches (Stevens and Crow, 2016). Hands-on-investigations and inquiry-based learning empower learners to develop their own understanding of the environment (Stern, 2014; Walsh et al., 2014; Burchett, 2015). Further, programs which actively involve participants are more likely to improve environmental behaviors (Reynolds, Brondizio, & Meta, 2010). Providing creative learning experiences that are hands-on and learner-centered, where students teach each other, and educators are mentors and facilitators, promotes higher order thinking and provides a cooperative context for learning and evaluation. Issue-and-action instruction and service learning have also contributed to the

development of environmental literacy (McBeth, Hungerford, Marcinkowski, Volk & Cifranick, 2011). These programs are most successful because they motivate and empower students transforming them as they examine their personal values, attitudes, feelings and behaviors. This leads us to the discussion about the importance of elective courses and how they may be an important tool for fostering environmental literacy by embedding environmental education components into the curriculum.

### The Importance of Elective Courses

Research clearly refutes the notion environmental literacy (or environmental education) is fostered solely through science-based courses (Nash, 2015). “There has been no single pathway to success in developing and implementing the sustainability education curriculum (Rowland, 2013)” Furthermore, effective environmental education ought not be confined to a textbook (Johnson, 2009). By helping learners perceive the meaning and relevance of new knowledge in terms of their prior knowledge and experience, educators can enhance learning. Elective courses are classes students choose based on their own interests. Student interests have been identified as one of the most important motivational constructs that influence students’ engagement and achievement in learning (Wentzel & Brophy, 2014). From an educational perspective, students come into the learning environment with a wide array of individual interests. Electives can provide students with learning experiences that are not included in formal courses of study, and in which students can voluntarily participate such as athletics, debate, newspaper, music, art, computer science and many other student interests depending on the school. Studies have found participation in elective courses have many positive

effects on students. These effects include: positive behaviors, better grades, school completion, positive aspects to become successful adults and social aspects (Massoni, 2011). The goal of embedding environmental education into elective courses is to transition environmentally responsible behaviors from something students should do into something they actively pursue by creating a learning environment that evokes or triggers situational interest into the development of individual interest.

Studies show learners who have an area of individual interest in a subject, display heightened attention, concentration, persistence, mastery orientation, positive affect, immediate comprehension of the material and strong subsequent test performance (Wentzel & Brophy, 2014). Students with prior knowledge in an area of individual interest usually have larger and better organized learning networks. This makes it easier for them to assimilate new information in their high interest areas. By creating immediate local contexts, relevant to students' everyday life the strategic engagement of desired information creates an emotional response by learners in their interest areas. Compared with evidence from other studies which indicates students may disengage from learning activities and tasks if they dislike or feel discomfort with what is being learned (Marcinkowski, 2013). If a student views the information as relevant to themselves as learners, particular curriculum subjects or to their personal professional futures they are more likely to become engaged in learning. Wentzel and Brophy (2014) warns the limitations of interest translating to curricular goals if the learning objectives are not strategically planned.

Elective courses have an opportunity to help foster environmental literacy based on student interest by designing curriculum that is relevant to the student using

constructivist theory. For example, a student who is interested in art may be reached by having a lesson where the teacher takes garbage and asks the student to create a piece of art from something others have thrown away. Another example may be, students taking Spanish classes conduct a case study about the Panama Canal and how it has impacted the ecosystem. Alternatively, students interested in debate may benefit from having a topic about the damming of a local river. Business-oriented students may benefit from learning about lifecycle assessments of a product of their choosing etc. These are only a few of the many examples of lesson plans that can be used to introduce environmental education concepts into elective courses while maintaining the integrity of the course.

It is clear elective courses are an avenue that can and should be pursued in environmental education as part of an interdisciplinary curriculum. Electives have the potential to greatly impact environmental literacy because the student already has an interest in the area being studied; therefore, student's exhibit greater attention to the subject being learned.

The factors that contribute to students' learning are multiple and varied. After over 40 years of research in environmental education there are still many unanswered questions, and aspects that require further study, and certain gaps. Environmental literacy studies are needed to determine which environmental education programs and approaches are effective. "Well-designed research studies are needed to further our understanding of how to maximize the potential of those environmental education programs and approaches that do advance environmental literacy (i.e., their promise and their limitation for different populations of learners) (Holloweg et al., 2011)." Could incorporating an

environmental education component into elective courses which align with the students' interest improve environmental literacy rates?

We are a long way from answering this question. The most successful environmental education programs are holistic. A major component I think contributes to the success of both environmental education programs and high environmental literacy is engaging the student based on their interests, which is why I decided to pursue this research project.

### Research Questions, Hypotheses and Specific Aims

My research aims to answer the following questions:

1. What relationships are formed from individuals' scores on the separate components of the environmental literacy assessment tool (attitude, behavior, knowledge and overall environmental literacy)?
2. Will there be a statistical difference in the subpopulations: (1) gender, (2) grade level, and (3) residence on the separate components of the environmental literacy assessment tool and overall environmental literacy?
3. What will be the extent of the relationship of an individual's score on the environmental literacy assessment tool and their participation in elective courses?

The following hypotheses are made based on correlations suggested from previous studies.

Hypothesis I: A student's score on the environmental literacy assessment, in relation to the demographics section, will be: (1) positively influenced by gender with males scoring higher than females, (2) positively influenced by grade level, (3) positively

influenced by residence with rural students scoring higher than urban and suburban students.

Hypothesis II: A student's score on the environmental literacy assessment, in relation to the elective courses section, will be: (1) positively associated with participation in (a) vocational education courses, (b) science and math based courses, (c) language and writing courses, (d) arts courses (e) cultural and foreign language courses, (f) physical education and (g) business and computer science courses, respectively.

My thesis has four specific aims.

1. Obtain a representative sample of schools and students in the population.
2. Design a survey which gathers student data and measures environmental literacy in a limited time-frame.
3. Develop a method of distributing and gathering surveys from sampled schools.
4. Analyze and report any quantifiable relationships between environmental literacy and student's demographic information and elective courses, including recommendations for improving environmental literacy through elective courses.

## Chapter II

### Methods

To assess the environmental literacy of public high school students across Oklahoma, the Oklahoma Environmental Literacy Assessment Tool (OELAT) was administered to 980 students to establish baseline information on the environmental literacy of students. I developed the OELAT to gather appropriate student data for the project and measure environmental literacy in a limited time-frame. In addition, the OELAT was used to determine if there were any correlations in environmental literacy in the following subpopulation categories: sex, class standing, residence and participation in elective courses. In this chapter, I will outline the steps taken during the study: 1) by providing a statement of research ethics, 2) outlining the study assumptions and delimitations, 3) discussing the OELAT, 4) describing the design of data collection and sampling methods, and 5) providing an overview of the statistical methods for analyzing the study data, 6) followed by a chapter summary.

### Research Ethics

This study was performed ethically and in compliance with all appropriate regulations including the U.S Department of Health and Human Subjects Revised Regulations that pertain to all forms of human subject's research involving minors. Harvard University Institutional Review Board (IRB) approved this study (IRB 16-0770) (Ancillary Appendix 1). School administrators signed a letter of acceptance to provide their written consent to participate in the study (Ancillary Appendix 1). Teachers hosting

the principle investigator for the administration of this study were provided letters of introduction (Ancillary Appendix 1). Participant guardians were given a passive consent form (Ancillary Appendix 1) and participants were given an assent form (Ancillary Appendix 1).

### Study Assumptions and Delimitations

During the study, the following assumptions were made:

1. The participants responded to the assessment tool honestly.
2. Variations in the time and location that the assessment tool was administered to the participants was not a factor.
3. Each dependent variable (knowledge, attitude and behavior) is normally distributed in the populations from which the samples are derived.
4. Each group and the respective population has the same variability.

The scope and methods of this study were delimited in several noteworthy ways:

1. This study was limited to students enrolled in public schools within Oklahoma in the 2016-17 school year;
2. Only schools which participate in the Oklahoma Secondary School Activities Association were selected for sampling purposes;
3. For practical and financial reasons, the number of schools selected for sampling purposes was limited to 20 schools;
4. Furthermore, the schools selected for sampling purposes were limited to schools with passive consent procedures for survey distribution to minors;
5. The population from which the study sample was drawn was limited to 9th, 10th, 11th and 12th grade students;

6. While environmental literacy has been defined in broader terms (e.g., Simmons, 1995; Wilke, 1995), only the environmental literacy components identified in the research question above was surveyed. The survey was designed to be administered in a 15-minute time period. As a result, the number of possible items that could be included in the measure for each component was limited to allow for this practical time constraint.

#### Oklahoma Environmental Literacy Assessment Tool

The OELAT (Appendix 1) was created in order to address the research questions, hypotheses and specific aims of this thesis in a limited time frame. It was divided into four sections. Section I gathered demographic and student course data. Sections II and III qualitatively evaluated the student based on their attitudes and behaviors of environmental issues, while Section IV quantitatively evaluated the student based on their knowledge of environmental issues. The internal consistency of the OELAT was found to be 0.6499 by using Cronbach alpha coefficient.

Section I of the OELAT is composed of three questions which was designed to capture relevant demographic and student curriculum data. The questions used in this section identified the nine independent variables of the study including: grade level, gender, residence and participation in various types of elective courses which were categorized into vocational education courses, science and math based courses, language and writing courses, arts courses, cultural and foreign language courses, physical education and business and computer science courses. The independent variables are presumed to affect or influence other variables. Table 3 outlines the Section I question justifications and level of difficulty.

Table 3. OELAT section I question justification and level of difficulty.

| Question | Level of Difficulty | Justification              |
|----------|---------------------|----------------------------|
| 1.       | Easy                | Identify gender.           |
| 2.       | Easy                | Identify grade level.      |
| 3        | Easy                | Identify elective courses. |

Section II assessed student attitudes regarding environmental issues. This section used six Likert-style questions to assess the student's ecocentric, technocentric and dual centric attitudes. The response options were on five-point scales in which the choices ranged from 1 to 5. Five points were assigned to "strongly agree," four to "agree," three to "neutral," two to "disagree," and one to "strongly disagree". The scores for each question were added together and divided by six. Therefore, the maximum score of attitudes dimension was five points, the minimum score was one. The higher score refers to a more favorable attitude toward the environment. In order to be considered environmentally literate in this section the participant must average 4 points. The questions were adapted from Altanlar (2011). The level of difficulty and question justifications for this section are summarized in Table 4. This section identified part of the dependent variables in the study. Dependent variables are presumed to be affected by one or more independent variables. In this study three components of environmental literacy (knowledge, attitudes and environmentally responsible behavior) were used as dependent variables.

Table 4. OLEAT section II question justification and level of difficulty.

| Question | Level of Difficulty | Justification                    |
|----------|---------------------|----------------------------------|
| 4.       | Easy                | Identify egocentric attitude.    |
| 5.       | Easy                | Identify egocentric attitude.    |
| 6.       | Easy                | Identify dual centric attitude.  |
| 7.       | Easy                | Identify dual centric attitude.  |
| 8.       | Easy                | Identify technocentric attitude. |
| 9.       | Easy                | Identify technocentric attitude. |

Section III used five Likert-style questions to assess the dependent variable, behavior. Like Section II, the response options were on five-point scales in which the choices ranged from 1 to 5 with 5 being the most often. Five points were assigned to “5,” four points to “4,” three points to “3,” two points to “2,” and one points to “1”. The scores for each question were added together and divided by five. The maximum score of the behavior domain was five points, while the minimum score was one. A higher score indicates the participant exhibited greater environmentally responsible behaviors. In order to be considered environmentally literate in this section the participant must have an average of 4 points. Questions adapted from Atlanter (2011), Michalos (2009) and Kibert (2000) were used in this section and Table 5 outlines the level of difficulty and question justifications.

Table 5. OELAT section III question justification and level of difficulty.

| Question | Level of Difficulty | Justification                              |
|----------|---------------------|--------------------------------------------|
| 10.      | Easy                | Identify recycling habits.                 |
| 11.      | Easy                | Identify stewardship behaviors.            |
| 12.      | Easy                | Identify conservation behaviors.           |
| 13.      | Easy                | Identify conservation behaviors.           |
| 14.      | Easy                | Identify exposure to environmental topics. |

Section IV was used to assess environmental knowledge (dependent variable).

The section consisted of ten multiple choice questions, each containing five or six answer choices. Each question contained only one correct answer, and in order to prevent guessing one of the answer choices was “do not know.” To compute the knowledge score, each correct response received a numeric value of 1 and incorrect responses were coded as 0. Therefore, the maximum score of knowledge dimension was ten, the minimum score was zero. To be considered literate in this section the participant must have scored an average of seven points. Section IV measured knowledge concepts including: biodiversity, natural resources, environmental quality and health, natural hazards and extreme weather, and land use. The questions in this section were adapted from Kibert (2000), Edquest Resources (2005), Hogden (2010) and O’Brien (2007). Table 6 identifies the section question justification and level of difficulty.

Table 6. OELAT section IV question justification and level of difficulty.

| <b>Question</b> | <b>Level of Difficulty</b> | <b>Justification</b>                                       |
|-----------------|----------------------------|------------------------------------------------------------|
| <b>15.</b>      | Easy                       | Identify knowledge of natural resources.                   |
| <b>16.</b>      | Medium                     | Identify knowledge of natural hazards and extreme weather. |
| <b>17.</b>      | Easy                       | Identify knowledge of biodiversity.                        |
| <b>18.</b>      | Medium                     | Identify knowledge of natural resources.                   |
| <b>19.</b>      | Easy                       | Identify knowledge of land use.                            |
| <b>20.</b>      | Medium                     | Identify knowledge of natural resources.                   |
| <b>21.</b>      | Hard                       | Identify knowledge of environmental quality and health     |
| <b>22.</b>      | Medium                     | Identify knowledge of environmental quality and health.    |
| <b>23.</b>      | Hard                       | Identify knowledge of environmental quality and health.    |
| <b>24.</b>      | Medium                     | Identify knowledge of biodiversity.                        |
| <b>25.</b>      | Medium                     | Identify knowledge of land use.                            |

### Research Setting and Participants

The target population for this study was ninth, tenth, eleventh and twelfth grade students in Oklahoma. The sampling frame included public high schools in Oklahoma which participate in the Oklahoma Secondary School Activities Association. From this group, 20 schools were selected using stratified sampling techniques. This technique was used because it generally provides increased accuracy in sample estimates without leading to substantial increases in costs, while not departing from random probability sampling. The population was divided into subpopulations (strata) and probability

sampling was conducted independently within each stratum (Ross, 2005). The variables which determined the strata were size and region. Schools per classified by the OSSAA as 3A, 4A, 5A and 6A were considered large schools, whereas B, A, and 2A were considered small schools. Four regions were determined geographically: northeast, northwest, southeast and southwest. Finally, schools were classified as rural, suburban and urban. Figure 1 depicts the distribution of the schools selected within the state:



Figure 1. Distribution map of schools sampled.

A priori determination of sample size was calculated for power of .95 and  $\alpha = 0.05$  this required a minimum sample size of  $n=468$ .

### Procedures for Obtaining Consent

To obtain school consent, I called the school administrator authorized to approve participation, described the study purpose and procedures, and asked for permission to

proceed with the research in that school. If the authorized administrator agreed, I sent an administrative consent form (Ancillary Appendix 1) to be signed by the participating school's authorized administrator as required by the IRB, and set up a date to administer the survey.

During the initial contact with the school, I asked the school administrator if the school requires active or passive parental consent. Only those schools with passive parental consent procedures were asked to participate in the study. Schools with passive consent procedures have student guardians sign a document at the beginning of the academic year giving the school permission to administer appropriate surveys and tests as part of their mission. Guardians were sent a letter at least two days prior to the administration of the OELAT explaining the purpose of the study and the procedures (Ancillary Appendix 1). The letters were distributed during the participant's class by their teacher. Teachers orally informed the students of the study during classroom time. If a guardian did not allow their child to participate or if the student did not wish to participate, they were excluded from the data collection. All non-responses by guardians were treated as offers of consent.

#### Method of Collecting Survey Data

On the date of the survey administration, I distributed the Student Assent Forms and Opt Out Literature, orally explained the study procedures and asked if the participants had any questions. After all questions were answered, I distributed the OELAT. The participants were instructed to bring the survey to a universal envelope once it was complete. After all of the students in the class completed the survey I orally

conducted a post survey follow-up to debrief the participants. After the administration, I manually scored the forms and input the data into a password protected Excel spreadsheet. The data collection process can be summarized as follows:

1. Ethical approval was sought for research from Harvard University as a result of human participants.
2. Ethical approval was also sought and received from the participating school boards.  
In an effort to maintain confidentiality the name of the participating schools and all of the participants are not included in this research.
3. A total of forty-six school districts were approached for permission to conduct research in the school district. Twenty school districts gave their permission, twenty-six did not.
4. Within a period of four months (September to December), permission forms were given to students in each of the teachers' classrooms to obtain guardian consent before the administration of the OELAT.
5. One hundred percent of all permission forms sent home for guardian consent were accepted.
6. The OELAT was administered to students at least two days after the guardian consent forms were sent home. An Opt-Out Article (Ancillary Appendix 1) was provided for students whose parents indicated they did not want them to participate or if the student did not wish to participate.
7. On the day of the survey, the OELAT booklets were given to students, they were told they could withdraw from participating at any time, the surveys were confidential and students were told not to write their names in the booklet.

