A PHILOSOPHICAL ANALYSIS OF DAVID ORR'S THEORY OF ECOLOGICAL LITERACY: BIOPHILIA, ECOJUSTICE AND MORAL EDUCATION IN MIDDLE SCHOOL LEARNING COMMUNITIES

by

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(Under the Direction of Michael P. Mueller)

ABSTRACT

In his writings, David Orr claims that the U.S. is in ecological crisis and that this stems from a crisis of education. He outlines a theory of ecological literacy, a mode by which we may better learn the ecology of the Earth and thus learn to live in a sustainable manner. Although from an anthropocentric view the diagnosis of crisis may be correct, it is not motivational to the youth of our nation. In this analysis of Orr's theory, it will be suggested that we move beyond the perspective of crisis. By extending Orr's ecological literacy with biophilia and ecojustice and by recognizing the importance of experience in learning, science education can be shifted to incorporate values and morals in a more sustainable approach to educational reform.

INDEX WORDS: biophilia, ecojustice, ecology, ecological literacy, ecosystem, experiential education, moral education, pragmatism, science education, values

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DEDICATION

This thesis is dedicated to my family and my teachers. Thank you for your patience and support and for sharing your experiences.

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1 Introduction

Growing up, I was fortunate to have a pond in my backyard. Making mud pies and watching minnows provided me with memories that allow me to still see the sun on the water and smell the decomposing grasses at the pond's edge. This is my earliest recollection of loving the outdoors. There have been many memories since that have contributed to the ongoing development of care for the environment within me. I care for the environment and I value it. Would I have developed this feeling of care without my experience at the pond? Perhaps. But I suspect it would have been more difficult to establish an emotional connection. Over time, this childhood experience has connected with other experiences in my life and has shaped my choices, such as the interest to study biology in college, and more recently, to study science education. I would like to help guide others towards experiences similar to mine at the pond. When and where does the development of care for the environment begin? Is it simply inherent in some individuals and not in others, or is it possible to create? Basically, is it nature or nurture? As each person has a unique genetic make up combined with a unique social and cultural background, it is feasible that care could grow from a balance of both, as a part of a continuum of nature and nurture. But there must be a seed. Asking myself about the connection between experience and care, that in turn translates to value of environment, has created this quest for me.

To gather more information during my student teaching, I gave a survey to a middle school life science class. The questions of this survey were geared at gauging the students' awareness of their relationships within ecosystems. One of the questions inquired about the students' development of care for the environment. Although these students had recently completed a unit on *ecology* covering this material, almost all of the 28 students responded with little sense of the "environment" and little recognition of human dependence on the health of ecosystems. For one student in this class and many of the students in this small town outside of a big city, the mental image of the outdoors is experienced for the most part from the inside a car window. To others, this experience with the outdoors extends to a playing field.

But consider another group of students in a middle school of a more urban setting, where the weekly chance to go outside onto a playing field is used as a reward. For these students, an outdoor experience at school is beneficial to the behavioral issues that are keeping them inside. Instead of breathing fresh air and absorbing the omnipresent physical laws and ecological cycles of natural surroundings, these students continue to practice math and reading indoors to reach the appropriate academic achievement levels. At this school, many of the adolescents have left their neighborhood only on rare occasions. They are not shown the natural environment in a way that is nurturing and consequently; they show disregard. Many of these students drop out before graduation, understandably disliking academics and feeling unwelcome in and unworthy of the "outdoors." As a relative novice in the field of classroom science education, I make note that good behavior often coincides with good grades. More parental figures at home and better paying jobs often coincide with time and resources that enhance the life experiences of children.

Considering yet another middle school, students develop a sense of care for the environment as members of a wildlife habitat club. This club, starting with the vision of a seventh grade life science teacher, evolves over five years from a barren field to a nationally certified wildlife habitat because of the hard work of students. Beginning with the planting of donated tree seedlings and then, tracking tree growth and habitat biodiversity as integral parts of lesson plans, a transformation occurs, from empty field to a secondary succession Southeastern U.S. Piedmont habitat within one school site. One student and her other co-club members are part of a rural area that is close enough to a big city in one direction and a university town in another to enjoy both a moderate level of affluence and a broader sense of the outdoors. The scenes from their hometown roadsides are pastures, or pastures recently developed into large lots with large homes, which is a stark contrast from my first description of a middle school neighborhood. During a workday at the habitat I visit these students as they offer to help teach me and share knowledge about their newly restored habitat. These students demonstrate care. They have a sense of belonging to a place, and this is evident, through their commitment to this geography.

These experiences, aforementioned, have provided personal evidence that outdoor experiences make a difference in the value that middle school students have for the environment. This age group of adolescents, between the wonder years of childhood and the responsibilities of adulthood, need to experience the earth, life and physical sciences through their senses, immersed in the interrelatedness of them, connecting their experiences in the present with their unique backgrounds, and thus, making scientific knowledge of their own. This knowledge of the natural world will carry forward into the future, and affect the ecological wellbeing of these students and the subjective wellbeing of future generations. This wellbeing may very well guide

their life decisions regarding natural resources and remain a large part of what frames their actions toward other humans and a more *sustainable* way of living with the Earth.

Outdoor experiences and education about the environment develop into care and value, such as that experienced by one female student already mentioned and her fellow habitat club members which in turn, develop into the value of other species, their habitats and the balance of environmental conditions that maintain their ecosystems. Planting the "seeds" of knowledge and fostering in children a value for the environment by incorporating outdoor experiences in science education is the most important step in bringing this experiencing-learning-caring continuum into balance. Unfortunately for many students, learning science does not involve these types of opportunities.

The purpose of this thesis is to argue for the need in the U.S. to recognize the value of experience in the natural environment as an essential part of the science education experience. The need for this study is evident. For a long time now, and with few exceptions, human choices are becoming less "just" towards other species. Future generations are less likely to have the same quality of environmental life as their grandparents. There is an increasing awareness of ecological imbalances worldwide and rapid increases in anthropogenic global climate warming.

The U.S. government has a history of acknowledging the importance of including the environment in our education process through acts and amendments that include environmental literacy and environmental education. For a large percentage of the U.S. population, just choices have not been realized. But I will argue that outdoor experiences included as part of the U.S. national educational standards can "even the playing field" in science education for middle school students regardless of geographic location while improving the health of the ecological, cultural and economical systems nationally and abroad.

There is no stage of educational development in greater need of a focus than during the middle school years. During these years, students struggle for identity and self-esteem. They are completing a passage from childhood to adulthood and encountering newly charted waters. This age is critical in preparing youth as present and future decision-makers. In a few years following middle school, these children become young adults, driving automobiles, working, voting, paying taxes, and for many, parenting children. Middle school is one of the last opportunities to reach youth in public education before their purchasing power greatly amplifies. Emphasizing *ecological literacy* in science education provides grounding for these youth, a sense of stability much needed in a country of increasing transience of mind and body (Mitchell & Mueller, 2008).