8. A total of 1000 booklets were given out. Twenty students withdrew from the survey. Students returned the survey once they were completed.

### Data Analysis

The OELAT responses were entered into a password protected Excel spreadsheet that coded the responses based on the Likert-type scale employed for the attitude and behavioral sections, and for correct answers in the knowledge section. Composite scores for each section and for the OELAT as a whole were then calculated. The scoring justification (Appendix 2) was adapted from McGinn (2014). If a participant left an attitude or behavior question blank the OELAT was discarded because there is no way of knowing how the participant would answer the question; however, if a participant left a knowledge question blank the question was scored as incorrect under the assumption the student did not know the correct answer.

Both descriptive and inferential statistics were used to analyze the data found in this study. Mean, median, mode, standard deviation, minimum and maximum were calculated as part of the descriptive statistical analysis. Inferential statistics were obtained by conducting a t-test to analyze the effect of gender on environmental literacy, and three separate MANOVAs to analyze the effect of grade level, residence, and participation in electives including: vocational education courses, science and math based courses, language and writing courses, arts courses, cultural and foreign language courses, physical education, and business and computer science courses. A MANOVA analysis was used because it examines two or more independent variables and two or more dependent variables simultaneously. Further, Tukey HSD statistics were used to determine specifically which groups were different from the other.

## Testing Hypothesis I

Independent t-tests were used to test for significant differences ( $p < 0.05$ ) in environmental literacy by gender. The two-tailed t-test of significance examined whether the mean of one distribution differed significantly from the mean of the other distribution, irrespective of direction (Garson, 2015).

A MANOVA analysis was used to test for significant differences in the environmental literacy scores of students in different grade levels (9-12). MANOVA was chosen to test whether there was sufficient evidence ( $p < 0.05$ ) to infer if the means of the various grades differed (Garson, 2015). Tukey HSD statistics were used to determine specifically which grade levels were different from the other.

Like the grade level analysis, a MANOVA was used to determine if there were significant differences ( $p < 0.05$ ) in any of the environmental literacy domains based on residence, including urban, suburban and rural and Tukey HSD statistics were used to determine which groups differed from one another.

## Tests of Hypothesis II

In order to test the significant difference of the environmental literacy domains based on elective courses, students were grouped into seven categories, and a MANOVA statistics test was used to test for significance.

## Chapter III

### Results

The purpose of this study was to test and describe the factors affecting the environmental literacy of Oklahoma public high school students. Environmental literacy was indicated by students' affective attitudes and behaviors toward environmental issues and knowledge of environmental science. This chapter presents results of data analysis from the Oklahoma Environmental Literacy Assessment Tool (OELAT) of high school students from twenty different high schools across Oklahoma selected from random stratified sampling techniques. Quantitative data included participant questionnaire OELAT data that were entered into SPSS (version 24.0) for descriptive statistics, t-tests, MANOVA significance testing and Tukey HSD testing.

#### Population Demographics

Students in 9-12 grade from twenty different public schools participated in this research. The total enrollment of the schools sampled varied considerably ranging from less than 200 to greater than 9,000. A total of 980 students were included in the data analysis. Of the 980 participants, 466 were female (48%) and 514 were male (52%) (Table 7). Further, 257 were ninth graders (26%), 284 were tenth graders (29%), 228 were eleventh graders (23%), and 211 (22%) were twelfth graders and 548 students (56%) were from rural schools, 157 (16%) from suburban schools, and 275 (28%) from

urban schools (Table 7). This resulted in the most equal distribution among the categories.

Table 7. Frequency statistics of participants by gender, grade level, residence and elective participation (N=980).

|                                    |                  | N   |
|------------------------------------|------------------|-----|
| Gender                             | Female           | 466 |
|                                    | Male             | 514 |
| Grade Level                        | Freshman         | 257 |
|                                    | Sophomores       | 284 |
|                                    | Juniors          | 228 |
|                                    | Seniors          | 211 |
| Residence                          | Rural            | 548 |
|                                    | Suburban         | 157 |
|                                    | Urban            | 275 |
| Arts                               | No participation | 570 |
|                                    | Participation    | 409 |
| Business and Computer Science      | No participation | 737 |
|                                    | Participation    | 242 |
| Cultural and Foreign Languages     | No participation | 687 |
|                                    | Participation    | 292 |
| Language Arts and Creative Writing | No Participation | 751 |
|                                    | Participation    | 228 |
| Physical Education                 | No participation | 569 |
|                                    | Participation    | 410 |
| Science and Math                   | No participation | 639 |
|                                    | Participation    | 340 |
| Vocational Education               | No Participation | 720 |
|                                    | Participation    | 259 |

The greatest number of participants indicated they participated in physical education (42%), followed by arts (42%), science and math (34%), cultural and foreign languages (29%), vocational education (26%), business and computer science (24%) and language arts and creative writing (23%).

### Data Analysis

The data analysis for each of the research questions is provided below and presented in the following order: attitude, behavior, knowledge, overall environmental literacy, gender, grade level, residence and elective participation. Each of the independent variables was tested against the dependent variables.

#### Question 1

What relationships are formed from individuals' scores on the separate components of the environmental literacy assessment tool (attitude, behavior, knowledge and overall environmental literacy)?

*Attitude domain.* Data from the Attitude domain were aggregated from Section II of the OELAT. This section used six Likert-style questions to assess the student's ecocentric, technocentric and dual centric attitudes.

As shown in Figure 2, 16% of the total participants were considered literate. The literacy distribution between the subdomains were generally consistent. Comparison of the gender subdomain revealed 16% of females and 17% of males exhibited positive attitudes toward the environment. A slight incline was revealed as students age where

9%, 17%, 16%, and 25% of students in grades 9-12, respectively were considered literate. Finally, the residential analysis indicated, 21% of urban and 14% of rural students and suburban students exhibit positive environmental attitudes.

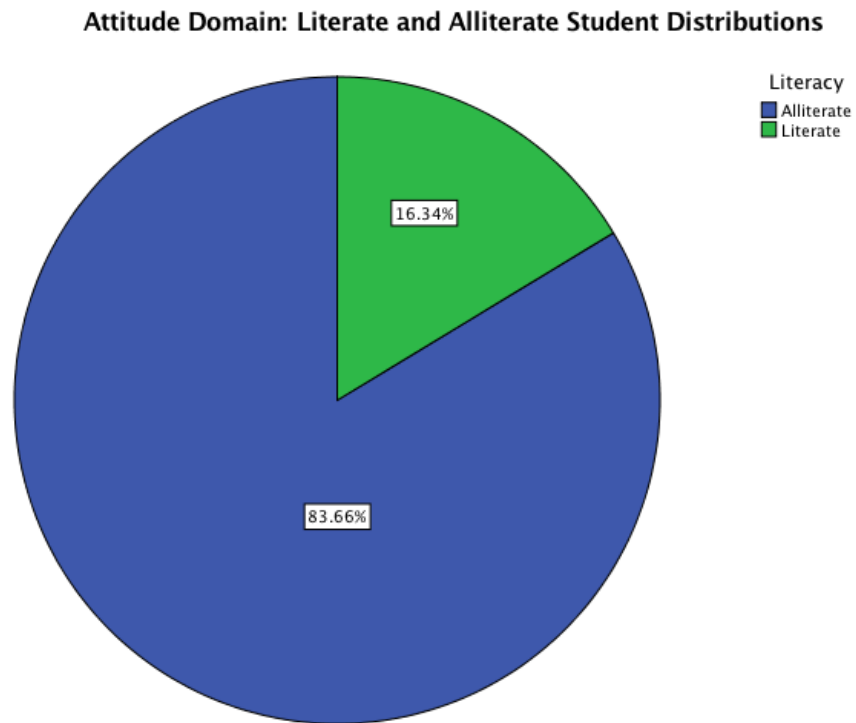


Figure 2. Attitude domain: literate and alliterate student distributions.

The neutral option provided in the Likert-scale was heavily used by many of the participants in this study. Over 40% of students selected being neutral about the idea of a major ecological catastrophe occurring if things continue on their present course, while over 50% of students selected neutral about believing the ecological crisis being greatly exaggerated. Over 25% of students selected having neutral beliefs that the earth has plenty of natural resources if we learn how to develop them, and over 30% of students were neutral about earth's carrying capacity. Twenty-seven percent of students were neutral about the belief that humanity will eventually learn enough to be able to control

nature, while 28% were neutral about being subject to the laws of nature. It is likely there are several reasons for the overwhelming amount of neutral responses. The students may feel ambivalent and are wanting to avoid the negative feelings associated with their conflicting feelings on the issues presented. They may feel social desirability and are reluctant to voice what they feel is a socially undesirable opinion (Krosnick et al. 2002). Finally, they may have elected to satisfice, or avoided the cognitive effort required to pick an answer in the domain (Edward & Smith, 2015).

Despite the large number of students that opted to use the neutral option, the Attitude domain did reveal several interesting student opinions. For example, a majority of students believe humans are still subject to the laws of nature (67%); however, when asked if they believed the earth has plenty of natural resources if we just learn how to develop them 62% of students agreed. Further, 16% of students believe humans will eventually learn enough about nature to be able to control it. These responses indicate strong technocentric beliefs in many of the students. Recall, a technocentric believes environmental problems may be solved by scientific and technological advancement, rather than seeing a need for reducing consumption. Intriguingly, the distribution of answers among the independent variables was nearly identical. In addition, less than 100 years ago Oklahoma faced one of the worst manmade ecological disasters in American history, The Dust Bowl. The Dust Bowl was a result of non-sustainable farming techniques used during the early 1900s. Interestingly, when students were asked if they believed if things continued on their present course there would soon be a major ecological disaster 48% agreed; however, students were much less likely to disagree that an ecological crisis has been greatly exaggerated (33%). These responses indicate slight

belief in the possibility of an ecological disaster, but also accentuate a lack of trust for environmental science and journalism.

*Behavior domain.* Data were gathered from Section III of the OELAT to analyze this domain.

As shown in Figure 3, 4% of the total participants were considered literate. The literacy distribution between the subdomains were variable. Comparison of the gender subdomain revealed 5% of females and 4% of the males exhibited positive behaviors. In the grade level analysis (9-12) 6%, 2%, 5%, and 4% of students respectively were considered literate. Finally, in the residential analysis, 3% of rural students, 7% of suburban students and 5% of urban students exhibited positive behaviors.

Large differences were identified among the subpopulations during the Behavior domain analysis. For example, large gaps were identified between rural, suburban and urban student recycling behaviors. Where 40% of rural students indicate they never recycle; 28% of suburban and 27% of urban students indicate they never recycle. Further, the number of rural students who always recycle (3%) compared to urban students is doubled (6%), and compared to suburban students is tripled (9%). There was a significant gap in students who would report always consciously trying to conserve energy (7%), compared to students who reported always turning off lights and appliances when they were not in use to conserve electricity (35%). In addition to training for sustainable behaviors, talking about the environment to students is important because it helps raise awareness for the environment and environmental concerns. In this study forty percent of

students reported that they never talk about the environment or environmental problems, while three percent reported they often talk about the environment.

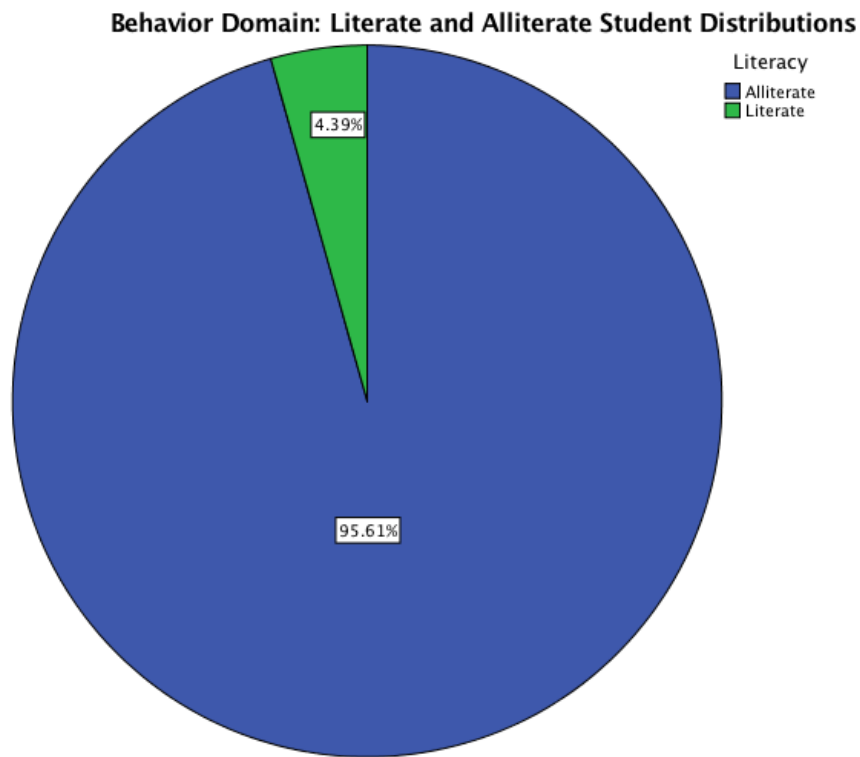


Figure 3. Behavior domain: literate and alliterate student distributions.

*Knowledge domain.* This domain measured knowledge of concepts including: biodiversity, natural resources, environmental quality and health, natural hazards and extreme weather and land use. The mean knowledge score was 3.37. The range high was nine indicating scores were present on both high and low ends of the spectrum. As shown in Figure 4, 9% of total participants were considered literate. Distribution between subdomains were variable. Seven percent of the female population and 11% of the male population were considered literate in this domain. The grade level analysis revealed 3%

of freshman, 8% of sophomores, 14% of juniors, and 13% of seniors received passing knowledge scores. Finally, in the residential analysis, 7% of rural students and 11% of suburban and urban students passed this domain.

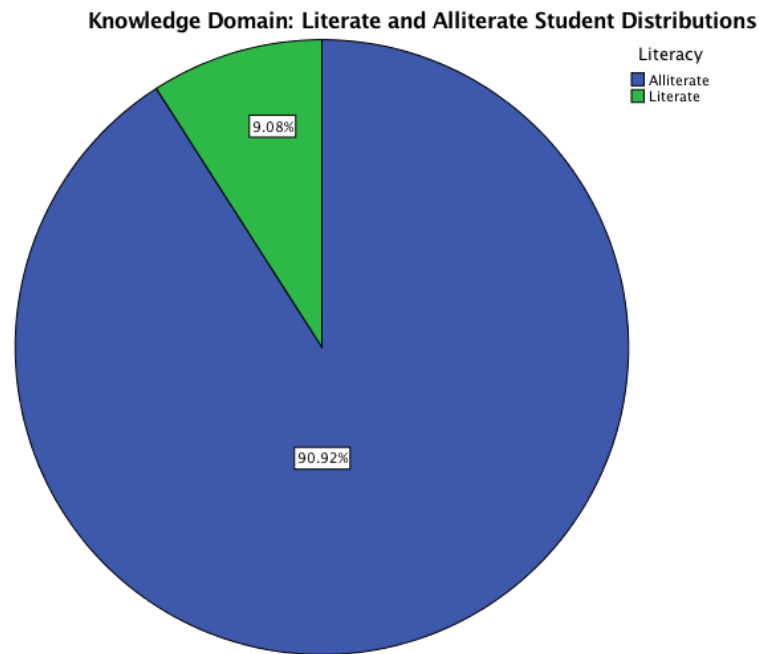


Figure 4. Knowledge domain: literate and alliterate student distributions.

Multiple participants who, when asked which is not an expected effect of climate change on the knowledge domain of the OELAT, indicated that they do not believe climate change exists by marking ostensibly on the assessment booklet.

*Overall Environmental Literacy.* Data from the attitude, behavior and knowledge domains were aggregated from the OELAT to analyze this section.

As shown in Figure 5, 2% of total participants were considered to have true environmental literacy. Comparison of the gender subdomain revealed 2% of females and

3% males exhibited true environmental literacy. In the grade level analysis 1% of freshman was literate, while 2% of sophomores, and 3% of juniors and seniors were literate. Finally, 1% of rural students, 3% of suburban students and 4% of urban students exhibited literacy.

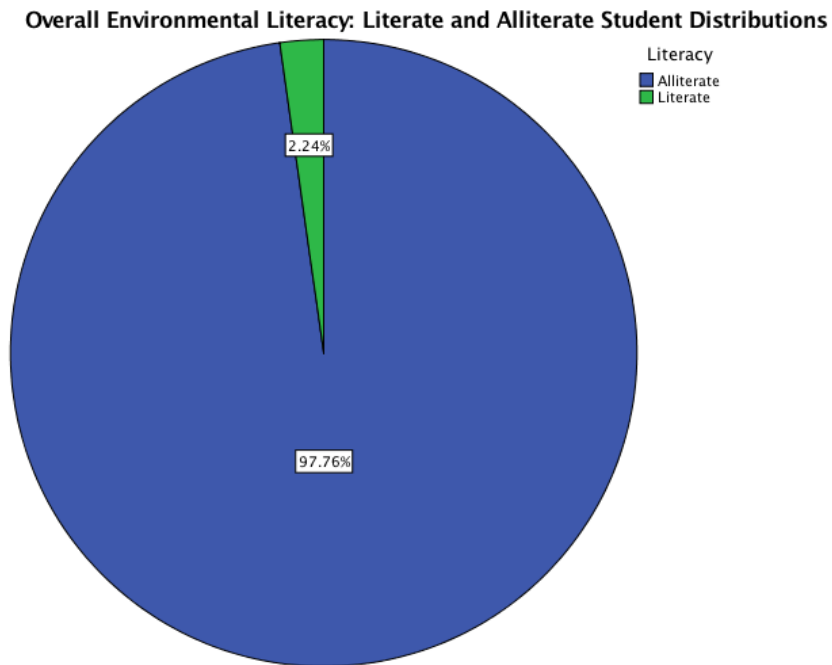


Figure 5. Overall environmental literacy: literate and alliterate student distributions.

## Question 2

Will there be a statistical difference in the subpopulations: (1) gender, (2) grade level, and (3) residence on the separate components of the environmental literacy assessment tool and overall environmental literacy?

A two-tailed t-test was used to analyze if there are significant differences between gender and environmental literacy, while, MANOVA and Tukey HSD were used to

identify significant differences between grade, residence and overall literacy. Data are reported in the form of descriptive statistics as summarized in Tables 8-10.

Table 8. Descriptive statistics by grade level.

|                                | Grade Level | Mean   | Std. Deviation | N   |
|--------------------------------|-------------|--------|----------------|-----|
| Attitude                       | Freshman    | 3.3226 | .42916         | 257 |
|                                | Sophomore   | 3.5670 | 1.87017        | 284 |
|                                | Junior      | 3.4399 | .45699         | 228 |
|                                | Senior      | 3.5118 | .53586         | 211 |
|                                | Total       | 3.4615 | 1.08543        | 980 |
| Behavior                       | Freshman    | 2.731  | .7323          | 257 |
|                                | Sophomore   | 2.689  | .6637          | 284 |
|                                | Junior      | 2.711  | .7727          | 228 |
|                                | Senior      | 2.949  | 1.5685         | 211 |
|                                | Total       | 2.761  | .9714          | 980 |
| Knowledge                      | Freshman    | 2.68   | 1.710          | 257 |
|                                | Sophomore   | 3.51   | 2.024          | 284 |
|                                | Junior      | 3.56   | 2.334          | 228 |
|                                | Senior      | 3.83   | 2.053          | 211 |
|                                | Total       | 3.37   | 2.074          | 980 |
| Overall Environmental Literacy | Freshman    | 2.8854 | .69877         | 257 |
|                                | Sophomore   | 3.2005 | .82138         | 284 |
|                                | Junior      | 3.2083 | .94233         | 228 |
|                                | Senior      | 3.3692 | .83327         | 211 |
|                                | Total       | 3.1560 | .84129         | 980 |

Table 9. Descriptive statistics by gender.

|                                | Gender | Mean   | Std. Deviation | N   |
|--------------------------------|--------|--------|----------------|-----|
| Attitude                       | Female | 3.5180 | 1.48823        | 466 |
|                                | Male   | 3.4100 | .48550         | 513 |
|                                | Total  | 3.4614 | 1.08599        | 979 |
| Behavior                       | Female | 2.830  | 1.1623         | 466 |
|                                | Male   | 2.700  | .7533          | 513 |
|                                | Total  | 2.762  | .9714          | 979 |
| Knowledge                      | Female | 3.18   | 2.062          | 466 |
|                                | Male   | 3.54   | 2.074          | 513 |
|                                | Total  | 3.37   | 2.075          | 979 |
| Overall Environmental Literacy | Female | 3.1170 | .83739         | 466 |
|                                | Male   | 3.1916 | .84488         | 513 |
|                                | Total  | 3.1561 | .84172         | 979 |

Table 10. Descriptive statistics by residence.

|                                | Residence | Mean   | Std. Deviation | N   |
|--------------------------------|-----------|--------|----------------|-----|
| Attitude                       | Rural     | 3.3953 | .45146         | 548 |
|                                | Suburban  | 3.5970 | 2.49178        | 157 |
|                                | Urban     | 3.5161 | .49625         | 274 |
|                                | Total     | 3.4614 | 1.08599        | 979 |
| Behavior                       | Rural     | 2.668  | .7095          | 548 |
|                                | Suburban  | 2.874  | .7644          | 157 |
|                                | Urban     | 2.887  | 1.4133         | 274 |
|                                | Total     | 2.762  | .9714          | 979 |
| Knowledge                      | Rural     | 3.11   | 2.072          | 548 |
|                                | Suburban  | 3.81   | 2.023          | 157 |
|                                | Urban     | 3.64   | 2.039          | 274 |
|                                | Total     | 3.37   | 2.075          | 979 |
| Overall Environmental Literacy | Rural     | 3.0349 | .81729         | 548 |
|                                | Suburban  | 3.3382 | .84766         | 157 |
|                                | Urban     | 3.2940 | .84941         | 274 |
|                                | Total     | 3.1561 | .84172         | 979 |

*Gender Analysis.* I did not find a significant difference between gender and overall scores ( $p=0.166$ ). However, during further analysis of the domains I did find a significant difference between gender and the behavior and knowledge domains. Analysis identified females exhibited higher positive environmental behaviors than males ( $p=0.036$ ), while males exhibited a higher environmental knowledge base ( $p=0.007$ ), thus the hypothesis was partially accepted. No significant difference was found in the environmental attitudes domain ( $p=0.120$ ). The p-values in Table 11 suggest the relationship between gender and environmental behaviors and knowledge is significant, and worth closer examination.

Table 11. Results of t-test gender comparisons of Oklahoma public high school students.

|                          |                                | Levene's Test<br>for Equality of<br>Variances |      | t-test for Equality of Means |         |                 | Mean<br>Difference | Std. Error<br>Difference | 95% Confidence Interval<br>of the Difference |        |
|--------------------------|--------------------------------|-----------------------------------------------|------|------------------------------|---------|-----------------|--------------------|--------------------------|----------------------------------------------|--------|
|                          |                                | F                                             | Sig. | t                            | df      | Sig. (2-tailed) |                    |                          | Lower                                        | Upper  |
| Std. Error<br>Attitude   | Equal variances<br>assumed     | .180                                          | .672 | .556                         | .10803  | .24984          | .10803             | .06945                   | -.02826                                      | .24431 |
|                          | Equal variances<br>not assumed |                                               |      | 1.496                        | .1301   | .2518           | .10803             | .07220                   | -.03379                                      | .24984 |
| Behavior                 | Equal variances<br>assumed     | .115                                          | .734 | 2.096                        | .1301   | .2543           | .1301              | .0621                    | .0083                                        | .2518  |
|                          | Equal variances<br>not assumed |                                               |      | 2.055                        | -.360   | -.100           | .1301              | .0633                    | .0058                                        | .2543  |
| Knowledge                | Equal variances<br>assumed     | .008                                          | .931 | -2.716                       | -.360   | -.100           | -.360              | .132                     | -.619                                        | -.100  |
|                          | Equal variances<br>not assumed |                                               |      | -2.717                       | -.07467 | .03099          | -.360              | .05384                   | -.619                                        | -.100  |
| Overall<br>Environmental | Equal variances<br>assumed     | .030                                          | .862 | -1.387                       | -.07467 | .03095          | -.07467            | .05382                   | -.18032                                      | .03099 |
| Literacy                 | Equal variances<br>not assumed |                                               |      | -1.387                       | 969.605 | .166            | -.07467            | .05382                   | -.18028                                      | .03095 |

*Grade Level Analysis.* In order to test for the significant difference in the environmental literacy scores of students in different grade levels a one-way MANOVA a statistically significant difference in environmental literacy based on grade level (Wilks'  $\lambda = .0944$ ,  $F(12, 2574.608) = 4.764$ ,  $p < .05$ , partial eta squared = .019) (Table 13).

Given the significance of the overall test, the univariate main effects were examined as shown in Table 14. Significant univariate main effects for grade level were obtained for behaviors ( $F(3, 976) = 3.474$ ,  $p < .05$ , partial eta square = .011, power = .778); knowledge ( $F(3, 976) = 14.711$ ,  $p < .05$ , partial eta square = .043, power = 1); and overall environmental literacy ( $F(3, 976) = 14.512$ ,  $p < .05$ , partial eta square = .043, power = 1). Significant regional pairwise differences were obtained in environmental literacy scores between the grade levels. The mean overall environmental literacy scores were 2.885 for freshman, 3.200 for sophomores, 3.208 for juniors and 3.369 for seniors.

Tukey HSD Multiple Comparisons were used to identify the statistical differences among the behaviors, knowledge and overall environmental literacy domains. Tables 15-17 show the hypothesis was partially supported in the grade level analysis. At the  $\alpha = .05$  level, there was a significant difference in behaviors, knowledge and overall environmental literacy, but not in the attitude domain. Seniors exhibited statistically significant positive behaviors toward the environment compared to sophomores and juniors, but there was not a statistical difference between the sophomores and juniors. Further, seniors exhibited statistically significant positive environmental knowledge compared to freshman, sophomores and juniors, but there was not a statistical difference between freshman, sophomores or juniors. Finally, sophomores, juniors and seniors exhibited positive overall environmental literacy scores over freshman.

Table 12. Result of MANOVA grade level comparisons of Oklahoma public high school students.

| Effect         |                       | Value       | F                      | Hypothesis<br>df | Error df        | Sig.        | Partial<br>Eta<br>Squared | Noncent.<br>Parameter | Observed<br>Power |
|----------------|-----------------------|-------------|------------------------|------------------|-----------------|-------------|---------------------------|-----------------------|-------------------|
| Intercept      | Pillai's Trace        | .978        | 10575.870 <sup>b</sup> | 4.000            | 973.000         | .000        | .978                      | 42303.481             | 1.000             |
|                | Wilks'                | .022        | 10575.870 <sup>b</sup> | 4.000            | 973.000         | .000        | .978                      | 42303.481             | 1.000             |
|                | Lambda                |             |                        |                  |                 |             |                           |                       |                   |
|                | Hotelling's<br>Trace  | 43.477      | 10575.870 <sup>b</sup> | 4.000            | 973.000         | .000        | .978                      | 42303.481             | 1.000             |
|                | Roy's Largest<br>Root | 43.477      | 10575.870 <sup>b</sup> | 4.000            | 973.000         | .000        | .978                      | 42303.481             | 1.000             |
| Grade<br>Level | Pillai's Trace        | .057        | 4.719                  | 12.000           | 2925.000        | .000        | .019                      | 56.632                | 1.000             |
|                | <b>Wilks'</b>         | <b>.944</b> | <b>4.764</b>           | <b>12.000</b>    | <b>2574.608</b> | <b>.000</b> | <b>.019</b>               | <b>50.352</b>         | <b>1.000</b>      |
|                | <b>Lambda</b>         |             |                        |                  |                 |             |                           |                       |                   |
|                | Hotelling's<br>Trace  | .059        | 4.799                  | 12.000           | 2915.000        | .000        | .019                      | 57.585                | 1.000             |
|                | Roy's Largest<br>Root | .048        | 11.675 <sup>c</sup>    | 4.000            | 975.000         | .000        | .046                      | 46.701                | 1.000             |

Table 13. Results from tests between subjects analysis of grade level comparatives.

| Source          | Dependent Variable             | Type III<br>Sum of<br>Squares | df  | Mean<br>Square | F         | Sig.        | Partial Eta<br>Squared | Noncent.<br>Parameter | Observed<br>Power |
|-----------------|--------------------------------|-------------------------------|-----|----------------|-----------|-------------|------------------------|-----------------------|-------------------|
| Corrected Model | Attitude                       | 8.763 <sup>a</sup>            | 3   | 2.921          | 2.491     | .059        | .008                   | 7.472                 | .619              |
|                 | Behavior                       | 9.760 <sup>b</sup>            | 3   | 3.253          | 3.474     | .016        | .011                   | 10.421                | .778              |
|                 | Knowledge                      | 182.166 <sup>c</sup>          | 3   | 60.722         | 14.711    | .000        | .043                   | 44.133                | 1.000             |
|                 | Overall Environmental Literacy | 29.589 <sup>d</sup>           | 3   | 9.863          | 14.512    | .000        | .043                   | 43.537                | 1.000             |
| Intercept       | Attitude                       | 11584.751                     | 1   | 11584.751      | 9877.795  | .000        | .910                   | 9877.795              | 1.000             |
|                 | Behavior                       | 7423.746                      | 1   | 7423.746       | 7926.556  | .000        | .890                   | 7926.556              | 1.000             |
|                 | Knowledge                      | 11143.582                     | 1   | 11143.582      | 2699.709  | .000        | .734                   | 2699.709              | 1.000             |
|                 | Overall Environmental Literacy | 9696.969                      | 1   | 9696.969       | 14268.061 | .000        | .936                   | 14268.061             | 1.000             |
| Grade Level     | Attitude                       | 8.763                         | 3   | 2.921          | 2.491     | .059        | .008                   | 7.472                 | .619              |
|                 | Behavior                       | 9.760                         | 3   | 3.253          | 3.474     | <b>.016</b> | .011                   | 10.421                | .778              |
|                 | Knowledge                      | 182.166                       | 3   | 60.722         | 14.711    | <b>.000</b> | .043                   | 44.133                | 1.000             |
|                 | Overall Environmental Literacy | 29.589                        | 3   | 9.863          | 14.512    | <b>.000</b> | .043                   | 43.537                | 1.000             |
| Error           | Attitude                       | 1144.660                      | 976 | 1.173          |           |             |                        |                       |                   |
|                 | Behavior                       | 914.089                       | 976 | .937           |           |             |                        |                       |                   |
|                 | Knowledge                      | 4028.634                      | 976 | 4.128          |           |             |                        |                       |                   |
|                 | Overall Environmental Literacy | 663.317                       | 976 | .680           |           |             |                        |                       |                   |
| Corrected Total | Attitude                       | 1153.423                      | 979 |                |           |             |                        |                       |                   |
|                 | Behavior                       | 923.849                       | 979 |                |           |             |                        |                       |                   |
|                 | Knowledge                      | 4210.800                      | 979 |                |           |             |                        |                       |                   |
|                 | Overall Environmental Literacy | 692.906                       | 979 |                |           |             |                        |                       |                   |

Table 14. Tukey HSD multiple comparisons of grade level and behavior.

|                    |                 |                 |                       |            |             | 95% Confidence Interval |             |
|--------------------|-----------------|-----------------|-----------------------|------------|-------------|-------------------------|-------------|
| Dependent Variable | (I) Grade Level | (J) Grade Level | Mean Difference (I-J) | Std. Error | Sig.        | Lower Bound             | Upper Bound |
| Behavior           | Freshman        | Sophomore       | .042                  | .0833      | .958        | -.172                   | .256        |
|                    |                 | Junior          | .019                  | .0880      | .996        | -.207                   | .246        |
|                    |                 | Senior          | -.219                 | .0899      | .072        | -.450                   | .013        |
|                    | Sophomore       | Freshman        | -.042                 | .0833      | .958        | -.256                   | .172        |
|                    |                 | Junior          | -.023                 | .0861      | .994        | -.244                   | .199        |
|                    |                 | Senior          | -.261*                | .0880      | <b>.016</b> | -.487                   | -.034       |
|                    | Junior          | Freshman        | -.019                 | .0880      | .996        | -.246                   | .207        |
|                    |                 | Sophomore       | .023                  | .0861      | .994        | -.199                   | .244        |
|                    |                 | Senior          | -.238                 | .0924      | <b>.050</b> | -.476                   | .000        |
|                    | Senior          | Freshman        | .219                  | .0899      | .072        | -.013                   | .450        |
|                    |                 | Sophomore       | .261*                 | .0880      | <b>.016</b> | .034                    | .487        |
|                    |                 | Junior          | .238                  | .0924      | <b>.050</b> | .000                    | .476        |

Table 15. Tukey HSD multiple comparisons of grade level and knowledge.

| Dependent Variable | (I) Grade Level | (J) Grade Level | Mean Difference    | Std. Error | Sig.        | 95% Confidence Interval |             |
|--------------------|-----------------|-----------------|--------------------|------------|-------------|-------------------------|-------------|
|                    |                 |                 |                    |            |             | Lower Bound             | Upper Bound |
| Knowledge          | Freshman        | Sophomore       | -.83 <sup>*</sup>  | .175       | <b>.000</b> | -1.28                   | -.38        |
|                    |                 | Junior          | -.88 <sup>*</sup>  | .185       | <b>.000</b> | -1.36                   | -.40        |
|                    |                 | Senior          | -1.16 <sup>*</sup> | .189       | <b>.000</b> | -1.64                   | -.67        |
|                    | Sophomore       | Freshman        | .83 <sup>*</sup>   | .175       | <b>.000</b> | .38                     | 1.28        |
|                    |                 | Junior          | -.05               | .181       | .993        | -.51                    | .41         |
|                    |                 | Senior          | -.33               | .185       | .288        | -.80                    | .15         |
|                    | Junior          | Freshman        | .88 <sup>*</sup>   | .185       | <b>.000</b> | .40                     | 1.36        |
|                    |                 | Sophomore       | .05                | .181       | .993        | -.41                    | .51         |
|                    |                 | Senior          | -.28               | .194       | .482        | -.78                    | .22         |
|                    | Senior          | Freshman        | 1.16 <sup>*</sup>  | .189       | <b>.000</b> | .67                     | 1.64        |
|                    |                 | Sophomore       | .33                | .185       | .288        | -.15                    | .80         |
|                    |                 | Junior          | .28                | .194       | .482        | -.22                    | .78         |

Table 16. Tukey HSD multiple comparisons of grade level and overall environmental literacy.

| Dependent Variable             | (I) Grade Level | (J) Grade Level | Mean Difference | Std. Error | Sig.        | 95% Confidence Interval |             |
|--------------------------------|-----------------|-----------------|-----------------|------------|-------------|-------------------------|-------------|
|                                |                 |                 |                 |            |             | Lower Bound             | Upper Bound |
| Overall Environmental Literacy | Freshman        | Sophomore       | -.3150*         | .07098     | <b>.000</b> | -.4977                  | -.1324      |
|                                |                 | Junior          | -.3229*         | .07500     | <b>.000</b> | -.5159                  | -.1299      |
|                                |                 | Senior          | -.4837*         | .07659     | <b>.000</b> | -.6808                  | -.2867      |
|                                | Sophomore       | Freshman        | .3150*          | .07098     | <b>.000</b> | .1324                   | .4977       |
|                                |                 | Junior          | -.0078          | .07331     | 1.000       | -.1965                  | .1808       |
|                                |                 | Senior          | -.1687          | .07493     | .110        | -.3615                  | .0241       |
|                                | Junior          | Freshman        | .3229*          | .07500     | <b>.000</b> | .1299                   | .5159       |
|                                |                 | Junior          | .0078           | .07331     | 1.000       | -.1808                  | .1965       |
|                                |                 | Senior          | -.1609          | .07875     | .173        | -.3635                  | .0418       |
|                                | Senior          | Freshman        | .4837*          | .07659     | <b>.000</b> | .2867                   | .6808       |
|                                |                 | Sophomore       | .1687           | .07493     | .110        | -.0241                  | .3615       |
|                                |                 | Junior          | .1609           | .07875     | .173        | -.0418                  | .3635       |

The differences identified in the Tukey HSD analysis are shown in Figures 6-9.