David Orr's (1989, 1992, 1994, 2006) theory of ecological literacy will be used for the basis of analysis for this thesis. Orr recognizes the importance of the natural environment as part of education and he acknowledges the weakening of social and cultural structures as well as the ecological degradation that has come with overemphasis on economics and physical distancing of humans from the land. His writing illuminates interconnections among the nature of science and the design of nature; human emotion and reason; and the development of care for the environment and morality in decisions regarding its use, which lead to its reverence. Orr articulates that experience in one's own natural environment shifts the human perspective from one of economic overemphasis to one of balance amongst economics, ecology and cultures. He says that the development of care for the Earth in our future leaders, through outdoor experiences and environmental education, is indeed, moral education.

Orr is a prolific writer on the topic of ecological literacy. Thus, I have narrowed my references for this thesis to his most cited works: *Ecological Literacy: Education and the Transition to a Postmodern World* (1992), *Earth in Mind* (1994) and *Ecological Literacy:*

Educating our Children for a Sustainable World (2006). A philosophical research perspective based on the pragmatism of John Dewey (and other early pragmatists) will guide this analysis of Orr's work and its intersection with *biophilia theory* (Wilson, 1984) and *ecojustice theory* (Bowers, 1996, 2004; Mueller, 2008). This analysis works towards the development of science education that will guide learners to be decision-makers that are well informed in science and also realize the consequences of their actions on the future of humans and other species on Earth.

1.1 Why Ecological Literacy?

Ecological literacy (Orr, 1992, 1994, 2006; Odum, 1984) in its broadest sense can be defined as an ability to "read" the many interwoven relationships (i.e., biotic and abiotic) that are built of the Earth. But what does that mean? Is it logical to assume that we can read the Earth?

Not too many years ago a large percentage of families in the U.S. made their living as traditional family farmers. They planted by the almanac of the moon and predicted the weather by watching the sky and biological signs (e.g., thickness of tree bark and animal activities), working with the land in a manner that was nurturing to the Earth and sustaining for humans and other species. They worked not with modern technologies such as electronics and synthetic chemicals, but by understanding nature's patterns, cycles and nested systems. Our long history of coexisting with our surroundings is written in the rocks, plant and animal ecology and on the fabric of relationships between humans and other species (Mueller, 2007). Many of us in the U.S. have lost our ability to "see" these relationships of the Earth because today we live our lives much differently. The understanding of patterns in nature has been deemphasized or ignored for a human economy based on the exchange of money for material stuff and conveniences of life. Along with the loss of how to observe ecological relationships as commonsense, there are now

detrimental effects on the health our nation's youth due to this lack of experience in the outdoors (Akinbami, 2006; Bloomgarden, 2004; Kuo & Taylor, 2004; Lord, 2008; Louv, 2005). This idea coincides with a seemingly greater regard for numbers (i.e., the "superiority" of mathematics) rather than humanity in the test score-centered and economics-focused education system of our nation. Although the U.S. education system concentrates on educating youth in a manner in which they can become financially successful, this does not equate with happiness. Many graduates seek happiness in the production, exchange, distribution, consumption and disposal of material stuff for many do not understand the impact that hyper-consumerism has on the Earth.

For nonhuman species, "economics" can be defined as the exchange of resources for an increased chance of having one's genes reproduced within the gene pool (Morrison, 1999; Wilson, 2003). Are humans that different from other nonhuman species? In ecology science, there are several concepts that apply to all species including humans. *Natural selection*, a term that often conjures mental images of fast cheetahs overtaking weak gazelles, favors the fittest, even for humans. The fittest is not necessarily the strongest or fastest though. For many species, the "fittest" is the best dancer with the brightest suit or the sweeter, more colorful, more accessible fruit with easily passable seeds. *Community* applies to humans as well as other species, although within the context of ecology science, a community includes more than one species. *Cooperation* is a mode of behavior that is beneficial in the promotion of greater good for the whole applies to all species as well, just as *reciprocal altruism*, which can be found with good neighbors or schooling fish. For many people in the U.S., the relationship of humans with the natural environment has shifted over time from one of *mutualism* and taking only what we need from the Earth, to *parasitism* and a habit of taking more than we can ever use (these are also both ecological concepts). Granted, all relationships among species are not meant to be the

same. Diversity strengthens the integrity of systems and applies to behaviors and relationships. Balance is the key, however, and a heavily weighted number of parasites will likely deplete the resources of a host more unhealthily and quickly than a limited number that is in balance with other aspects of ecological resources and relationships. As older generations of people in the U.S. remember the "way things used to be" with traditional farming ways of living replaced with the economic-focused *monocultures* of newer generations, the success of the Earth as a whole recedes in the wake of short-sighted illusions of success for the individual being. Most of us know deep down that a successful life is composed of more than money-for-stuff economics. But for many humans in the U.S., being economically successful has come to translate to reproductive success and the continuation of one's genes through a sort of modern day natural selection process. In a world of economic decline, this cannot be the only measure of success.

Ecological literacy emphasizes the ecology that underlies this economy. It places humans as integral parts of ecosystems and recognizes the impact of relationships among humans and other species. Ecological literacy includes the need for understanding ecological relationships and basic thermodynamic laws and doing so through immersion in the natural environment. Ecological literacy is holistic, emphasizing connectivity and continuity with fewer divisions and disciplines, recognizing commonalities among organisms and promoting the strength that exists in diversity. It gives great importance to relationships within human communities and social infrastructures, highlighting interactions amongst humans as most important in the educational experience rather than the scores embedded within testing priorities. Ecological literacy's approach begins with the development of care and the voices of individuals. It works its way out and up, not from the top-down, with authoritative commands. Ecological literacy fosters respect and care for other humans, for other species and their ecological needs for survival, especially

those species whose voices are not being "heard." Ecological literacy is more than a simple name change from the environmental literacy goal for the U.S. educational system set forth by the government in 1965, with this statement: "It is also vital that our entire society develops a new understanding and a new awareness of man's relation to his environment" (Nixon, 1970). Ecological literacy does not necessarily require the ability to read ecological literature or the ability to read at all. It does, however, include "reading" the patterns, cycles and systems of the Earth, knowing that the whole of the Earth as an ecosystem is greater than the sum of its many parts (Odum, 1984) and realizing that human actions should nurture the integrity of the Earth.

1.2 Why David Orr?

David Orr first introduced the term "ecological literacy" in 1989. In an essay titled *Ecological Literacy*, Orr states that environmental education should change how humans live, and if environmental education is leading toward a sustainable lifestyle, then competence, which only happens by doing, will come with it. Knowing, caring and practical competence form the basis for ecological literacy (Orr, 1989). In 1992, Orr further develops the concept of ecological literacy by stating that "the disorder of ecosystems reflects a disorder of mind, thus an ecological crisis is an education crisis" (Orr, 1996, p. 9). Rounding out this stance he adds that if the role of education is to assist in the improvement of minds, then it follows that our education's focus should be environmental in nature. Orr's defining statement, "all education is environmental education" (p. 12) captures his philosophy that what a student is surrounded by, in physical surroundings and in curriculum, both hidden and not, determines his or her inclusion of self in nature or not (Orr, 1992). Orr recognizes the many interrelations of ecological literacy with other disciplines and aspects of our lives. He claims that our environmental crisis is due to the inability

of humans to think about "ecological patterns, systems of causation and long term effects of human actions" (Orr, 1994).