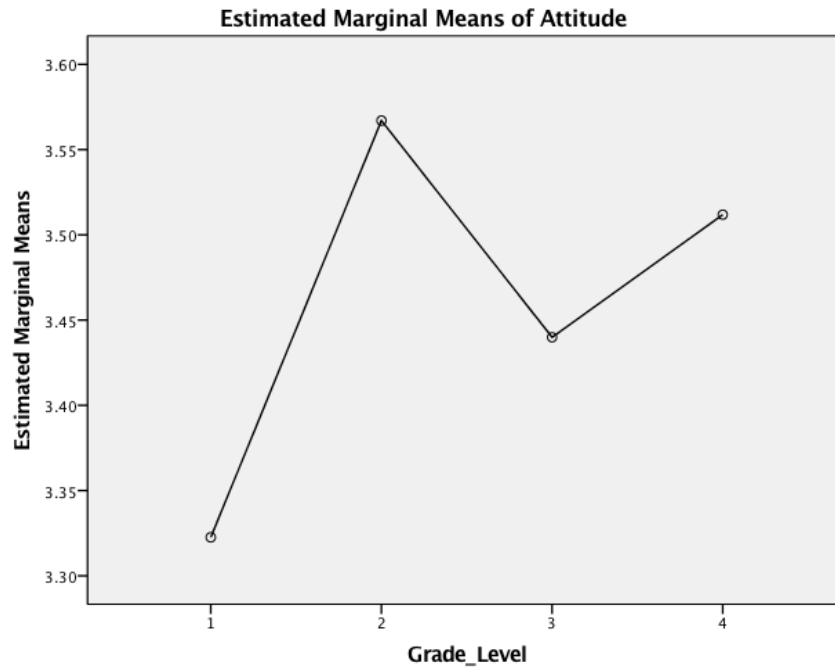


Figure 6. Estimated marginal means of attitude compared to grade level.

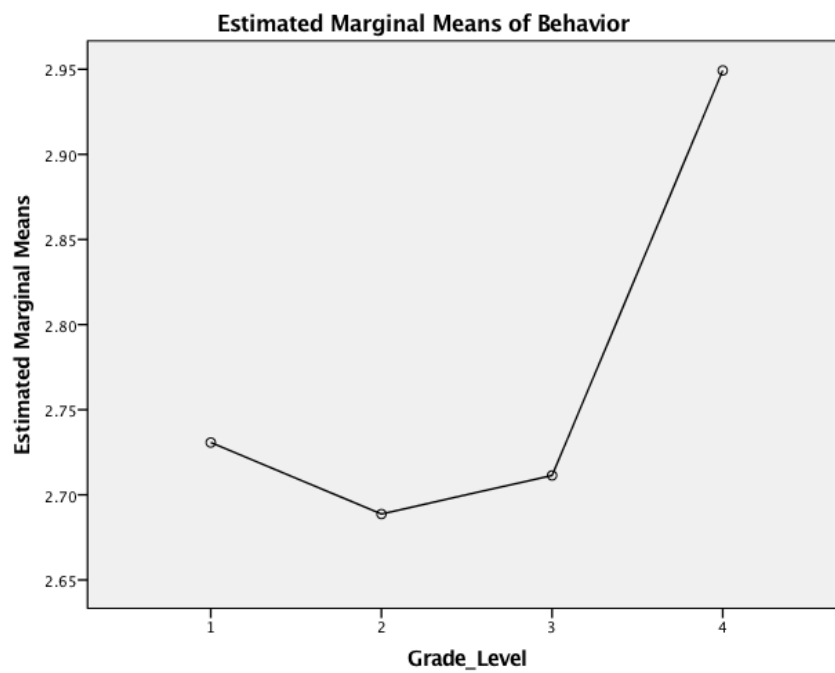


Figure 7. Estimated marginal means of behavior compared to grade level.

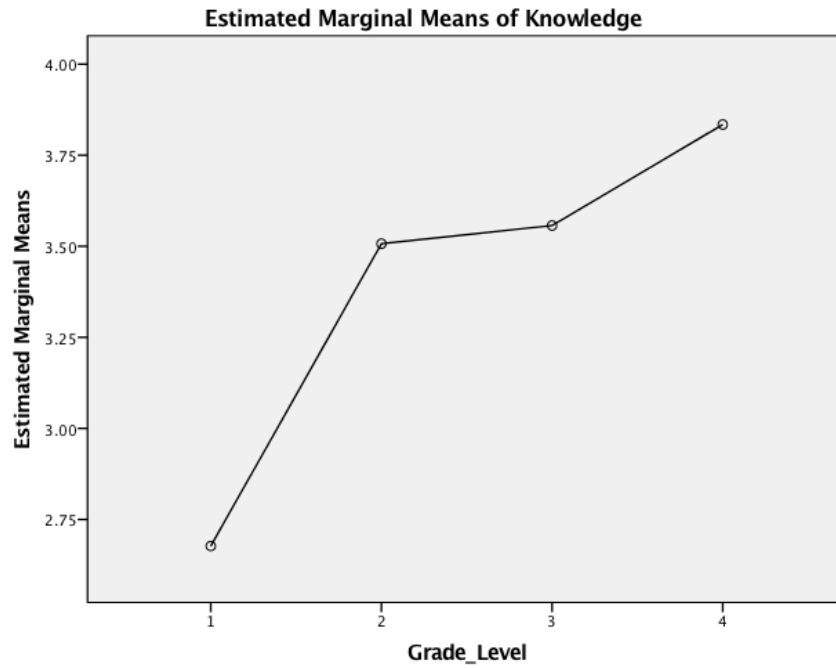


Figure 8. Estimated marginal means of knowledge compared to grade level.

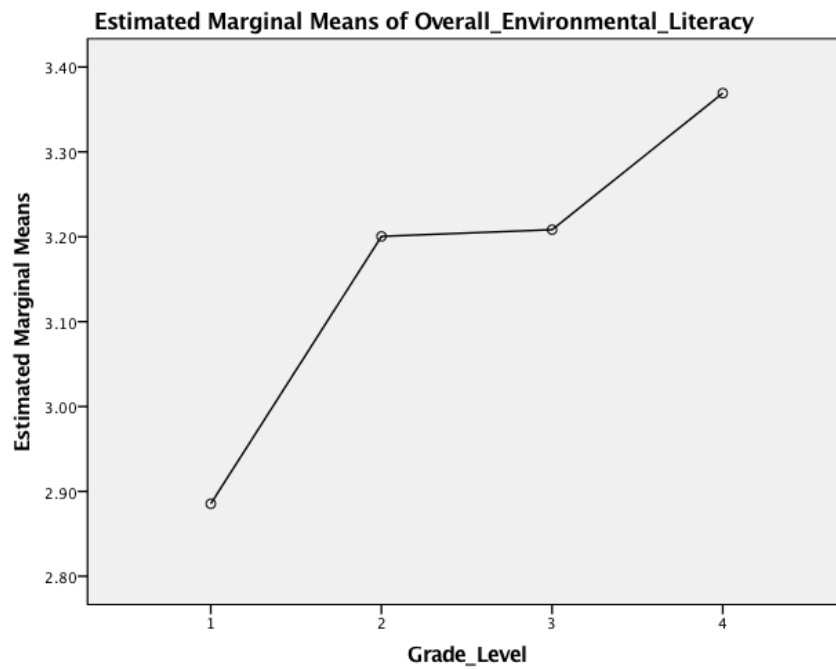


Figure 9. Estimated marginal means of overall environmental literacy compared to grade level.

*Residence Analysis.* A one-way MANOVA revealed there was a significant difference in environmental literacy based on residence in different parts of the state (Wilks'  $\lambda = .0967$ ,  $F(8, 1946.000) = 4.147$ ,  $p < .05$ , partial eta squared = .017) (Table 17).

The univariate main effects were examined given the significance of the overall test (Table 18). Significant univariate main effects for residence were obtained for behaviors ( $F(2, 976) = 5.946$ ,  $p < .05$ , partial eta square = .12, power = .778); knowledge ( $F(2, 976) = 10.388$ ,  $p < .05$ , partial eta square = .21, power = 1); and overall environmental literacy ( $F(2, 976) = 13.361$ ,  $p < .05$ , partial eta square = .27, power = 1).

Tukey HSD Multiple Comparisons were used to identify the statistical differences among the behaviors, knowledge and overall environmental literacy domains. Tables 19-22 revealed a significant difference in the behaviors, knowledge and overall environmental literacy scores between rural and suburban schools ( $p < 0.05$ ), and between rural and urban schools ( $p < 0.05$ ), but not between urban and suburban schools ( $p=0.990$ ), ( $p=0.697$ ), ( $p=0.856$ ), respectively, where urban and suburban schools exhibited higher scores than rural students. This result was counter to the hypothesis.

Table 17. Results of MANOVA residential comparisons of Oklahoma public high school students.

| Effect    |                      | Value       | F                        | Hypothesis<br>df | Error df        | Sig.        | Partial Eta<br>Squared | Noncent.<br>Parameter | Observed<br>Power |
|-----------|----------------------|-------------|--------------------------|------------------|-----------------|-------------|------------------------|-----------------------|-------------------|
| Intercept | Pillai's Trace       | .972        | 8435.667 <sup>b</sup>    | 4.000            | 973.000         | .000        | .972                   | 33742.669             | 1.000             |
|           | Wilks' Lambda        | .028        | 8435.667 <sup>b</sup>    | 4.000            | 973.000         | .000        | .972                   | 33742.669             | 1.000             |
|           | Hotelling's Trace    | 34.679      | 8435.667 <sup>b</sup>    | 4.000            | 973.000         | .000        | .972                   | 33742.669             | 1.000             |
|           | Roy's Largest Root   | 34.679      | 8435.667 <sup>b</sup>    | 4.000            | 973.000         | .000        | .972                   | 33742.669             | 1.000             |
| Residence | Pillai's Trace       | .033        | 4.122                    | 8.000            | 1948.000        | .000        | .017                   | 32.973                | .994              |
|           | <b>Wilks' Lambda</b> | <b>.967</b> | <b>4.147<sup>b</sup></b> | <b>8.000</b>     | <b>1946.000</b> | <b>.000</b> | <b>.017</b>            | <b>33.177</b>         | <b>.995</b>       |
|           | Hotelling's Trace    | .034        | 4.173                    | 8.000            | 1944.000        | .000        | .017                   | 33.381                | .995              |
|           | Roy's Largest Root   | .033        | 8.025 <sup>c</sup>       | 4.000            | 974.000         | .000        | .032                   | 32.101                | .998              |

Table 18. Results from tests between subjects analysis of residence comparisons.

| Source          | Dependent Variable             | Type III Sum<br>of Squares | df  | Mean<br>Square | F         | Sig.        | Partial<br>Eta<br>Squared | Noncent.<br>Parameter | Observed<br>Power |
|-----------------|--------------------------------|----------------------------|-----|----------------|-----------|-------------|---------------------------|-----------------------|-------------------|
| Corrected Model | Attitude                       | 6.103 <sup>a</sup>         | 2   | 3.052          | 2.596     | .075        | .005                      | 5.192                 | .518              |
|                 | Behavior                       | 11.110 <sup>b</sup>        | 2   | 5.555          | 5.946     | .003        | .012                      | 11.892                | .879              |
|                 | Knowledge                      | 87.757 <sup>c</sup>        | 2   | 43.879         | 10.388    | .000        | .021                      | 20.776                | .988              |
|                 | Overall Environmental Literacy | 18.465 <sup>d</sup>        | 2   | 9.232          | 13.361    | .000        | .027                      | 26.721                | .998              |
| Intercept       | Attitude                       | 9323.364                   | 1   | 9323.364       | 7931.192  | .000        | .890                      | 7931.192              | 1.000             |
|                 | Behavior                       | 5997.927                   | 1   | 5997.927       | 6420.144  | .000        | .868                      | 6420.144              | 1.000             |
|                 | Knowledge                      | 9416.617                   | 1   | 9416.617       | 2229.300  | .000        | .696                      | 2229.300              | 1.000             |
|                 | Overall Environmental Literacy | 7890.485                   | 1   | 7890.485       | 11418.570 | .000        | .921                      | 11418.570             | 1.000             |
| Residence       | Attitude                       | 6.103                      | 2   | 3.052          | 2.596     | .075        | .005                      | 5.192                 | .518              |
|                 | Behavior                       | 11.110                     | 2   | 5.555          | 5.946     | <b>.003</b> | .012                      | 11.892                | .879              |
|                 | Knowledge                      | 87.757                     | 2   | 43.879         | 10.388    | <b>.000</b> | .021                      | 20.776                | .988              |
|                 | Overall Environmental Literacy | 18.465                     | 2   | 9.232          | 13.361    | <b>.000</b> | .027                      | 26.721                | .998              |
| Error           | Attitude                       | 1147.318                   | 976 | 1.176          |           |             |                           |                       |                   |
|                 | Behavior                       | 911.814                    | 976 | .934           |           |             |                           |                       |                   |
|                 | Knowledge                      | 4122.647                   | 976 | 4.224          |           |             |                           |                       |                   |
|                 | Overall Environmental Literacy | 674.438                    | 976 | .691           |           |             |                           |                       |                   |
| Corrected Total | Attitude                       | 1153.422                   | 978 |                |           |             |                           |                       |                   |
|                 | Behavior                       | 922.924                    | 978 |                |           |             |                           |                       |                   |
|                 | Knowledge                      | 4210.404                   | 978 |                |           |             |                           |                       |                   |
|                 | Overall Environmental Literacy | 692.903                    | 978 |                |           |             |                           |                       |                   |

Table 19. Tukey HSD multiple comparisons of residence and attitude.

| Dependent Variable | (I) Residence | (J) Residence | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval |             |
|--------------------|---------------|---------------|-----------------------|------------|------|-------------------------|-------------|
|                    |               |               |                       |            |      | Lower Bound             | Upper Bound |
| Attitude           | Rural         | Suburban      | -.2018                | .09815     | .100 | -.4321                  | .0286       |
|                    |               | Urban         | -.1208                | .08022     | .289 | -.3091                  | .0675       |
|                    | Suburban      | Rural         | .2018                 | .09815     | .100 | -.0286                  | .4321       |
|                    |               | Urban         | .0809                 | .10853     | .736 | -.1738                  | .3357       |
|                    | Urban         | Rural         | .1208                 | .08022     | .289 | -.0675                  | .3091       |
|                    |               | Suburban      | -.0809                | .10853     | .736 | -.3357                  | .1738       |

Table 20. Tukey HSD multiple comparisons of residence and behavior.

| Dependent Variable | (I) Residence | (J) Residence | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval |             |
|--------------------|---------------|---------------|-----------------------|------------|------|-------------------------|-------------|
|                    |               |               |                       |            |      | Lower Bound             | Upper Bound |
| Behavior           | Rural         | Suburban      | -.206*                | .0875      | .049 | -.412                   | -.001       |
|                    |               | Urban         | -.219*                | .0715      | .006 | -.387                   | -.051       |
|                    | Suburban      | Rural         | .206*                 | .0875      | .049 | .001                    | .412        |
|                    |               | Urban         | -.013                 | .0967      | .990 | -.240                   | .214        |
|                    | Urban         | Rural         | .219*                 | .0715      | .006 | .051                    | .387        |
|                    |               | Suburban      | .013                  | .0967      | .990 | -.214                   | .240        |

Table 21. Tukey HSD multiple comparisons of residence and knowledge.

| Dependent Variable | (I) Residence | (J) Residence | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval |             |
|--------------------|---------------|---------------|-----------------------|------------|------|-------------------------|-------------|
|                    |               |               |                       |            |      | Lower Bound             | Upper Bound |
| Knowledge          | Rural         | Suburban      | -.70 <sup>*</sup>     | .186       | .001 | -1.14                   | -.26        |
|                    |               | Urban         | -.53 <sup>*</sup>     | .152       | .001 | -.89                    | -.18        |
|                    | Suburban      | Rural         | .70 <sup>*</sup>      | .186       | .001 | .26                     | 1.14        |
|                    |               | Urban         | .17                   | .206       | .697 | -.32                    | .65         |
|                    | Urban         | Rural         | .53 <sup>*</sup>      | .152       | .001 | .18                     | .89         |
|                    |               | Suburban      | -.17                  | .206       | .697 | -.65                    | .32         |

Table 22. Tukey HSD multiple comparisons of residence and overall environmental literacy.

| Dependent Variable             | (I) Residence | (J) Residence | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval |             |
|--------------------------------|---------------|---------------|-----------------------|------------|------|-------------------------|-------------|
|                                |               |               |                       |            |      | Lower Bound             | Upper Bound |
| Overall Environmental Literacy | Rural         | Suburban      | -.3033 <sup>*</sup>   | .07525     | .000 | -.4799                  | -.1267      |
|                                |               | Urban         | -.2591 <sup>*</sup>   | .06151     | .000 | -.4035                  | -.1147      |
|                                | Suburban      | Rural         | .3033 <sup>*</sup>    | .07525     | .000 | .1267                   | .4799       |
|                                |               | Urban         | .0442                 | .08321     | .856 | -.1511                  | .2395       |
|                                | Urban         | Rural         | .2591 <sup>*</sup>    | .06151     | .000 | .1147                   | .4035       |
|                                |               | Suburban      | -.042                 | .08321     | .856 | -.2395                  | .1511       |

These differences can be visualized in the graphs below (Figures 10-13).

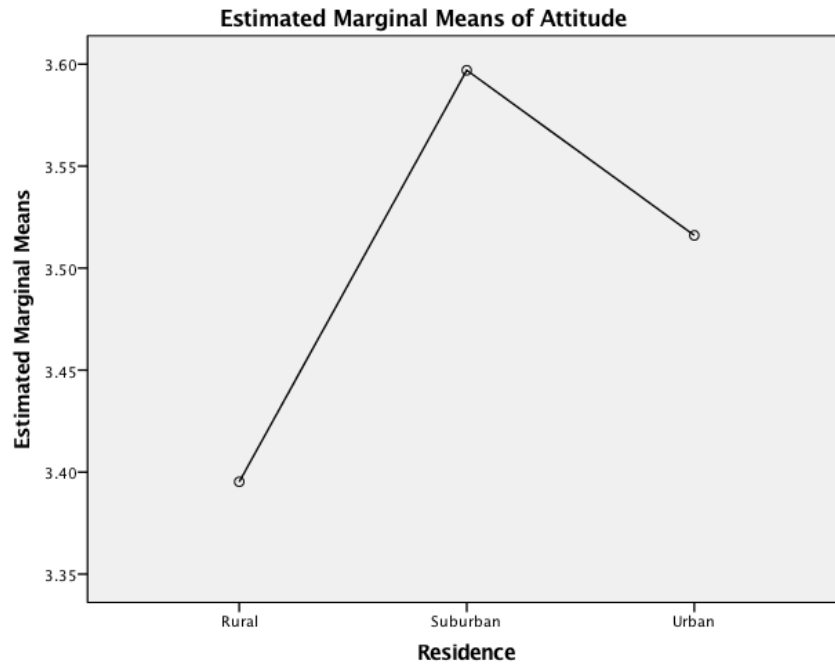


Figure 10. Estimated marginal means of attitude compared to residence.

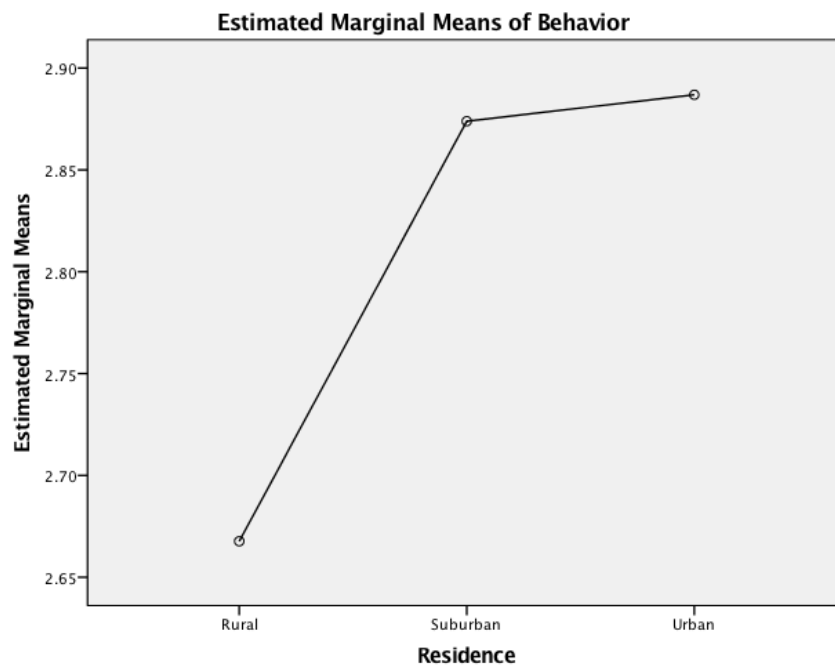


Figure 11. Estimated marginal means of behavior compared to residence.

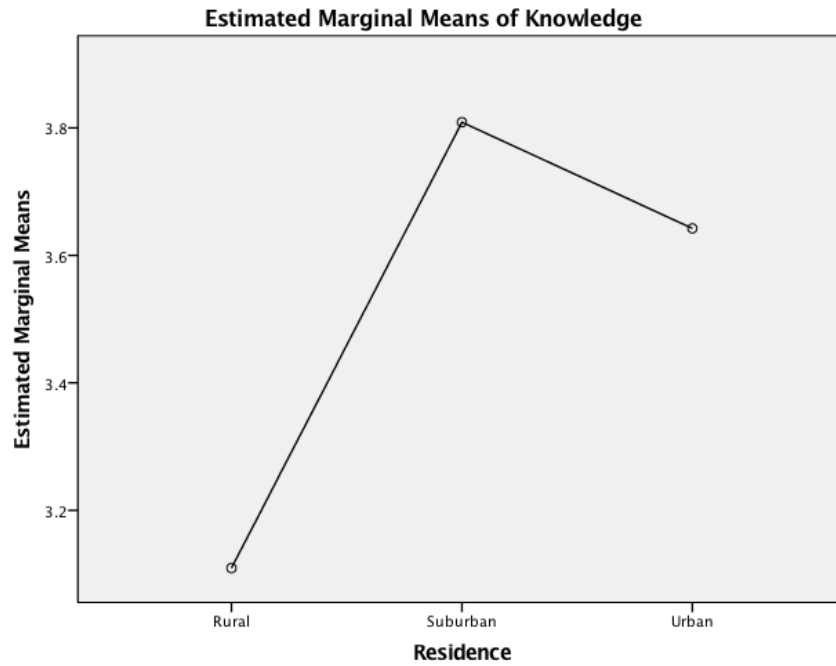


Figure 12. Estimated marginal means of knowledge compared to residence.

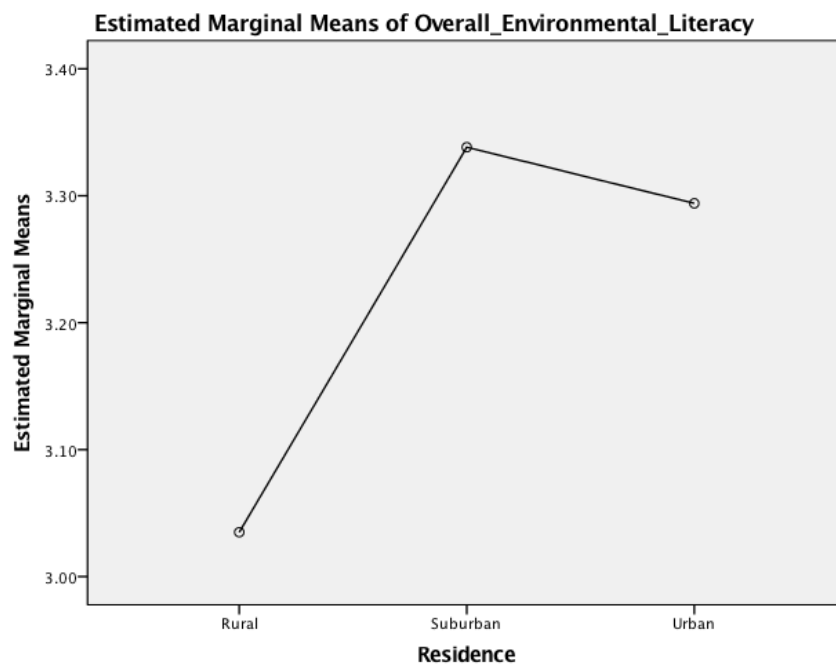


Figure 13. Estimated marginal means of overall environmental literacy compared to residence.

### Question 3

What will be the extent of the relationship of an individual's score on the environmental literacy assessment tool and their participation in elective courses?

Due to the size of the data the descriptive statistics of the elective course participation compared to student attitudes, behaviors, knowledge and overall environmental literacy may be found in Ancillary Appendix 2. The results of the MANOVA (Table 23) revealed there was not a statistically significant difference in environmental literacy based on participation in elective courses (Wilks'  $\lambda = .0609$ ,  $F(448, 3453.352) = 1.018$ ,  $p = 0.391$ , partial eta squared = .117), thus the hypothesis was rejected.

Table 23. Results of MANOVA elective course participation comparisons of Oklahoma public high school students.

| Effect    |                      | Value       | F                     | Hypothesis df  | Error df        | Sig.        | Partial Eta Squared | Noncent. Parameter | Observed Power |
|-----------|----------------------|-------------|-----------------------|----------------|-----------------|-------------|---------------------|--------------------|----------------|
| Intercept | Pillai's Trace       | .940        | 3362.075 <sup>b</sup> | 4.000          | 863.000         | .000        | .940                | 13448.298          | 1.000          |
|           | Wilks' Lambda        | .060        | 3362.075 <sup>b</sup> | 4.000          | 863.000         | .000        | .940                | 13448.298          | 1.000          |
|           | Hotelling's Trace    | 15.583      | 3362.075 <sup>b</sup> | 4.000          | 863.000         | .000        | .940                | 13448.298          | 1.000          |
|           | Roy's Largest Root   | 15.583      | 3362.075 <sup>b</sup> | 4.000          | 863.000         | .000        | .940                | 13448.298          | 1.000          |
| Electives | Pillai's Trace       | .456        | .995                  | 448.000        | 3464.000        | .522        | .114                | 445.704            | 1.000          |
|           | <b>Wilks' Lambda</b> | <b>.609</b> | <b>1.018</b>          | <b>448.000</b> | <b>3453.352</b> | <b>.391</b> | <b>.117</b>         | <b>456.054</b>     | <b>1.000</b>   |
|           | Hotelling's Trace    | .542        | 1.043                 | 448.000        | 3446.000        | .271        | .119                | 467.168            | 1.000          |
|           | Roy's Largest Root   | .278        | 2.153 <sup>c</sup>    | 112.000        | 866.000         | .000        | .218                | 241.140            | 1.000          |

## Chapter IV

### Discussion

The purpose of this study was to get a descriptive view of the environmental literacy of students in grades 9 through 12 in Oklahoma public schools. While some of my hypotheses were partially confirmed, others were not, although the results revealed many statistically significant differences. Nevertheless, the data provided an opportunity to better understand the strengths and weaknesses of the student's environmental attitudes, behaviors, knowledge and overall literacy, and established a baseline for which future assessments may be compared. This chapter uses the findings to draw conclusions, discuss implications, recommend practices to school districts and finally recommends further research opportunities.

#### Conclusions by Research Question

Let us look at the findings for each of the three research questions.

##### Research Question I

Here I attempted to determine the extent of environmental literacy and the relationship of an individual's score on the separate components of the OELAT. The results revealed nominal levels of environmental literacy in students, as only 2% of the total participants were considered to have true overall environmental literacy. Analysis of the attitude domain revealed a 16% pass rate, while the knowledge domain had a 9% pass rate and the behavior domain had a 4% pass rate.

In order to begin to improve overall environmental literacy, it is first necessary to observe what is happening within specific domains. It appears anti-environmental conservative beliefs are deeply rooted in the Oklahoma culture and the rejection of scientific principles by leaders in the community affect both knowledge and attitude domains. Who can blame the students that specifically wrote on their test booklets climate change does not exist? As certain political leaders in Oklahoma claim climate change is a “hoax,” and to prove such brought a snowball onto the Senate floor less than two years ago. The Yale Project on Climate Change Communication (2014) estimates the percentage of climate change skeptics in Oklahoma (24%) is greater than the aggregate United States (19%). Further, a science teacher from a small rural community that is economically supported by wind turbines rebuked me on an administration day stating, “I am not an environmentalist. I believe in fracking.” These were the only words the teacher spoke throughout the administration event. This encounter, although not a part of the research, was very important to understanding the necessity of teacher in-service and sensitivity training to aid in the development of an anti-bias classroom.

Certain participant behaviors were found to correlate to their residence, while others we hypothesize are from using different areas of the brain. For example, the disparity found in recycling habits between rural and urban/suburban communities is likely a deficiency in the solid waste management programs in rural communities. Most residents in rural communities do not have access to curbside recycling at home, work or school, and drop-off sites can be over an hour away in some areas of the state. On the other hand, most likely the students who reported always turning off lights and appliances (35%) were using a part of the brain called the basal ganglia, which is where our habit-

making behaviors can be traced. It is also likely this type of habit was formed at an early age. However, the students who reported always consciously trying to conserve energy (7%) are most likely using the prefrontal cortex or decision-making portion of the brain. Despite the low level of conscious environmentally responsible behaviors there is evidence of much higher habitual behaviors, therefore, it is possible greatly improve the behavior domain by training students starting at a young age.

## Research Question II

The study attempted to analyze the differences among the student's demographic information compared to the environmental literacy domains.

My hypothesis was partially supported in the gender analysis. Using a two-tailed t-test, females exhibited significantly higher behavior scores than males ( $p = 0.036$ ), and males exhibited significantly higher knowledge scores than females ( $p = 0.007$ ). A significant difference was not found in overall environmental literacy or in the attitude domain.

The grade level analysis determined my hypothesis was partially supported. Significant differences ( $p < 0.05$ ) were found in student behaviors, knowledge and overall environmental literacy, but not in attitudes. Seniors exhibited significant positive behaviors toward the environment compared to sophomores and juniors. Further, seniors obtained significantly higher knowledge scores compared to freshman, sophomores and juniors. Finally, sophomores, juniors and seniors exhibited positive overall environmental literacy scores over freshman.

Interestingly, if a line of best fit was drawn on the estimated marginal means graphs (Figures 6-9), it can be inferred that student's environmental literacy increased with increasing grade levels. Suggesting that as students mature and acquire additional knowledge they become more literate.

The residential analysis revealed there was a significant difference in the behaviors, knowledge and overall environmental literacy scores between rural and suburban schools ( $p < 0.05$ ), and between rural and urban schools ( $p < 0.05$ ), but not between urban and suburban schools ( $p=0.99$ ), ( $p=0.70$ ), ( $p=0.86$ ), respectively. Contradictory to the hypothesis urban and suburban schools exhibited higher scores than rural students.

A plausible explanation for this result is likely due to the greater academic opportunities students have in larger suburban and urban schools. Bigger budgets and higher student populations allow schools to adequately fund their science programs and incorporate advanced placement and stand-alone courses into the curricula. Larger schools are also able to support a greater variety of academic clubs and field trips easier than small rural schools.

### Research Question III

Counter to the hypothesis there were no differences in composite environmental literacy scores compared to elective course participation ( $p=0.39$ ). This may be due to the large number of elective categories that were ultimately sampled in the study. Though many of the groups did exhibit differences within the domains of environmental literacy, the differences were very small and were not sufficient to indicate a true difference.

Further research is needed to test whether there is a difference among individual elective categories in a more controlled environment with less unexplained variables.