Since the introduction of Orr's ecological literacy, other scholars have written on the topic, enlarging how it should be situated within environmental education, environmental literacy and other areas of knowledge, such as cultures and traditions, belief systems, morals and values and social status. For example, Woolhorton and Bennell (2007) define ecological literacy by their work with the Noongar Aboriginal people of Australia, and note that ecological literacy is "understanding basic principles of ecology and being able to embody them in everyday life" (p. 1). They make a point that ecological literacy is not new, and this is an important point! Ecological intelligence is an intelligence that has for a long time now governed the operations of sustainable societies and is something that members of non-sustainable societies should strive to regain as part of what incorporates cultural literacy as a significant aspect of ecological literacy.

In this paper, ecological literacy is being examined from the perspective of David Orr (1992, 1994, 2006). There are several reasons for this. While his definition develops over the years by incorporating the contributions of others, Orr continues to support the essence of his original vision. In addition to being an environmental philosopher, David Orr is an educator. He is an eloquent writer and speaker, a deep thinker and architectural designer. He understands the importance of relationships of all things. Orr, formerly a professor of political science at the University of North Carolina, is now a professor of environmental studies at Oberlin College in Ohio. In between these academic positions, Orr chose to live as Thoreau did, deliberately and wisely. He moved, with his wife, to a plot of land in Arkansas where far from any towns, they built a house and lived there for eleven years. He relies on this experience to ground his writings that provide the justifications for his arguments that are only possible from personal experiences

in nature. He implements his ideas in courses at Oberlin College, in the nationally recognized Environmental Studies Center that he designed and from research that he conducts at the Meadowbrook Project, a 'model' sustainable community on his property in Fox, Arkansas. Orr is a systems thinker and maintains a holistic view. He recognizes a passion for the natural sciences. In his writings, Orr incorporates many categorizations of human life, such as politics, economics, pedagogy, love and virtue. He asks and answers a philosophical question: "what is education for?" (Orr, 1994, p. 15). He writes effectively about the structural relationships between the methods of science and the diversity of society, depicting with words the way in which thermodynamics and traditions are interwoven in real experiences. From his many topics, a few will be highlighted in this paper.

Orr's (1992) original vision of ecological literacy was not about creating more divisions between disciplines. Recently, a team of ecologists (Jordan et al., 2008) initiated the development of a guiding framework for moving the public toward ecological literacy, noting that the time is right, and that we have a great need for national reform documents in education. The time is also right for breaking down the walls of disciplines and the authoritarian view of humans over everything else, which is a limitation of Orr's original theory I will explore later.

Orr (1994, 2006) emphasizes the role that teachers have in shaping the minds of learners by what they do or do not include in their learning environments. Learning environments and experience with constructed and physical environments are integral to education. New teachers in a classroom soon learn that their ability to take disciplinary action takes precedence over the lesson content, for words mean nothing if the ears are not listening (safely). Orr's ecological literacy is similar in that learning begins with experiences in ecosystems that develop into care and guide appropriate and significant choices and actions, not through the regurgitation of

ecological facts and concepts on an end-of-course test. Understanding gained from immersion in the relationships of the ecosystem is far greater than learning about individual ecological parts. But it takes a sense of humility to get there, something I will also explore in this thesis.

1.3 Why Philosophical Research in Science Education?

Philosophical research is concerned with the determination of "what should be" while scientific research focuses on "what is." Although scientific research plays an important part in our understanding of the natural world, philosophical research with its time honored tradition of analyzing ideologies can play an important role as well, depending on the questions at hand. Philosophical arguments do not try to establish facts as scientific arguments do. Instead they try to establish norms and standards, and try to make the case for "what is the best, the right, the good, the beautiful, the fair and just, the true." (Thayer-Bacon & Moyer, 2006, p. 8). Philosophical arguments are supported with reasons and judged by the soundness and external coherence of the logic. In constructing a philosophical argument, philosophers do not rely solely on reason but also incorporate "other tools that are just as important: intuition, emotions, imagination, and their communication and relating skills" (Thayer-Bacon, 2000).

A philosophical approach to the establishment of norms and standards, or "what should be" is appropriate in science education and the national goal of promoting scientifically literate citizens capable of using scientific information to guide decision-making. Because of the ever-changing nature of science and the variability of students, calculating "what is" in science education is not a complete evaluation of "success." Because issues in the environment will be of even greater concern (and increasingly uncertain) in the future due to questions of how a rapidly increasing human population will learn to deal with diminishing agricultural and natural

resources, the need to develop citizens that are not just scientifically literate but also ecologically literate through the recognition and incorporation of curiosity, imagination, intuition, emotions, process and communication is apparent and significant.

Scientific language can sometimes seem exclusive, which means not meant for the general public. Many people assume scientific competence is proven with facts, not realizing the small part this evidence plays in understanding the whole. Science educators must teach for the future, bridging the gap between today's science and society and tomorrow's, establishing abilities of problem solving and decision-making based on logical evidence for the continued wellbeing of our students and for others. Humans have a unique nature of relationships with each other and within their natural environments, and one of the most comprehensive approaches for teachers in science education is established through philosophical research. Because "educational philosophers have long recognized that what is described by scientists is not a conclusion of how the world should be" (Mueller, 2008, p. 17), philosophical research is a more appropriate method than scientific research for the form of analysis of Orr's ecological literacy in this thesis project.

1.4 Why Pragmatism?

The changes in how humans frame their relationship with the Earth (suspected to be fostered through ecological literacy) is grounded in our actions and extends from experience with other individuals and the environment. This is captured in a methodology of American pragmatism.

Charles Peirce (1839-1914), a physical scientist with great interest in probability -- turned philosopher -- was one of the early founders of American pragmatism. He argues that the world and all mental interpretations of it is ever-evolving. He considers philosophy to be most aligned with the philosophy of traditional science. Peirce's "pragmatism," later renamed "pragmaticism"

to distinguish it from other emerging concepts of pragmatism, is based on the following thought: the meaning of a conception constitutes it's entire set of practical consequences, and a meaningful conception has experiential value that is applied to possible empirical observations (Peirce, 1958). In other words, there are epistemological ideals (or ways of thinking what is ideal) and these ideals are only known through the actual experiences of individuals in the world.

At the turn of the twentieth century, William James (1901) and John Dewey (1938) further developed American pragmatism. Both James and Dewey had an educational basis in psychology. James focused more on psychology of experience and Dewey focused more on a functional psychology of mentality and behavior as adaptations to one's environments. James' (1901) philosophy concentrated on using experiences to determine the best choices for practical outcomes in the future and he is best known for application of this philosophy to recommend the benefits of religious belief to improving quality of life. Dewey's (1938) philosophy stemmed from his thoughts that beliefs are habits of behavior (cultural traditions) that have proven to be successful (and which lasted the test of time, so to speak). These beliefs are part of knowledge, and therefore, knowledge is based in experience and practice. The process of acquiring knowledge is education, situated in the contexts of the local community and natural environment.

Dewey (1938) considers education to be based on experience and believes in the continuity of all experience. Dewey's holistic approach to American pragmatism recognizes that there are relationships and continuations amongst all things, with the goal of reducing dualisms and dichotomies such as mind and body, good and evil, and theory and practice. Dewey envisions teachers as guides of experience in the classroom by the choices they make about their environments and attitudes that frame preferences or aversions, thus determining the quality of future experiences. In other words, how people frame the world is how they will likely behave

towards it. Education guides societal freedom by contributing to the capacity of the learner to make good decisions in future situations. Dewey does not separate the knower and the known. He puts great emphasis on *interaction*, an ever-present occurrence during which contributing factors are assigned equal rights. In fact, to Dewey, “even when a person builds a castle in the air he [sic] is interacting with the objects which he constructs in fancy” (Dewey, 1938, p.44). Dewey views education as building on the past (cultural traditions) and connecting the present with the future. Growth in intelligence occurs during the process of overcoming problems in the present (which inform future choices). Current problems stimulate thinking and quests for information that combine with prior knowledge to lead to new experiences and new problems, and so forth.

Dewey (1938) is considered an influential educational reformer. Dewey envisions schools and civil society as in need of constant reconstruction, believing that democracy results from thorough formation of public consensus reached by way of communication among citizens, experts and politicians. In this manner, democracy is a product of education. Dewey also notes that being human involves contact and communication. He writes, "what nutrition and reproduction are to physiological life, education is to social life. This education consists primarily in transmission through communication. Communication is a process of sharing experience till it becomes a common possession” (Dewey, 1916, p. 9). Dewey notes that traditional education sets forth conditions that are assumed desirable (such as testing priorities) but does not consider the students (or contexts they are embedded within). The traditional scheme is “one of imposition from above and from the outside” (Dewey, 1938, p. 18), imposing adult standards on those growing slowly toward maturity. Dewey intends to provide the missing frame of reference in school education, which is connecting education and personal experience of the learner, thus establishing a new philosophy of education based on the philosophy of

experience and replacing the autocratic frame of the "old school" with a new frame of participatory democracy. Dewey notes, "although it is easier to walk in the paths that have been beaten" and "to follow the line of least resistance provided by the old intellectual habit," to promote the most good for the most people requires growth in a new direction (p. 30).

Dewey (1938) was a great proponent of what is now called, "experiential education," or "learning by doing" – sometimes called *Project Based Learning* (PBL). PBL is where students are active researchers by participating in a project in the community or environment. Dewey believes educational value should be positioned in occurrences, or situations, based on transactions and relationships. Dewey's emphasis on experiential learning and communication has an integral place in science education. For example, science as inquiry is one of eight categories in the National Science Education Standard's (NSES) Science Content Standards section (NRC, 1996). This NSES section is intended to guide the development of students beyond science as a process, by encouraging students to ask questions, design and conduct investigations, connect evidence and explanation and communicate their findings (NRC, 1996).

The philosophies of both John Dewey (1938) and David Orr (1994) have many similarities. Both philosophers are educators and holisitic thinker-doers. Their tenets for arguments are founded in practice and their works strive to illuminate the continuity of all experience to begin to dissolve the walls of academia. Both scholars believe in the strength of human transaction and communication. Dewey's recognition of context in the determination of meaning is a strong foundation and drive for educational reform, which recognizes that perspectives and positions of students are mirrored by a focus on communities and environments – similar to that of Orr's (1992, 1994) theory of ecological literacy. Dewey wrote of moral education as the only education, not a separate subcategory but as describing all of education, for

"no teaching/learning deserves to be described as 'education' unless informed by and conducive to nurturing the moral point of view" (as cited in Prakash, 1995, p. 3). Orr's (1994) statement, "all education is environmental education" nearly a century later is explained in much the same way (p. 12). The alignment of these two philosophers, Dewey and Orr brings up a connection between morality and our view of the environment that needs to be realized in science education. As part of my central claim, I argue that all education should be moral and environmental education (I will return to this point in section 4). Students in a science classroom learn by engaging with both physical and social environments that guide them along the pathways of intellectual and moral growth. These environments carry with them some assumptions about the world and deeply embedded knowledge, according to what is included in or what is left out of school (Orr, 1992). In other words, the assumptions embedded in our thinking are responsible in a large part to our associated acts. Pragmatism helps scholars pay attention to these underlying assumptions associated with our actions, which makes it an important methodology for analyzing David Orr's (1992, 1994) ecological literacy and environmental education in science education.

1.5 Roadmap

In this thesis, David Orr's theory of ecological literacy will be presented in the next section. Through a pragmatic point of view, its hypothetical application to the system of science education in the U.S. will be analyzed. Specific points of Orr's theory will be incorporated, such as the need to diminish disciplinary divisions, the inclusion of values in science, and the importance of environment and experience in science education. Throughout these examples, the point will be made that simply "walking through" the steps of applying ecological literacy are not enough to catalyze changes in attitudes and behaviors. Change comes from being actively

involved with fellow community members in hands-on experiences. These experiences should incorporate collaboration and innovative constructions from the available resources in the local ecosystems.

In section 3, potential challenges to Orr's theory will be addressed. A main challenge to ecological literacy resides in Orr's assumption that our ecological status as a nation and as a planet is actually one of true crisis (meaning implicit, but objective "Truth" knowledge). The ecological crisis could well be a *human economic* crisis to some, especially those living at a level of consumption that cannot be supported into the future, due to the demand exceeding resources to sustain production. But more than that, ecological crisis cannot sustain motivations for action.

Orr's (1994) ecological literacy theory will be amended and extended by developing a better understanding of what the role of biophilia (Wilson, 2002) offers Orr's theory and addressing the significance of ecojustice (Bowers, 2004; Mueller, 2008) for ecological literacy. Both of these perspectives will be used to enlarge current conceptions of ecological literacy for science education, and provide the additional justifications to support my argument for schools.

Finally, the last section will delve into ways to take ecological literacy from theory to tangibility, such as the restructuring of middle school daily schedules. Fruitful recommendations for preparing new teachers in ecological literacy and professional development, as well as mental images of school families and middle school learning communities will be included.

Incorporating points of Orr's theory of ecological literacy in our educational system can lead to transformation of our educational focus from one based exclusively on economy to one of holistic ecological focus, leading to educational and social transformation and to a deeper understanding of the dependence of humans on ecosystems. This movement toward reforming schools is likely to incorporate outdoor learning that develops care for other humans and Earth.