### Implications and Recommendations for Educational Institutions

Preparing Oklahoma students to understand and participate in managing the complex relationships impacting our communities is critical to continuing our heritage and sustaining our rich natural resources for future generations. Education for environmental literacy and sustainability in pre-kindergarten through twelfth grade schools provides a foundation where young people acquire the critical thinking and problem solving skills they will need to be successful in this changing world. Efforts from both state and local levels are needed to advance the education for environmental literacy in Oklahoma's educational institutions.

At a state level, the primary goal should be to develop a statewide environmental literacy plan with the goal of advancing the environment literacy of students. The implementation of a state plan would allow for a more coordinated and collaborative approach to education for environmental literacy in Oklahoma public schools and can help districts save money, prepare students with the skills and experiences they will need to be successful, and provide consistency, accuracy and excellence in environmental curricula. No longer would teachers be left to their own time, money and resources to do a job that rightfully belongs to the state. The plan would provide a framework to support local school districts with the integration of environmental education and environmental literacy into a required curriculum as well as provide support to schools and teachers. The plan should include a means to fund environmental education efforts and assist schools

with locating, writing and applying for grant opportunities. It is essential the plan act as a living document which provides up-to-date resources and tools available for school districts to help implement local environmental programs. Finally, the plan must include a means to assess programs and establish benchmark standards.

In coordination with a state environmental literacy plan, it is essential an environmental education component be added to the required curriculum standards for all Oklahoma public schools at all grade levels. A statewide requirement is necessary because a low level of environmental education inherently results in a low level of public understanding and support for environmental policies. The requirement will serve to greatly increase student's knowledge and overall environmental literacy, and will allow students to become informed citizens capable of making informed decisions about environmental concerns. The curriculum included in this requirement should place a focus on the understanding of environmental systems and earth processes, human impact on the environment, and connecting sound scientific understanding to environmental policies. It should ensure students have a background in life, physical and social science; have out of classroom experiences to provide students opportunities to engage in projects and research; and finally strive to develop stewards of the environment.

At a local level, it is recommended all school districts establish a two-tiered environmental program. Aid from the state environmental literacy plan and appropriate funding will help ensure the success of the program.

Tier One seeks to design a curriculum with the goal of improving environmental literacy in students. At a minimum each school should have a science lab and access to an outdoor classroom to enhance student learning in environmental education. Ideally, the

environmental program would include offering courses devoted solely to the study of environmental science such as AP environmental science, and offer student-led programs proven to enhance environmental literacy including: a formal recycling program, environmental club and/or gardening club.

The goal of Tier Two would be to initiate a “green” school movement. The large amounts of energy, paper, food, water, and cleaning products that are consumed, and the waste, pollution and greenhouse gas emissions that originate from schools annually may be alleviated through green school initiatives, ultimately saving the district money. Schools have the potential to use resources more efficiently and can become producers of their own power through collaboration and grant opportunities. The most important reason to become a green school is so that the school itself can act as a teaching tool and serve as a model of environmental sustainability for the community.

Finally, it is recommended that each school hold in-service training for all teachers over environmental education curriculum. Training should include experience with using facilities and materials so that the teacher will gain skills with various tools and teaching methods. The training should be provided locally as part of the teachers’ staff development time. Sensitivity training and perception of relevance should be taken into account during teacher education programs; therefore, a local teacher who has had success integrating environmental education into his or her classroom, or a teacher who is excited about the anticipated environmental program will have more success during the training than an outside consultant. Finally, the training should provide a framework for addressing the pedagogies for teaching environmental dilemmas in an interdisciplinary classroom.

### Further Research

This study showed that the environmental literacy of Oklahoma public high school students is nominal. Additional research is needed to validate the findings of this study. It is recommended that future research efforts further separate the curricula choices of students. For example, it would be interesting to study whether there are correlations between AP science courses and environmental literacy. A study in Oklahoma public schools with established AP environmental science programs already in place, such as at Norman High School or Moore High School, would be good candidates for this type of study.

Although this study focused on comparing the types of electives, it may be advisable to develop a qualitative follow-up study to evaluate the top performing schools in this study to find out why and how their students performed so well on the environmental literacy survey. This should include interviews with the participating principals, teachers and students involved.

Comprehensive environmental literacy assessments are needed throughout the state to improve the understanding and status of environmental literacy. Perhaps beginning with a comparison of schools with environmental programs and interdisciplinary environmental efforts may provide additional data from which to develop improved environmental education curricula and programs.

Further research might alleviate the following major limitations of this study:

1. The data collected by the survey instrument is self-reported and not from direct observations.

2. The survey instrument only assesses the attitudes, behaviors and knowledge of students and does not identify student cognitive skills.
3. The research does not determine if significant life experiences of individual students affect the outcomes of the study.

## Appendix 1

### OELAT

#### Environmental Survey

This is a quick survey that could help us understand the levels of Environmental Literacy in Oklahoma high schools. We are measuring students' attitudes, behaviors and knowledge about the environment. This survey will not take more than 20 minutes to complete. Please, take your time to answer each question as best as you can. If you wish to opt out of the survey, please leave this section blank. As an alternative you may read "Easy Ways You Can Go Green," or quietly sit at your desk until the survey administration is complete.

#### Section 1: Student Information

1. What is your gender?  
☐ Male  
☐ Female
2. What is your current grade level?  
☐ Freshman  
☐ Sophomore  
☐ Junior  
☐ Senior
3. Please identify what categories of elective courses you have been or are actively involved in at school.  
☐ Arts based courses  
☐ Business and Computer Science courses  
☐ Cultural and Foreign Language courses  
☐ Language and Writing courses  
☐ Physical Education courses  
☐ Science and Math based courses  
☐ Vocational Education courses

#### Section 2: Student Attitudes

Please indicate how you feel about each statement below. There are no right or wrong answers. Read each statement carefully. Mark your answer in the space that best indicates the extent to which you agree or disagree with each statement.

| Question                                                                                              | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|-------------------------------------------------------------------------------------------------------|-------------------|----------|---------|-------|----------------|
| 4. If things continue on their present course we will soon experience a major ecological catastrophe. |                   |          |         |       |                |
| 5. We are approaching the limit of the number of people that the earth can support.                   |                   |          |         |       |                |
| 6. The earth has plenty of natural resources if we just learn how to develop them.                    |                   |          |         |       |                |
| 7. Despite our special abilities humans are still subject to the laws of nature.                      |                   |          |         |       |                |
| 8. Humans will eventually learn enough about nature to be able to control it.                         |                   |          |         |       |                |
| 9. The so-called ecological crisis facing humankind has been greatly exaggerated.                     |                   |          |         |       |                |

### Section 3: Student Behaviors

On a scale of 1 - 5 with 5 being the most often, how often do you complete each statement below. There are no right or wrong answers. Read each statement carefully. Mark your answer in the space that best indicates the extent to which you agree with each statement.

| Question                                                                                                  | 1 | 2 | 3 | 4 | 5 |
|-----------------------------------------------------------------------------------------------------------|---|---|---|---|---|
| 10. How often do you recycle?                                                                             |   |   |   |   |   |
| 11. How often do you pick up litter when you see it on the ground?                                        |   |   |   |   |   |
| 12. How often do you consciously try to conserve energy?                                                  |   |   |   |   |   |
| 13. How often do you turn off lights and appliances when they are not being used to conserve electricity? |   |   |   |   |   |
| 14. How often do you talk about the environment or environmental problems?                                |   |   |   |   |   |

### Section 4: Student Environmental Knowledge

For each of the following questions, circle the correct answer.

15. Approximately what percent of the earth's water is available as fresh drinking water?
  - a. more than 90%
  - b. around 45%
  - c. around 20%
  - d. less than 3%
  - e. do not know
16. Which of these is NOT an expected effect of climate change?
  - a. sea levels rising
  - b. flooding in coastal cities
  - c. expanding glaciers
  - d. extreme weather
  - e. do not know
17. The MOST influential reason for a decrease in biodiversity is...
  - a. habitat pollution
  - b. introduction of exotic species
  - c. over-exploitation
  - d. habitat destruction
  - e. do not know
18. The United States consumes most of its oil for:
  - a. transportation
  - b. electricity generation
  - c. home heating
  - d. industrial uses
  - e. do not know

19. Which is the MOST common contamination source for freshwater resources?
- agricultural runoff
  - digging wells
  - factory effluent
  - acid rain
  - do not know
20. Sustainable agriculture aims to...
- produce enough food to sustain human society
  - meet the demand for food at any costs
  - produce enough food while maintaining stable economic costs
  - produce enough food while maintaining a stable environment
  - meet the requirement for food while maintaining a healthy social, economic, and ecological environment
  - do not know
21. In some regions, the combination of acid rain and smog causes damage to forests that is worse than the impact of either acid rain or smog on its own. This is an example of
- specificity
  - acute toxicity
  - chronic toxicity
  - synergistic action
  - do not know
22. There are many waste-reducing practices, which are being suggested to lower the impact we are making in our environment. The most effective practice is....
- reusing
  - reducing
  - reclaiming
  - recycling
  - do not know
23. In the United States, the largest single component of municipal solid waste is
- glass
  - paper
  - food scraps
  - wood and other construction debris
  - plastic
  - do not know
24. The carrying capacity of a population is determined by its
- population growth rate
  - natality
  - mortality
  - limiting factors
  - do not know
25. Which is a farming technique that could improve the soil and the environment?
- using fueled machines that will turn the soil continuously
  - creating undisturbed layers of mulch in the soil
  - placing inorganic chemical fertilizers in the soil
  - irrigating the soil with salty water
  - do not know

## Appendix 2

### OELAT Scoring Justification

Table 24. Environmental literacy threshold scores.

| Domain                                | Score         |
|---------------------------------------|---------------|
| <b>Attitude Domain</b>                |               |
| Alliterate                            | Mean of 1-3.9 |
| Literate                              | Mean of 4-5   |
| <b>Behavior Domain</b>                |               |
| Alliterate                            | Mean of 1-3.9 |
| Literate                              | Mean of 4-5   |
| <b>Knowledge Domain</b>               |               |
| Alliterate                            | Mean of 0-6   |
| Literate                              | Mean of 7-10  |
| <b>Overall Environmental Literacy</b> |               |
| Alliterate                            | Mean of 1-4.9 |
| Literate                              | Mean of 5-6.8 |

Table 25. Attitude domain scoring justification.

| <b>Likert Scale</b> | <b>Description</b> | <b>Score</b> | <b>Justification</b>                                                                                                 |
|---------------------|--------------------|--------------|----------------------------------------------------------------------------------------------------------------------|
| 1                   | Strongly Disagree  | 1            | The student does not care and is considered alliterate.                                                              |
| 2                   | Disagree           | 2            | The student does not care, but does not disagree passionately.                                                       |
| 3                   | Neutral            | 3            | The student does not have an opinion, which does not constitute a minimum score necessary to be considered literate. |
| 4                   | Agree              | 4            | The student agrees, but not passionately, which indicates that the student meets standard environmental literacy.    |
| 5                   | Strongly Agree     | 5            | The student cares passionately.                                                                                      |

Table 26. Behavior domain scoring justification.

| <b>Likert Scale</b> | <b>Description</b> | <b>Score</b> | <b>Justification</b>                                                                                       |
|---------------------|--------------------|--------------|------------------------------------------------------------------------------------------------------------|
| 1                   | 1                  | 1            | The student takes no action and is considered alliterate.                                                  |
| 2                   | 2                  | 2            | The student takes very little action, which does not constitute a minimum score to be considered literate. |
| 3                   | 3                  | 3            | The student takes some action, which does not constitute a minimum score to be considered literate.        |
| 4                   | 4                  | 4            | The student takes action, which places him or her at the top threshold of standard environmental literacy. |
| 5                   | 5                  | 5            | The student exhibits exemplary action and has a high level of literacy.                                    |

Table 27. Knowledge domain scoring justification.

| <b>Number Correct</b> | <b>Score</b> | <b>Justification</b>                                                                                                                                                 |
|-----------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0-6                   | 0-6          | The student correctly answered only the most basic questions. The student is considered alliterate.                                                                  |
| 7                     | 7            | The student incorrectly answered some of the questions. The student is placed at the minimum level of knowledge necessary to be considered environmentally literate. |
| 8                     | 8            | The student answered most the questions correctly. The student is placed at the maximum level of knowledge necessary to meet the standard level.                     |
| 9-10                  | 9-10         | The student answered all questions correctly or answered one incorrectly. The student has a high level of environmental literacy.                                    |

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## Ancillary Appendix 1

### Additional Survey Materials

#### Opt-Out Literature

##### **Easy Ways You Can Go Green**

Elizabeth Hoyt

Here are 12 easy ways you can live greener while you're a student:

##### **1. Adopt Reusable Bag Practices**

Take reusable bags to the store with you to grocery shop instead of opting for paper or plastic. It's wasteful and unnecessary – and several bags with every grocery trip can add up to a whole lot of garbage over a lifetime.

##### **2. Nix Bottled Water**

Reuse old water bottles or purchase water bottles that you can refill instead of tossing out a new bottle every time you need to quench your thirst.

According to The Water Project, it's estimated that up to 80 percent of water bottles in the United States never get recycled. In addition, it takes three times the amount of water that's in a water bottle to create the bottle in the first place!

The Water Project also notes that, "U.S. landfills are overflowing with 2 million tons of discarded water bottles alone."

So getting a BPA-free water bottle shows the earth – and your wallet – love.

##### **3. Recycle**

By now, this should be a no-brainer. When you're able, recycle. Whether it's paper products, plastics or recycling old items, it's important to think about which trash can be saved from a landfill.

##### **4. Power Down**

When you're not using appliances or you're not in a room, turn off lights and other electronics. An easy way to implement this is by connecting your electronics to a surge protector and flipping the switch when you leave the room. Bonus: your electric bill will thank you!

##### **5. Buy Less or Borrow**

Only buy what you actually need. In a consumer culture, it's easy to fall into overbuying habits. If you only purchase what's necessary, you'll not only be going green but saving green as well.

If you have the option, borrow items instead of buying them. There are plenty of items available for rent, like DVDs, which can reduce waste. In addition, you can download music and movies electronically instead of purchasing hard copies.

##### **6. Walk or Bike More**

In addition to helping you live a healthier lifestyle, trying to cut down on driving can help the environment and save you a lot of gas money as well.

##### **7. Use Energy Efficient Light Bulbs**

Try to switch your bulbs to energy-efficient compact fluorescent (CFLs) or LED bulbs. Though they may be a little more expensive, it's worth it because they can last up to five times longer than regular light bulbs and are very bright so you won't need to turn on as many lights.

## 8. Save Energy

Set your thermostats a few degrees lower or your air conditioner a few degrees higher. You probably won't notice much of a difference, but the environment will!

## 9. Decrease Meat Consumption

Raising livestock produces large amounts of greenhouse gases into the environment. According to a United Nations report, "cattle-rearing generates more global warming greenhouse gases, as measured in CO<sub>2</sub> equivalent, than transportation, and smarter production methods, including improved animal diets to reduce enteric fermentation and consequent methane emissions, are urgently needed." Additionally, "when emissions from land use and land use change are included, the livestock sector accounts for 9 per cent of CO<sub>2</sub> deriving from human-related activities, but produces a much larger share of even more harmful greenhouse gases. It generates 65 per cent of human-related nitrous oxide, which has 296 times the Global Warming Potential (GWP) of CO<sub>2</sub>." Eating less meat – even omitting it from a meal one day a week – can positively influence change. When you do eat meat, look for labels that specify free range, organic and hormone and antibiotic free. There are resources to help you find sustainable food locally so you know exactly where your food is coming from – especially since it can not only affect the environment, but your health as well.

## 10. Don't Purchase Aerosol Sprays

With millions of beauty products out there, it's easy to find products in pump sprays as an alternative. Try to look for items with environmentally responsible brand seals.

## 12. Think About Your Water Usage

Remember that old adage you'd repeat at the grade school drinking fountain, "save some for the fish?" You can do this in your daily life by turning off water while brushing your teeth, washing your face or shaving. In addition, cutting down your shower time can save more water and make a bigger impact than you'd think. According to Living Green and Saving Energy, "Using an average number of 2.5 gallons per minute from the typical shower head, reducing your shower length by 4 minutes per day would save (assuming you shower every day, ahem) 3,650 gallons per year." Now that's a lot of water saved for such a small sacrifice!

## 12. Support Better Brands

If you're going to give brands you're support through purchasing their products, read labels carefully. Look for beauty and cleaning products brands that are responsible in their production, looking for responsible brand seals. Check out [birchbox.com](http://birchbox.com), where you can find a list of environmentally responsible brand seals.

## District Consent Form

Dear District Administrator,

I am currently doing graduate work at Harvard University, and I am conducting a state-wide environmental literacy assessment of Oklahoma public high school students. The purpose of this study is to explore the level of environmental literacy among secondary school students across Oklahoma. Twenty schools have been selected based on a stratified random sampling technique stratified by zip code for geographic representation and student enrollment to participate in this study.

I am asking for your approval to conduct an action research project at your school. What I am proposing will involve holding one 20-minute survey with one science class from each class in grades 9-12. I will administer the survey to the students. I am also requesting your school send out passive guardian consent letters two days prior to the administration of the survey.

The 20-minute survey will be held at your school's convenience, but prior to November 1, 2016.

The survey is designed to gather information on student's environmental knowledge, attitudes and behaviors, as well as their grade level, gender and elective course participation.