2 David Orr's Theory of Ecological Literacy

2.1 Introduction

Many choices and actions of humans prove to be without "just" considerations for other humans and other than human species. Increased understanding of the interrelatedness of all beings and their ecosystems, including the relationship between human economy and ecology, will better inform decision-making processes. An approach to encourage an increase in ecological understanding is *ecological literacy*. This term introduced in 1989 by David Orr and developed through subsequent writings defines a path toward a more sustainable world by educational reform. The main purpose of this section is to lay out a clear description of Orr's theory of ecological literacy.

2.2 Orr's Developing Theory of Ecological Literacy

In his book *Ecological Literacy: Education and the Transition to a Postmodern World* (1992), Orr extensively develops ecological literacy as an approach to addressing what he identifies as a "crisis of sustainability" in the U.S. Orr explains his thoughts regarding education's role in moving beyond the modernistic "blind" acceptance of development and "limitless" natural resources to a post-modernistic socially and spiritually constructive and holistic view of humans living as part of the biosphere.

Orr (1992) defines a sustainable society as one that "does not undermine the resource base and biotic stocks on which its future prosperity depends" (p. 23) and claims that the U.S. is not sustainable due to a prevailing quest for instant gratification combined with an urge to

dominate nature. Orr suggests several possible reasons for this: Was the idea of resource availability skewed upon discovery of the New World? Did humans make "an evolutionary wrong turn" (p. 16) when transitioning from nomadic foragers to sedentary agriculturalists supporting larger populations? Or are we simply flawed creatures with great affinity for situations of short-term benefit in exchange for long-term loss, or "social traps" (p. 5)? Whatever the causes, the crisis of sustainability among humans also reflects a "crisis of spirit" (p. 4).

Orr (1992) describes ecological literacy as a path for humans to follow, similar to a recipe for sustainability. It rests on six foundations: all education is environmental education; environmental issues cannot be understood through a single discipline; environmental education requires dialogue with place; process is as important as content; experience in the natural world is essential to understanding it; and education for sustainability requires the understanding of natural systems. For Orr, ecological literacy extends beyond scientific facts and highlights the larger picture of ecological relationships and human-nonhuman animal-plant-land interactions.

Orr (1992) draws from Aldo Leopold's concern for the future among a people lacking harmony with the land. How does one learn harmony? To teach harmony, should education address intellect only, or should it also include "character, intuition, feeling, practical ability and instincts" (1992, p. 142)? Orr recommends a paradigm shift in education to include these aspects of humanity, promoting humans as an integral part of the natural world and reestablishing harmony with the land.

In his 1994 book *Earth in Mind*, Orr recognizes that environmental crisis grows with increasing disconnection of humans from nature, a result of an overemphasis on economic success and disjointed disciplines in school combined with overbooked schedules and technological pastimes outside of school. A destabilization of communities and traditions has

resulted as well as subsequent loss among our nation's youth of morals, values and the *sense of wonder* (Carson, 1984), or the sense of sheer joy in the natural world. Orr notes that, "without significant precautions, education can equip people merely to be more effective vandals of the earth" (p. 5).

In addressing the dangers of education Orr (1994) questions the omission of "love, the most powerful of human emotions, in relation to science, the most powerful and far-reaching of human activities" (p. 44). After all, the best science is driven by passion, and emotions must have been important to humans over time or they would not be present among humans today. Orr gives E.O. Wilson's (1992) theory of "biophilia," or the inherent affinity of humans for the living, as a source of hope for humanity. Through biophilia, care and love for the environment can be developed among humans, followed by more sustainable choices. Orr (1994) notes that human survival in a more sustainable past depended on moral participation in a mutualistic and cooperative interdependence among humans, or a "moral ecology" (p. 62). Reestablishment of human community and inclusion of morals and values in education will result in replenishment of human spirit. Orr (1992) adds that the transition to a sustainable society will require "an uncompromising commitment to life and its preservation. Anything less is morally indefensible" (p. 133).

Orr (2006a) explores the importance in education of *place*, a concept that refers to composition of an environment and associated experiences. Having a *sense of place* separates temporary "residents" from more permanent "dwellers," rooted in a particular place with knowledge, care and even love. Historically, dwellers are good neighbors and psychologically healthy due to the development of mind with natural environment. They contrast sharply with the modern day "cult of homelessness" -- wanderers -- resulting from the "unraveling of community

structure and ecological integrity" (Orr, 1992, p. 131). Orr (2006b) emphasizes that relationship with place is not an endeavor of humans alone, and that although a lifetime of schooling is irrelevant to what is required to live well on the land, school is a significant place to start. This relationship with place comes by no other means than time spent with the natural environment.

In *Ecological Literacy: Educating our Children for a Sustainable Future* (Stone & Barlow, 2006), ecological literacy is further developed by other writers along with Orr and grounded in examples of sustainable action. These experiences support the idea of sustainability as not solely a thing of the past or a hopeful cheer for the future, but an active reality in the here and now found in the integrity of nature. In the Stone and Barlow introduction, Capra (2006) simplifies life on Earth to basic repeating patterns of web, cycles and flow within nested systems connecting through time and space, which serves as a reminder that sustainability is not new and is not lost. Recognition of the analogous structure of all systems provides a framework for understanding ecology. Natural systems provide a proven model of design for manmade systems.

2.3 Summary

In sum, Orr's (1992, 1994) words are that we are in a "crisis of sustainability." According to Orr, the U.S education system teaches for human economic success without teaching the ecological basis for the economy. Thus, "ultimately, the ecological crisis is a crisis of education" (Orr, 1996, p.9). Ecological literacy reflects "what should be" in education -- a theory of schooling. Using natural systems as a model for understanding ecology, ecological literacy draws on biophilia to reestablish among humans a sense of place in the natural environment. Through strengthened relationships based in morals, we will choose and act for the good of the whole.

3 Challenges of David Orr's Theory of Ecological Literacy

3.1 Introduction

Some major points of David Orr's theory provide a beginning definition for "ecological literacy" while illuminating the uniqueness of its application to individual and shared experiences as well as the ecosystems in which they are situated. Analysis of different writings regarding Orr's theory over a period of two decades allows for observation of how his theory developed over time. In this next segment, areas that could have been further developed will be addressed. Let's now analyze Orr's theory of ecological literacy.

3.2 Limitations of Orr's Theory

One main limitation of Orr's (1992, 1994, 2006a) theory of ecological literacy is that it is based on the premise of ecological or "environmental crisis." Environmental philosophers often use scientific ideas to support the idea of an ecological crisis even when actual crisis cannot be *proven* by the sciences (Mueller, 2008b). While degradation of the Earth's natural resources is apparent along with the loss of habitat and biodiversity due to the encroachment of a growing human population, the Earth itself would not be in a crisis if it were not for humans and our ideals and actions. In the event that global warming goes unchecked, severely altering species diversity, food availability for all, and the ecological infrastructure on which we all depend, there is likely to be human suffering and loss -- however, the Earth will balance itself eventually. So the concerns over crisis are really related to humans rather than the Earth's diverse ecosystems.