It is hoped that this survey will result in an improved understanding of environmental literacy in high schools across Oklahoma. A report of this survey will be published as a Thesis, and the results will be presented to the Oklahoma Department of Education. Upon request, I will forward you the survey results of your school.

I will keep all the data I collect completely confidential, and I will *not* use your school's name nor any students' names in any research reports. Any information that I present will *not* be linked to any personal information that could be used to identify individual students. I am confident that I have taken the necessary steps to ensure that my research will be conducted in ways that meet ethical standards. I have attached a copy of the Environmental Literacy Assessment and the consent letters that I wish to give to the students and to their parents/guardians.

This research has been reviewed by the Committee on the Use of Human Subject in Research at Harvard University. They can be reached at 617-496-2847, 1414 Massachusetts Avenue, Second Floor, Cambridge, MA 02138. or [cuhs@fas.harvard.edu](mailto:cuhs@fas.harvard.edu)

Please sign below and return a copy of this letter to me indicating whether or not you give me permission to conduct this research project.

Thank you for your consideration.

Sincerely,

Riley Williams, ASP



- ☐ I give permission for you to conduct the action research project described above.
- ☐ I am requesting school-specific survey results.
- ☐ I do not give permission to you to conduct the action research project described above.

|                                     |      |
|-------------------------------------|------|
| Signature of District Administrator | Date |
|-------------------------------------|------|

## Guardian Consent Form

|                                                                                        |
|----------------------------------------------------------------------------------------|
| Study Title: Environmental Literacy Assessment of Oklahoma Public High School Students |
| Investigator: Riley Williams, ASP                                                      |

### Participation is voluntary

It is your choice whether or not to permit your child to participate in this research. If you choose to allow him or her to participate, you may change your mind and have him or her leave the study at any time. Refusal to participate or stopping participation will involve no penalty or loss of benefits to which you or your child are otherwise entitled.

### What is the purpose of this research?

The purpose of this research is to provide feedback to Oklahoma educators on the current level of environmental literacy among public high school students which will serve to improve the quality of environmental education in schools statewide. The research is also designed to determine if any quantifiable connections exist between high environmental literacy and student participation in school electives.

### How long will my child take part in this research?

Your child's participation will involve one twenty minute survey.

### What can I expect if my child takes part in this research?

As a participant, your child will quietly fill out an anonymous survey during their class time and place it in a universal envelope along with other participants in the study.

### What are the risks and possible discomforts?

If you choose to allow your child to participate, there are no reasonable foreseeable risks or discomforts that may result from participating in the study.

### If my child takes part in this research, how will our privacy be protected? What happens to the information you collect?

The data we collect will not include any identifiable information about your child. The information will be stored for a minimum of three years under the protection of the principle investigator, Riley Williams, and will be used in a graduate-level thesis.

### If I have any questions, concerns or complaints about this research study, who can I talk to?

The researcher for this study is Riley Williams who can be reached at [REDACTED]  
[REDACTED] The faculty sponsor is Dr. Mark Leighton who can be reached at [REDACTED]

If you have questions, concerns, or complaints,

- If you would like to talk to the research team,
- If you think the research has harmed your child, or
- If you wish to withdraw your child from the study.

This research has been reviewed by the Committee on the Use of Human Subjects in Research at Harvard University. They can be reached at 617-496-2847, 1414 Massachusetts Avenue, Second Floor, Cambridge, MA 02138, or cuhs@fas.harvard.edu for any of the following:

- If your questions, concerns, or complaints are not being answered by the research team,
- If you cannot reach the research team,
- If you want to talk to someone besides the research team, or
- If you have questions about your or your child's rights as a research participant.

### What should I do if I do not want my child to participate?

If you do not want your child to participate in this research study please call or email the Principle Investigator, Riley Williams, prior to your child's scheduled survey date to opt-out of the study. She can be reached at [REDACTED]

## Student Assent Form

|                                                                                        |
|----------------------------------------------------------------------------------------|
| Study Title: Environmental Literacy Assessment of Oklahoma Public High School Students |
| Investigator: Riley Williams, ASP                                                      |

My name is Riley Williams. I am a researcher at the Harvard University Extension School. I am trying to learn more about the environmental literacy of Oklahoma public high students. I will use the information I learn from this study to provide feedback to Oklahoma educators on the current level of environmental literacy among public high school students which will serve to improve the quality of environmental education in schools statewide. I am also looking to see if any quantifiable connections exist between environmental literacy and student participation in school electives. To do this, I am asking you and students in grades 9-12 to take part in my research study.

If you decide you want to be in my study, I will ask you to fill out a 25 question survey which should take no more than 20 minutes.

The survey is broken into four sections:

**Student Information and Demographics.** In this section please mark the answer that best applies to you.

**Student Attitudes.** These questions ask you to indicate how you feel about each statement and to what extent you agree or disagree with the statement. Mark the box that best applies to you.

**Student Behaviors.** These questions ask you to indicate how often you complete each of the statements on a scale of 1-5 with 5 being the most often. Mark the box that best applies to you.

**Student Knowledge.** These questions are multiple-choice and there is only one best response to every item. Circle the answer you think is correct.

In order to keep your confidentiality, please do not put your name on the survey.

This study is considered minimal risk and we do not anticipate any harm will come to you from participating.

I will keep all the data I collect completely confidential, and I will not use your name in any research reports. Any information that I present will not be linked to any personal information that could be used to identify you.

My telephone number is [REDACTED]. You can call me if you have questions about the study.

It is your choice whether or not to participate in this research. If you choose to participate, you may change your mind and leave the study at any time. Your teacher will not know if you participate in this research. Refusal to participate or stopping your participation will not affect your grade or any other benefits to which you are entitled.

If you decide to be in this study, please sign your name below. I will give you a copy of this form to keep.

### Agreement

I have decided to be in the study even though I know that I do not have to. Riley Williams has answered all my questions.

\_\_\_\_\_  
Signature of Study Participant

\_\_\_\_\_  
Date

## Letter of Introduction to Teachers

Dear Oklahoma Educator,

My name is Riley Williams. I am a graduate student in the Harvard University Extension School Sustainability program. I am conducting research to assess the environmental literacy of Oklahoma public high school students for a Master's thesis project. You were identified by an administrator in your school as an individual who is willing to assist in this research project.

First, I would like to express how grateful I am for your help. Your kindness and dedication to supporting education is truly appreciated.

My priority is to make participating in this project as least disruptive for you as possible. As a participating teacher your role in this research will be to announce to your class(es) that there is a voluntary research survey that will be administered during class time on the scheduled administration date. The announcement should only serve to notify the student; they should not be encouraged or feel pressure to participate. Additionally, prior to administering the survey, parental consent forms must be sent home with the student at least *two days* prior to the scheduled administration date. These forms do not need to be returned. These procedures are a requirement of the Harvard University Institutional Review Board for all research projects involving minors.

On the scheduled administration date, I will administer the surveys to participants. I will introduce myself to the participants and give them full disclosure about the research project. Next, I will distribute assent documentation, surveys and alternative literature for students who choose to opt out of the study. The evaluation should take approximately 20 minutes to administer. Finally, I will conduct a post survey debriefing to answer questions from participants. During the administration of the actual survey I must ask for you to leave the room in order to mitigate any potential feelings of undue pressure to participate from the students.

Should you have any questions or concerns please feel free to contact me at [REDACTED] or [REDACTED]

Again, thank you very much for your assistance.

Sincerely,

Riley Williams, ASP

[REDACTED]

Attachment: Guardian Consent Forms

## Institutional Review Board Letter of Approval



**HARVARD**

Human Research Protection Program

Harvard University-Area  
Committee on the Use of Human Subjects  
1414 Massachusetts Avenue, 2nd Floor  
Cambridge, MA 02138  
IRB Registration - IRB00000109  
Federal Wide Assurance - FWA00004837

### Notification of Initial Study Approval

August 11, 2016

Riley Williams  
rileysailor@sbcglobal.net

**Protocol Title:** Oklahoma Public High School Environmental Literacy Assessment  
**Principal Investigator:** Riley Williams  
**Protocol #:** IRB16-0770  
**Review Date:** 8/11/2016  
**STUDY Effective Date:** 8/11/2016  
**Expiration Date:** 8/10/2017  
**IRB Review Type:** Expedited  
**IRB Review Action:** Approved

The Institutional Review Board (IRB) of the Harvard University-Area approved this Initial Study. **Please note that the approval for this protocol will lapse on 8/10/2017.**

The documents that were finalized for this submission may be accessed through the IRB electronic submission management system at the following link: [IRB16-0770](#).

The IRB made the following determinations:

- Special Populations: Children
- Waivers: Waiver of parental permission (passive consent is obtained but no parent signatures are gathered)
- Risk Determination: No greater than minimal risk
- Research Information Security Level: The research is classified, using Harvard's Data Security Policy, as Level 1 Data.

The IRB requests the following:

- When all school permissions have been secured, please add these to the study record through submission of a Modification.

Please contact me at [REDACTED] with any questions.

Yours sincerely,  
Laura Henderson  
Senior IRB Administrator

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University Area IRB <http://cuhs.harvard.edu>  
Longwood Medical Area IRB <http://www.hsph.harvard.edu/ohra/>

## Ancillary Appendix 2

### Descriptive Statistics of Elective Course Participation

|          | Electives | Mean   | Std. Deviation | N  |
|----------|-----------|--------|----------------|----|
| Attitude | 1         | 3.4955 | .44345         | 22 |
|          | 2         | 3.4551 | .48992         | 98 |
|          | 3         | 3.2483 | .41543         | 29 |
|          | 4         | 5.4000 | 7.93032        | 15 |
|          | 5         | 3.3000 | .44593         | 36 |
|          | 6         | 3.5162 | .51667         | 37 |
|          | 7         | 3.6100 | .45570         | 10 |
|          | 8         | 3.5857 | .59000         | 7  |
|          | 9         | 3.2933 | .26851         | 15 |
|          | 10        | 3.9091 | .42061         | 11 |
|          | 11        | 3.1000 | .              | 1  |
|          | 12        | 3.6500 | .21213         | 2  |
|          | 13        | 3.8000 | .              | 1  |
|          | 14        | 3.7833 | .60139         | 6  |
|          | 15        | 4.3000 | .              | 1  |
|          | 16        | 3.2904 | .40932         | 94 |
|          | 17        | 3.3000 | .49666         | 19 |
|          | 18        | 3.3688 | .46292         | 16 |
|          | 19        | 3.7000 | .20000         | 4  |
|          | 20        | 3.3550 | .35015         | 20 |
|          | 21        | 3.7625 | .69475         | 8  |
|          | 22        | 3.2667 | .30111         | 6  |
|          | 23        | 3.5400 | .05477         | 5  |
|          | 24        | 3.6000 | .24495         | 4  |
|          | 25        | 3.4500 | .21213         | 2  |
|          | 26        | 3.0500 | .07071         | 2  |
|          | 27        | 3.9000 | .26458         | 3  |
|          | 28        | 3.1000 | .              | 1  |

|    |        |        |    |
|----|--------|--------|----|
| 29 | 3.3143 | .44314 | 42 |
| 30 | 3.4231 | .57901 | 13 |
| 31 | 3.3600 | .92898 | 5  |
| 32 | 3.2250 | .78899 | 4  |
| 33 | 3.6429 | .68034 | 7  |
| 34 | 3.3000 | .51478 | 5  |
| 35 | 4.0000 | .      | 1  |
| 36 | 2.9000 | .56569 | 2  |
| 37 | 3.3778 | .33082 | 9  |
| 38 | 3.4636 | .45667 | 11 |
| 39 | 3.9250 | .59090 | 4  |
| 40 | 3.6000 | .37148 | 11 |
| 41 | 3.3000 | .68702 | 6  |
| 42 | 3.3571 | .65027 | 7  |
| 43 | 3.3000 | .      | 1  |
| 44 | 3.3400 | .23022 | 5  |
| 45 | 3.6000 | .      | 1  |
| 46 | 3.2938 | .43123 | 16 |
| 47 | 3.5875 | .43239 | 8  |
| 48 | 3.3000 | .43589 | 3  |
| 49 | 3.2857 | .35322 | 7  |
| 50 | 3.5400 | .32863 | 5  |
| 51 | 3.5000 | .38079 | 5  |
| 52 | 3.7500 | .55076 | 4  |
| 53 | 4.1000 | .      | 1  |
| 54 | 3.2286 | .52509 | 7  |
| 55 | 3.3750 | .53151 | 4  |
| 56 | 3.3667 | .32660 | 6  |
| 57 | 3.4333 | .34448 | 6  |
| 58 | 3.3308 | .38597 | 13 |
| 59 | 3.5778 | .54949 | 9  |
| 60 | 3.5286 | .53140 | 7  |
| 61 | 3.8818 | .53818 | 11 |
| 62 | 3.3754 | .48396 | 61 |
| 63 | 3.5500 | .52384 | 18 |
| 64 | 3.0860 | .40985 | 5  |
| 65 | 3.4000 | .24495 | 4  |
| 66 | 3.5667 | .16330 | 6  |

|     |        |        |    |
|-----|--------|--------|----|
| 67  | 3.6000 | .70711 | 2  |
| 68  | 3.6333 | .41633 | 3  |
| 69  | 3.3000 | .      | 1  |
| 70  | 3.4333 | .11547 | 3  |
| 71  | 3.8000 | .      | 1  |
| 72  | 4.1000 | .      | 1  |
| 73  | 3.6000 | .      | 1  |
| 74  | 3.3923 | .32115 | 26 |
| 75  | 3.1417 | .37769 | 12 |
| 76  | 3.3000 | .43589 | 3  |
| 77  | 3.8000 | .28284 | 2  |
| 78  | 3.2900 | .33813 | 10 |
| 79  | 3.8000 | .      | 1  |
| 80  | 3.1000 | .      | 1  |
| 81  | 4.0000 | .      | 1  |
| 82  | 4.0000 | .      | 1  |
| 83  | 3.5000 | .      | 1  |
| 84  | 3.3000 | .      | 1  |
| 85  | 3.5667 | .57155 | 6  |
| 86  | 3.8000 | .28284 | 2  |
| 87  | 3.1000 | .      | 1  |
| 88  | 3.7500 | .35355 | 2  |
| 89  | 3.4000 | .56569 | 2  |
| 90  | 3.5000 | .      | 1  |
| 91  | 3.9500 | .64031 | 4  |
| 92  | 4.6000 | .      | 1  |
| 93  | 3.3000 | .      | 1  |
| 94  | 3.3667 | .55076 | 3  |
| 95  | 3.5500 | .07071 | 2  |
| 96  | 3.5000 | .      | 1  |
| 97  | 3.8833 | .64317 | 6  |
| 98  | 3.4000 | .35590 | 4  |
| 99  | 3.6000 | .      | 1  |
| 100 | 3.6143 | .56400 | 7  |
| 101 | 3.8000 | .28284 | 2  |
| 102 | 3.3600 | .19494 | 5  |
| 103 | 3.4500 | .21213 | 2  |
| 104 | 3.5333 | .50332 | 3  |

|          |       |        |         |     |
|----------|-------|--------|---------|-----|
|          | 105   | 2.3000 | .       | 1   |
|          | 106   | 3.6333 | .66833  | 6   |
|          | 107   | 3.2000 | .14142  | 2   |
|          | 108   | 3.2200 | .43818  | 5   |
|          | 109   | 3.4000 | .47610  | 4   |
|          | 110   | 3.8500 | .36968  | 4   |
|          | 111   | 3.3200 | .39623  | 5   |
|          | 112   | 4.5000 | .       | 1   |
|          | 113   | 3.5444 | .57470  | 9   |
|          | Total | 3.4608 | 1.08580 | 979 |
| Behavior | 1     | 2.545  | .7176   | 22  |
|          | 2     | 2.706  | .8169   | 98  |
|          | 3     | 2.931  | .7077   | 29  |
|          | 4     | 2.693  | 1.0793  | 15  |
|          | 5     | 2.806  | .6684   | 36  |
|          | 6     | 2.724  | .7293   | 37  |
|          | 7     | 2.700  | .6342   | 10  |
|          | 8     | 2.600  | .3055   | 7   |
|          | 9     | 2.827  | .7363   | 15  |
|          | 10    | 2.855  | .7160   | 11  |
|          | 11    | 2.600  | .       | 1   |
|          | 12    | 3.100  | .1414   | 2   |
|          | 13    | 3.400  | .       | 1   |
|          | 14    | 3.067  | .5465   | 6   |
|          | 15    | 2.800  | .       | 1   |
|          | 16    | 2.613  | .7331   | 94  |
|          | 17    | 2.674  | .6740   | 19  |
|          | 18    | 2.463  | .8156   | 16  |
|          | 19    | 2.250  | 1.0630  | 4   |
|          | 20    | 2.650  | .5799   | 20  |
|          | 21    | 2.525  | .3370   | 8   |
|          | 22    | 2.167  | .3670   | 6   |
|          | 23    | 3.120  | 1.0257  | 5   |
|          | 24    | 2.950  | .7724   | 4   |
|          | 25    | 2.600  | .2828   | 2   |
|          | 26    | 3.000  | 1.4142  | 2   |
|          | 27    | 2.867  | .8327   | 3   |
|          | 28    | 2.000  | .       | 1   |