The impact of one mass extinction theory -- the meteor that killed the dinosaurs -- destroyed enough life to change the levels of CO_2 and cause a massive "Ice Age." Through volcanism and the reestablishment of living organisms, the atmosphere of the Earth changed to promote warmer conditions allowing tremendous biodiversity to thrive. The Earth is a system with checks and balances just like human systems. We must recognize that humans are part of this system of balances. Saying that the Earth is "in crises" has very short-term impacts in comparison to the longer-term impacts that are possible when people recognize the conditions of the places where they live in such a way that they participate more fully in decision-making and advocate more fully for the Earth's other species and physical places. This notion is evidenced by an environmental movement that has been around since the late 1800s but is just beginning to gain widespread awareness and acceptance in the United States. Individuals make shorter-term changes when confronted with crises. However, what about the longer-term goals of sustainability for humankind and how people should live with one another and the Earth? The ecological crisis approach seems to limit these longer term goals of ecological literacy, which is why ecological literacy needs something larger than the "ecological crisis" perspective.

David Sobel (1986) says that laying the weight of the Earth's problems on children may lead to techniques of protecting and preserving themselves from the responsibility and pain of saving the environment, literally turning them away from the outdoors all together. Sobel says we need to move beyond "ecophobia," or a fear of the natural environment, possibly triggered by terms like "crisis," and to do so by guiding children in getting to know their local outdoor places. This suggestion could be extended without resistance to all humans regardless of age, gender, or cultural and ecological backgrounds. By *not* promoting fear of the natural environment,

educators are better able to focus on cultivating love and awakening, or an inherent *biophilia* (Wilson, 1989, 2003).

Examples of sustainability and educational success stories in Stone and Barlow (2006) are evidence that ecological literacy is possible without the limitations of an "eco-crisis." "Ecological crisis" surely does not have the feeling of eminence for those involved in the Edible Schoolyard and STRAW projects as it does for those encountering the term without the same collection of life skills and experiences. The educators of these successful programs do not rely on the limits of an ecological crisis to stimulate ecological literacy. Orr's (1992, 1994) use of "crisis" misguides those in pursuit of encouraging science based on the resilience of the Earth. Ecological crisis serves to limit children's ability to "thinking about" the Earth rather than to "thinking with" the Earth, meaning thoughts guided by observations of the relationships and processes in the natural environment. Orr's statement regarding "ecological crisis as an educational crisis" is not true for all educators, which is an important exclusion to his theory. Teachers are already incorporating the outdoors and skills and experiences of others in lessons and promoting love and stewardship of the Earth in many contexts around the world.

Ecological literacy provides the basis for making just choices, such as taking into consideration the needs of others over personal wants. This also depends on the existence of morals or values that consider and give weight to the needs of others. But using an ecological crisis narrative to support moving in the direction of ecological literacy is premised on the idea that science is more legitimate for getting people to change their lifestyles because of the high status that science has in society. Unfortunately, science has not historically addressed how ethics and morals are a large part of doing science. Instead science has presented itself as void of these things. In science classrooms, ethics and morals are only now starting to gain popularity

with teachers. Interestingly, ethics and morals are not part of many states' standards, and a knowledge of how ethics and morals influences scientific work will not be tested on high-stakes exams. A contradictory idea is that Orr reinforces using higher status knowledges to promote science and that of ecological literacy even while he emphasizes the need for values as part of what it takes to be ecologically literate. The ecological crisis narrative serves to limit what kind of education students will encounter in their science classrooms, and ultimately, creates a gap between what students can know and an impossible standard of certainty underlying the sciences.

Orr goes beyond the inclusion of morals in the classroom and ventures to say that in order to reach sustainability, there is a need for biophilia as a "religion" (Orr, 1994). Recognizing an inherent characteristic such as biophilia as a common thread among all humans is a strong foundation for integration. However, in the U.S. public education system and in society in general, the mention of religion or morals is cause for a separation based on a fear of the loss of individuality. This separation translates into a lack of direction that is obvious among students, especially those of middle school age. As the roles of family and church in the lives of youth have changed from those of the past, the relaying of values is becoming more of a responsibility of schools. Overlooking morals and values among humans is overlooking an aspect of humanity. Rather than drawing attention to "religion" and connoting an image of integration of church and state, biophilia should be recognized for its part in the development of care and as an imperative for ecological literacy. Care is something that many people value and respect when approaching questions of how we should live together with Earth, other species, and physical environments.

Orr (1992, 1994) does not extend ecological literacy specifically to science education. The science classroom is an exemplary place for the implementation of ecological literacy and the interdisciplinary aspect of ecological literacy (by description) embodies the nature of science.

The science standards (NRC, 1996) emphasize observation, communication and honesty along with using models to see patterns, systems and cycles, and understanding that science methods are shaped and defined through problem solving, and inherent change and uncertainty. Realizing the interconnectedness of these aspects of thinking and being as part of what constitutes ecological literacy is aligned with what Orr advocates. Moreover, the realization of and existence of values, morals and ethics, in science and education are necessary. Orr's idea that all education is environmental education resonates with Dewey's (1938) theory that all education is moral education for it should not be considered education if not moral. Schools are moral subjects too. Since science classrooms are part of what constitutes schooling, a large part of morality is omitted when teachers fail to recognize the morality of including just relations for other species.

In Orr's (1992) earlier work the absence of examples for how to implement ecological literacy in practice creates a pragmatic disconnection between imagination and reality and between theory and practice. However Orr's work is amended by his collaborators presented in Stone and Barlow (2006) which offers effective models of putting creative connective ideas into action (through the Center for Ecological Literacy based in Berkeley California). It has been noted by science education researchers surveying science teachers that the vast majority surveyed see environmental education as being driven by their personal interests (Cutter-MacKenzie & Smith, 2003). In Stone and Barlow (2006) a similar motivation is recounted, or among teachers there are those who prefer to incorporate the natural environment as a teaching topic and tool and those who are indifferent to the need for the natural environment in their work. Although this seems like a block to the implementation of projects incorporating the ideals of ecological literacy, Stone and Barlow (2006) give several accounts of school-centered environmental project-based learning that turn out to be successful even after the original

resistance of teachers. They point to the examples of Martin Luther King Jr. Middle School in Berkeley, CA (MLK), the Mary E. Silveira School in San Raphael, CA and the STRAW (Students and Teachers Restoring a Watershed) project also based in the San Francisco Bay Area, which serve as pragmatic models of the underlying theory girding ecological literacy.

More specifically, at MLK, students and teachers continue to work on an "edible schoolyard project" in which they have transformed an asphalt parking lot into a kitchen garden. Students grow, cook and serve the food making an obvious connection between what they eat and where it comes from while learning skills that strengthen social and community structures. The principal at MLK notes that this project enhances cultural experiences and creates a renewed food culture within their school. The process that the administration, teachers and parents went through in order to begin the project is outlined in Stone & Barlow (2006). The difficulty in implementing such a project is outlined as well. One of the main points discussed is the transformation made possible at this school when the principal included the teachers as part of the decision-making team. Without their buy-in, there would not be an edible schoolyard project. The principal knew that for this idea to work "the teacher has to want to do it" (p. 140). Another adjustment that allows this project to work at MLK is the implementation of a "block schedule" allowing enough time for teachers to work within a curriculum that permits enough time to go outdoors and which allows students to move around and learn by experiencing the outdoors. The outdoors could have easily been restricted, but in this case, administrators and teachers worked together to make sure the project would move ahead by taking slow steps and involving parents.

Another example is Silveira (Stone & Barlow, 2006), where students apply for jobs and work at school. This is reminiscent of one of Dewey's (1938) visions that the school is a microcosm of society. Student jobs range from waste management, to garden assistants, to

conflict resolution counseling. The structure of learning created within this school reflects a model of an interconnected network rather than the hierarchical tiers of a pyramid that are often established among the students, teachers, parents and administration or among the employees and supervisors of offices or businesses. The development of social skills is highlighted and results in a sense of pride, responsibility, ability and self-worth amongst students, along with a profound sense of place, which works towards fostering an ecologically literate student body.

Yet another example, the STRAW project (Stone & Barlow, 2006) exemplifies what a concerted willingness to work towards ecological literacy looks like for teachers, students and citizens working together. Triggered by a concerned student after a film about endangered rainforest species, a fourth grade teacher finds a way to involve her students in adopting an endangered freshwater shrimp species native to their area in California. So students research it. They find that the California freshwater shrimp is endangered due to habitat destruction and the result of cattle living adjacent to the stream habitats. The teacher makes arrangements with a local rancher to begin a stream restoration project that involves planting a buffer of native plants alongside the stream to uptake excess nutrients from cattle waste, and to put up a fence to keep cattle out of the stream itself and to restore the stream bank. This project continues for fifteen years on neighboring lands and eventually develops into a forested corridor that has increased the number of shrimp and also the diversity of plants, birds and other species in the area. The original class of students is interviewed years later and many students comment on what a defining experience this project is in their lives. The teacher that heads up the project comments that one great lesson she learns is “realizing that kids don’t need immediate payoffs” (p. 167). This is evidence that although effects are not necessarily seen immediately, ecological literacy methods of learning result in experiential lessons of a lifetime that carry forward into adulthood.

3.3 Summary

Orr's (1992, 1994, 2006) theory of ecological literacy is misguided in its foundational focus on ecological crisis. This focus invokes fear and actually feeds into an already present fear of the unknown or fear of uncertainty. This opposes the intention proposed by ecological literacy, the underlying intention of education in general, and especially the uncertain process-oriented nature of science. Invoking fear does not coincide with Dewey's (1938) emphasis on influential effects of experience and education, and perhaps does not contribute to morality in education. The examples provided of successful educational projects are not guided by this "air" of crisis-talk.

Moreover Orr's theory (1992, 1994, 2006), while well developed in regard to the breadth and depth of its meaning, is underdeveloped in its vision of implementation in science education. Orr's vision becomes better defined with the examples of projects given by Stone and Barlow (2006), which show the continuing solidification of his theory through an application of its defining principles. The success of these projects, incorporating the principles of Orr's ecological literacy is evidence that the use of an ecological crisis again is too limiting for how we are to live with each other and with the Earth over the longer-term. Including the natural environment in classroom education teaches concepts in a poignant manner, nurtures human relationships, and cultural traditions, and fosters meaningful connections with place, ecosystems, and other species.

4 Modifications

4.1 Introduction

In the previous segment, the limitations of David Orr's theory of ecological literacy were presented. These limitations exist in areas in which further development would contribute to the understanding and the application of Orr's theory. Modifications and possible extensions for Orr's theory will be introduced here. Orr uses the thoughts of other great thinkers such as E.O. Wilson's biophilia (1984, 2003) to elaborate on his own ideas. But Orr may not go into enough depth such that biophilia will be understood in a way that is effective in school. Biophilia will be used in conjunction with ecojustice theory (Bowers, 2004; Mueller, 2008a, 2008b), which Orr has not used to better support ecological literacy. A synthesized biophilia and ecojustice will be examined here for the purpose of amending gaps in Orr's ecological literacy and extending it to relevant topics in science teaching. Now let's explore modifications to Orr for science education.

4.2 Biophilia

Edward O. Wilson (1984, 2003), coined the phrase *biophilia* which he believes applies to the mystery of life he learned through a lifelong study of ants. Biophilia is the notion that humans are innately drawn to the life and natural processes outside of human life. Wilson summarizes this idea as the "innate tendency to focus on life and life-like process" (1984, p. 1). His development of biophilia recognizes an association between humans and the rest of nature that is genetically-based and culturally inspired, beginning in human evolution with the emergence of the genus *Homo.* Accompanying Wilson's hypothesis are the following assumptions: biophilia is

inherent and biologically based; it is part of our species' evolutionary heritage; it is associated with human genetic fitness; it is likely to increase the possibility of personal fulfillment; and it is the basis for a human ethic of care and conservation of nature (Kellert & Wilson, 1993). An innate affiliation for nature is recognized to pertain for physical survival needs such a food and shelter and also for psychological human survival needs such as aesthetic affiliation to the Earth. Biophilia is further defined by *biophobia*, or an innate fear of living things. Biophobia is considered to exist because of biophilia, and thus, is a subset of it. Biophobia is an expression of the remnants of "biophilic learning rules" that remain in humans, although atrophied, still attached to symbolic artifacts, such as snakes from generation to generation, even upon removal from nature (Kellert & Wilson, 1993, p. 32). These rules go beyond instinct and are learned responses that have remained part of the human genetic package due to gene-culture *coevolution*.

Wilson (1984) names the loss of biological diversity as the "folly our descendants are least likely to forgive us." (p. 121) and Wilson asks the question: "Is it possible that humanity will love life enough to save it?" (p. 145). In order to answer this question, Wilson recommends that we "look to the very roots of motivation and understand why, in what circumstances and on which occasions, we cherish and protect life" (pp. 138-139).

Where do the roots of motivation lie? The motivation of a single person is as unique as that individual and yet the effects extending from choices based in motivation reach many. One educational psychologist has created a formula to better understand motivation (Knapp, 2002). The formula of "expectancy x value" relates motivation to two main factors, expectancy of being able to complete a task and the value of successfully completing it. Some examples of influences of expectancy are: self-efficacy, support, time and resources, and locus of control or the feeling of having control over one's own success. Some examples of influences of value are: intrinsic

interest, instrumental value, prior need status, self-image, relational value (i.e., valuable to beings that we care about), and risk, or the balance between penalty for failure and penalty for trying (Knapp, 2002). This formula is useful for educators in understanding students and structuring lessons to suit the various backgrounds of learners for it takes into account the variability that is associated with individuality. It can be applied to any subject matter including choices regarding the environment. Morals, however, and their value to the individual, determine whether the outcome is a moral choice. For example, if a student holds his or her self-image above their relational value, they will make a moral choice for self over others.