|    |       |        |    |
|----|-------|--------|----|
| 29 | 2.667 | .6099  | 42 |
| 30 | 2.815 | .6504  | 13 |
| 31 | 2.560 | .4561  | 5  |
| 32 | 2.900 | .3464  | 4  |
| 33 | 3.286 | .4451  | 7  |
| 34 | 2.520 | .5586  | 5  |
| 35 | 3.200 | .      | 1  |
| 36 | 4.200 | 1.1314 | 2  |
| 37 | 2.467 | .5745  | 9  |
| 38 | 3.127 | .6886  | 11 |
| 39 | 2.800 | .3651  | 4  |
| 40 | 2.927 | .3003  | 11 |
| 41 | 2.500 | .3033  | 6  |
| 42 | 2.686 | .5273  | 7  |
| 43 | 1.800 | .      | 1  |
| 44 | 2.480 | .9121  | 5  |
| 45 | 3.400 | .      | 1  |
| 46 | 2.575 | .7655  | 16 |
| 47 | 3.000 | .4536  | 8  |
| 48 | 2.800 | .6928  | 3  |
| 49 | 2.686 | .7198  | 7  |
| 50 | 3.160 | .5177  | 5  |
| 51 | 2.920 | .9011  | 5  |
| 52 | 3.200 | .9798  | 4  |
| 53 | 3.000 | .      | 1  |
| 54 | 2.686 | .4880  | 7  |
| 55 | 2.650 | .6403  | 4  |
| 56 | 2.467 | .4502  | 6  |
| 57 | 2.433 | .5428  | 6  |
| 58 | 2.954 | .9597  | 13 |
| 59 | 2.822 | .4738  | 9  |
| 60 | 2.543 | .8142  | 7  |
| 61 | 2.945 | .7160  | 11 |
| 62 | 3.021 | 2.6995 | 61 |
| 63 | 3.200 | 1.3975 | 18 |
| 64 | 2.480 | .9859  | 5  |
| 65 | 2.100 | .4761  | 4  |
| 66 | 2.567 | .5989  | 6  |

|     |       |        |    |
|-----|-------|--------|----|
| 67  | 2.900 | .1414  | 2  |
| 68  | 2.733 | .6429  | 3  |
| 69  | 3.600 | .      | 1  |
| 70  | 2.267 | .9452  | 3  |
| 71  | 3.600 | .      | 1  |
| 72  | 4.000 | .      | 1  |
| 73  | 2.600 | .      | 1  |
| 74  | 2.869 | .6012  | 26 |
| 75  | 2.483 | .8288  | 12 |
| 76  | 2.200 | .5292  | 3  |
| 77  | 2.900 | .1414  | 2  |
| 78  | 2.500 | .4546  | 10 |
| 79  | 3.600 | .      | 1  |
| 80  | 3.200 | .      | 1  |
| 81  | 5.000 | .      | 1  |
| 82  | 2.200 | .      | 1  |
| 83  | 2.600 | .      | 1  |
| 84  | 2.800 | .      | 1  |
| 85  | 2.900 | 1.0488 | 6  |
| 86  | 3.200 | .2828  | 2  |
| 87  | 3.200 | .      | 1  |
| 88  | 2.500 | .1414  | 2  |
| 89  | 2.900 | .1414  | 2  |
| 90  | 3.000 | .      | 1  |
| 91  | 3.300 | .5292  | 4  |
| 92  | 2.400 | .      | 1  |
| 93  | 2.800 | .      | 1  |
| 94  | 2.667 | .9452  | 3  |
| 95  | 2.800 | .5657  | 2  |
| 96  | 2.800 | .      | 1  |
| 97  | 2.767 | .3882  | 6  |
| 98  | 2.700 | .2582  | 4  |
| 99  | 3.200 | .      | 1  |
| 100 | 3.029 | .4536  | 7  |
| 101 | 2.900 | .9899  | 2  |
| 102 | 2.920 | .7014  | 5  |
| 103 | 3.300 | .7071  | 2  |
| 104 | 2.000 | .8718  | 3  |

|           |       |       |        |     |
|-----------|-------|-------|--------|-----|
|           | 105   | 1.800 | .      | 1   |
|           | 106   | 2.633 | .5428  | 6   |
|           | 107   | 2.500 | .7071  | 2   |
|           | 108   | 3.000 | .2828  | 5   |
|           | 109   | 2.600 | .8641  | 4   |
|           | 110   | 2.700 | .4761  | 4   |
|           | 111   | 2.840 | 1.0139 | 5   |
|           | 112   | 3.800 | .      | 1   |
|           | 113   | 3.067 | .5196  | 9   |
|           | Total | 2.761 | .9718  | 979 |
| Knowledge | 1     | 2.59  | 1.843  | 22  |
|           | 2     | 2.74  | 1.939  | 98  |
|           | 3     | 3.14  | 1.787  | 29  |
|           | 4     | 4.07  | 1.751  | 15  |
|           | 5     | 2.69  | 1.411  | 36  |
|           | 6     | 3.95  | 1.914  | 37  |
|           | 7     | 3.90  | 2.283  | 10  |
|           | 8     | 3.00  | 1.528  | 7   |
|           | 9     | 2.07  | 1.335  | 15  |
|           | 10    | 3.82  | 2.639  | 11  |
|           | 11    | 6.00  | .      | 1   |
|           | 12    | 5.00  | 2.828  | 2   |
|           | 13    | 1.00  | .      | 1   |
|           | 14    | 5.17  | 2.317  | 6   |
|           | 15    | 4.00  | .      | 1   |
|           | 16    | 2.84  | 2.157  | 94  |
|           | 17    | 2.21  | 1.813  | 19  |
|           | 18    | 3.50  | 1.414  | 16  |
|           | 19    | 4.00  | 2.944  | 4   |
|           | 20    | 3.55  | 1.572  | 20  |
|           | 21    | 5.13  | 1.458  | 8   |
|           | 22    | 3.33  | 1.506  | 6   |
|           | 23    | 4.40  | 1.517  | 5   |
|           | 24    | 3.75  | 2.986  | 4   |
|           | 25    | 1.00  | 1.414  | 2   |
|           | 26    | 5.50  | .707   | 2   |
|           | 27    | 8.67  | .577   | 3   |
|           | 28    | 7.00  | .      | 1   |

|    |      |       |    |
|----|------|-------|----|
| 29 | 2.50 | 1.502 | 42 |
| 30 | 3.85 | 1.994 | 13 |
| 31 | 2.80 | 1.483 | 5  |
| 32 | 6.00 | 1.826 | 4  |
| 33 | 5.00 | 1.414 | 7  |
| 34 | 2.20 | 1.483 | 5  |
| 35 | 5.00 | .     | 1  |
| 36 | 3.00 | 2.828 | 2  |
| 37 | 2.89 | 2.369 | 9  |
| 38 | 3.45 | 2.207 | 11 |
| 39 | 3.00 | .816  | 4  |
| 40 | 4.09 | 2.663 | 11 |
| 41 | 4.00 | 2.608 | 6  |
| 42 | 3.57 | 2.225 | 7  |
| 43 | 3.00 | .     | 1  |
| 44 | 3.40 | 2.881 | 5  |
| 45 | 2.00 | .     | 1  |
| 46 | 4.75 | 1.807 | 16 |
| 47 | 2.63 | 1.302 | 8  |
| 48 | 6.00 | 1.732 | 3  |
| 49 | 4.00 | 2.828 | 7  |
| 50 | 3.20 | 1.924 | 5  |
| 51 | 3.20 | 1.643 | 5  |
| 52 | 4.75 | .957  | 4  |
| 53 | 6.00 | .     | 1  |
| 54 | 2.43 | 1.618 | 7  |
| 55 | 3.50 | 1.915 | 4  |
| 56 | 4.50 | 2.739 | 6  |
| 57 | 4.17 | 1.602 | 6  |
| 58 | 3.62 | 1.850 | 13 |
| 59 | 3.78 | 2.279 | 9  |
| 60 | 2.86 | 1.952 | 7  |
| 61 | 4.18 | 1.888 | 11 |
| 62 | 3.13 | 2.493 | 61 |
| 63 | 3.22 | 1.629 | 18 |
| 64 | 4.40 | 1.140 | 5  |
| 65 | 4.75 | 2.872 | 4  |
| 66 | 3.00 | 2.191 | 6  |

|     |      |       |    |
|-----|------|-------|----|
| 67  | 2.50 | 2.121 | 2  |
| 68  | 4.00 | .000  | 3  |
| 69  | 1.00 | .     | 1  |
| 70  | 1.33 | .577  | 3  |
| 71  | 4.00 | .     | 1  |
| 72  | 7.00 | .     | 1  |
| 73  | .00  | .     | 1  |
| 74  | 3.58 | 1.837 | 26 |
| 75  | 2.92 | 1.443 | 12 |
| 76  | 3.00 | .000  | 3  |
| 77  | 7.00 | .000  | 2  |
| 78  | 2.80 | 1.476 | 10 |
| 79  | 5.00 | .     | 1  |
| 80  | 5.00 | .     | 1  |
| 81  | 5.00 | .     | 1  |
| 82  | 2.00 | .     | 1  |
| 83  | 4.00 | .     | 1  |
| 84  | .00  | .     | 1  |
| 85  | 4.67 | 2.805 | 6  |
| 86  | 5.00 | 2.828 | 2  |
| 87  | 4.00 | .     | 1  |
| 88  | 5.00 | 2.828 | 2  |
| 89  | 5.50 | 3.536 | 2  |
| 90  | 3.00 | .     | 1  |
| 91  | 6.00 | .000  | 4  |
| 92  | 3.00 | .     | 1  |
| 93  | 6.00 | .     | 1  |
| 94  | 4.67 | 1.528 | 3  |
| 95  | 6.50 | 2.121 | 2  |
| 96  | 7.00 | .     | 1  |
| 97  | 3.83 | 1.835 | 6  |
| 98  | 3.50 | 1.291 | 4  |
| 99  | 5.00 | .     | 1  |
| 100 | 1.00 | 1.000 | 7  |
| 101 | 4.00 | 1.414 | 2  |
| 102 | 4.40 | 2.074 | 5  |
| 103 | 7.00 | 1.414 | 2  |
| 104 | 4.00 | 4.583 | 3  |

|               |       |        |         |     |
|---------------|-------|--------|---------|-----|
|               | 105   | 4.00   | .       | 1   |
|               | 106   | 3.67   | 1.966   | 6   |
|               | 107   | 3.50   | .707    | 2   |
|               | 108   | 2.80   | 1.304   | 5   |
|               | 109   | 2.75   | .957    | 4   |
|               | 110   | 4.75   | 1.500   | 4   |
|               | 111   | 3.80   | 1.643   | 5   |
|               | 112   | 4.00   | .       | 1   |
|               | 113   | 5.33   | 2.345   | 9   |
|               | Total | 3.37   | 2.075   | 979 |
| Overall       | 1     | 2.8727 | .71858  | 22  |
| Environmental | 2     | 2.9398 | .83280  | 98  |
| Literacy      | 3     | 3.0779 | .70527  | 29  |
|               | 4     | 3.3000 | .75404  | 15  |
|               | 5     | 2.9222 | .56422  | 36  |
|               | 6     | 3.3676 | .81379  | 37  |
|               | 7     | 3.3800 | 1.05177 | 10  |
|               | 8     | 3.0429 | .68765  | 7   |
|               | 9     | 2.7200 | .52400  | 15  |
|               | 10    | 3.5182 | 1.12944 | 11  |
|               | 11    | 3.9000 | .       | 1   |
|               | 12    | 3.9000 | .98995  | 2   |
|               | 13    | 2.7000 | .       | 1   |
|               | 14    | 4.0000 | 1.09362 | 6   |
|               | 15    | 3.7000 | .       | 1   |
|               | 16    | 2.8872 | .88939  | 94  |
|               | 17    | 2.6947 | .71295  | 19  |
|               | 18    | 3.0813 | .61560  | 16  |
|               | 19    | 3.2750 | 1.15289 | 4   |
|               | 20    | 3.1500 | .65333  | 20  |
|               | 21    | 3.7625 | .62550  | 8   |
|               | 22    | 2.9000 | .50596  | 6   |
|               | 23    | 3.6400 | .61482  | 5   |
|               | 24    | 3.4500 | 1.28712 | 4   |
|               | 25    | 2.3000 | .28284  | 2   |
|               | 26    | 4.0500 | .35355  | 2   |
|               | 27    | 5.1667 | .47258  | 3   |
|               | 28    | 4.0000 | .       | 1   |

|    |        |         |    |
|----|--------|---------|----|
| 29 | 2.8024 | .62839  | 42 |
| 30 | 3.3538 | .87903  | 13 |
| 31 | 2.8600 | .59833  | 5  |
| 32 | 4.0250 | .89954  | 4  |
| 33 | 3.9571 | .51594  | 7  |
| 34 | 2.6400 | .35071  | 5  |
| 35 | 4.0000 | .       | 1  |
| 36 | 3.3500 | .77782  | 2  |
| 37 | 2.8889 | .81769  | 9  |
| 38 | 3.3273 | .84509  | 11 |
| 39 | 3.2000 | .35590  | 4  |
| 40 | 3.5182 | .88410  | 11 |
| 41 | 3.2500 | 1.10227 | 6  |
| 42 | 3.1857 | .94062  | 7  |
| 43 | 2.7000 | .       | 1  |
| 44 | 3.0400 | 1.32212 | 5  |
| 45 | 3.0000 | .       | 1  |
| 46 | 3.5125 | .70793  | 16 |
| 47 | 3.0500 | .59761  | 8  |
| 48 | 4.0000 | .88882  | 3  |
| 49 | 3.2914 | 1.02495 | 7  |
| 50 | 3.2800 | .60992  | 5  |
| 51 | 3.1600 | .71274  | 5  |
| 52 | 3.8500 | .58023  | 4  |
| 53 | 4.3000 | .       | 1  |
| 54 | 2.7857 | .58146  | 7  |
| 55 | 3.1750 | .92511  | 4  |
| 56 | 3.4167 | 1.03618 | 6  |
| 57 | 3.3833 | .54924  | 6  |
| 58 | 3.2692 | .72501  | 13 |
| 59 | 3.3889 | .78014  | 9  |
| 60 | 2.9286 | 1.01278 | 7  |
| 61 | 3.6364 | .83937  | 11 |
| 62 | 3.0541 | 1.01973 | 61 |
| 63 | 3.2167 | .82051  | 18 |
| 64 | 3.2800 | .30332  | 5  |
| 65 | 3.4000 | .96264  | 4  |
| 66 | 3.0000 | .90554  | 6  |

|     |        |         |    |
|-----|--------|---------|----|
| 67  | 3.0000 | .98995  | 2  |
| 68  | 3.4333 | .30551  | 3  |
| 69  | 2.6000 | .       | 1  |
| 70  | 2.3333 | .45092  | 3  |
| 71  | 3.8000 | .       | 1  |
| 72  | 5.0000 | .       | 1  |
| 73  | 2.0000 | .       | 1  |
| 74  | 3.2423 | .60872  | 26 |
| 75  | 2.8667 | .75959  | 12 |
| 76  | 2.8000 | .26458  | 3  |
| 77  | 4.5500 | .07071  | 2  |
| 78  | 2.8700 | .32677  | 10 |
| 79  | 4.1000 | .       | 1  |
| 80  | 3.7000 | .       | 1  |
| 81  | 4.6000 | .       | 1  |
| 82  | 2.7000 | .       | 1  |
| 83  | 3.3000 | .       | 1  |
| 84  | 2.0000 | .       | 1  |
| 85  | 3.6833 | 1.27815 | 6  |
| 86  | 3.9500 | .91924  | 2  |
| 87  | 3.4000 | .       | 1  |
| 88  | 3.7500 | .77782  | 2  |
| 89  | 3.9500 | 1.34350 | 2  |
| 90  | 3.1000 | .       | 1  |
| 91  | 4.4000 | .42426  | 4  |
| 92  | 3.5000 | .       | 1  |
| 93  | 4.0000 | .       | 1  |
| 94  | 3.5333 | .15275  | 3  |
| 95  | 4.2500 | .49497  | 2  |
| 96  | 4.4000 | .       | 1  |
| 97  | 3.4333 | .70048  | 6  |
| 98  | 3.1750 | .50580  | 4  |
| 99  | 3.9000 | .       | 1  |
| 100 | 2.5000 | .30000  | 7  |
| 101 | 3.5500 | .91924  | 2  |
| 102 | 3.5400 | .93434  | 5  |
| 103 | 4.6500 | .35355  | 2  |
| 104 | 3.1333 | 1.40475 | 3  |

|       |        |        |     |
|-------|--------|--------|-----|
| 105   | 2.7000 | .      | 1   |
| 106   | 3.1167 | .80353 | 6   |
| 107   | 3.0500 | .49497 | 2   |
| 108   | 2.9600 | .47749 | 5   |
| 109   | 3.1500 | .45092 | 4   |
| 110   | 3.7500 | .62450 | 4   |
| 111   | 3.3000 | .90277 | 5   |
| 112   | 4.1000 | .      | 1   |
| 113   | 3.9667 | .96954 | 9   |
| Total | 3.1558 | .84168 | 979 |