This brings us back to Orr (1992, 1994) and his call for the reestablishment of the moral ecology that governed the actions of ancient humans, or ecological virtue (Orr, 1994, p. 62). For example, the return of a widespread practice of mutual dependence among humans similar to the past, or those who retain their past, embody the virtues of an ecological history of embeddedness. Without the reminders of morality that are provided through experiences in nature and embodied in some communities, many humans operate without the *patience* required to wait past the shorter-term goals of instant gratification and the *trust* that gratification will be experienced in the longer-term. Instant gratification associated with financial success has led us to a lack of faith in the relationships of living well with the land, and thus, a lack of moral reciprocity with ecosystems. Many of us are not willing to wait for or even to look for evidence that making a choice for "others" -- meaning other humans and other biological species -- will eventually get us what we need. Is biophilia, or the human love of life, strong enough to "save" life as we know it? "If biophilia is destined to become a powerful force for conservation then it must become a religion-like movement" (Kellert & Wilson, 1993, p. 454). Only a religion-like movement will

have the power and momentum to overcome the generally accepted greed and promotion of some Western views and why natural environments should be shared in common (Hardin, 1968).

Orr (1992, 1994) states that in order to move toward sustainability through ecological literacy coupled with a biophilia revolution, there must be changes included in science education. He lists these as the recovery of childhood, the recovery of a sense of place, the establishment of a new covenant with animals, and the incorporation of a love for the natural world in education, economics, and patriotism (Orr, 1994). In other words, by striving to get ahead in an economically successful present, we rush our children past childhood, leave them few options for developing feelings of belonging or care for places and the other species that inhabit them. It's difficult to love without a sense of care, and difficult to care without a sense of knowing place.

Orr (1992, 1994) states that the required transition within biophilia from eros to agape will remain partial until all animals are recognized as having value (Orr, 1994) or what ecojustice scholars (Bowers, 2004; Mueller, 2008b) describe as moral reciprocity. Many Americans have a prejudice with regards to other species that they must overcome (Lopez, 1989). Moreover, many Americans ought to learn to see all species as having *intrinsic value* that is value simply in being itself, not *instrumental value* alone, such as the value given for animals that are used by humans. Frederick Ferré (1993) recognized that the intrinsic value of everything is based on the "tendency to prefer," a characteristic that can even apply to electrons. There is a great deal more that humans would learn from recognizing the moral worth of other species, such as lessons in courtesy that can found in the "etiquette of the wild" (Snyder, 1990, pp. 3-24). Sharing and caring are essential to ecological wellbeing. My argument is that all education is environmental and moral education.

4.3 Ecojustice

Ecojustice perspectives analyze the destruction of the world's ecosystems and cultures and methods with which to resist this destruction of natural and cultural commons (Bowers, 1996, 2004; Martusewicz, 2007; Mueller, 2008a, 2008b). Ecojustice extends social justice to ecological well being, environmental issues, and a recognition of the significance of preserving the cultural and environmental commons and the role that they play in maintaining the integrity of the Earth. Ecojustice ethics brings into the foreground the moral consideration of species other than humans (Mueller, 2008b). I would argue that ecojustice is compatible with biophilia and ecojustice ethics takes ecological literacy a step further to the consideration of morals and values.

The work of Chet Bowers (1996, 2004), an influential writer of ecological philosophy helps us to better understand ecojustice. For Bowers (1996) the commons represent natural systems, including air, water, soil, and others and cultural systems, such as arts, ceremonies and intergenerational knowledges. The commons should be shared by all without cost. This idea differs from Hardin's (1968) commons. With the globalization of the economy there has come a reduction of diversity in the commons. Bowers calls for educational reform that emphasizes conservation and the revitalization of the commons by incorporating more sustainable practices.

Bowers (1996) addresses the cultural implications of Orr's statement of "all education is environmental education" by pointing out that some environmental education is actually destructive to nature. This idea, according to Bowers, is because environmental education may at times come from an economic perspective, which involves the natural world as a resource only. Bowers restates Orr's statement in the following way: "all forms of communication essential to sustaining cultural patterns are part of the process of environmental education" (Bowers, 1996, p. 6). To further ensure the appropriate consideration of cultural conservation, Bowers amends

ecological literacy "to include an awareness of how the assumptions, values, technologies, and categories of thinking of a culture influence how humans relate to the environment" (p. 6).

While the loss of nature is important for some humans who extend feelings toward other living things -- animals and plants -- and even to inanimate objects like rocks, there are other humans that do not consider other species as deserving the equal consideration of humans. For those who do not see that other species deserve moral and subjective considerations, it is necessary to point out that by not preserving the commons, the preservation of humankind also suffers. This emphasis on humankind hits "closer to home" and is more likely to strike a chord signaling the need for action promoting conservation. To assist in understanding the rights of others, methods of approaching ethics have been established to help determine right relationships (or just, good, and healthy relationships).

While Bowers (1996, 2004) lays out why ecojustice ethics are necessary, Mueller (2008b) has connected ecojustice with a morally defensible environmentalism of *biocentric pluralism*, based on James Sterba's (1995, as cited in Mueller, 2008b) "principles of biocentric pluralism." This ethic is "life-centered" and provides a defense for the moral consideration of all living things through environmentalism. Biocentric pluralism moves beyond the individualistic connotation of *biocentrism* and brings into perspective ecological wholes, such as ecosystems and species. The principles of biocentric pluralism are based on the following principles:

> (a) A Principle of Human Defense – Actions that defend oneself and other humans beings against harmful aggression even when they necessitate killing or harming individuals animals or plants or even destroying whole species pr ecosystems.
>
> (b) A Principle of Human Preservation - Actions that are necessary for meeting one's basic needs or the basic needs of other human beings are permissible even when they require aggressing against the basic needs of individual animals and plants even of whole species or ecosystems.

(c) A Principle of Disproportionality – Actions that meet nonbasic or luxury needs of humans are prohibited when they aggress against the basic needs of individual animals and plants, or whole species or ecosystems.

(d) A Principle of Restitution – Appropriate reparation or compensation is required whenever the other principles have been violated (Sterba, 2001, pp. 33-49, as cited in Mueller, 2008b).

Biocentric pluralism (Mueller, 2008b; Sterba, 1995) is an ethic that extends moral consideration not only to other species but to the needs implicit within ecosystems required for their survival. Even rocks are worthy of moral consideration for they greatly contribute to the maintenance of the integrity of the whole. Rocks give minerals to the soil as they are weathered by rain; they provide substrate for the collection of particles encouraging soil formation and subsequent seed germination; and they provide a surface allowing solar warming of the cold-blooded lizard that becomes food for the birds of prey (that humans enjoy watching). In accordance with principles of biocentric pluralism, conservation of the environmental commons includes everything found in nature, recognizing that everything has a reason for existing and everything is interdependent.

The U.S. educational system has a history of striving to provide opportunities that are equitable to all. We call this social justice. Great strides have been made in multicultural, technological, and special education movements nationally and abroad. These movements focus on the backgrounds of learners and the individual experiences they bring with them to the classroom. Without providing students with opportunities to experience the natural environment, the educational system is not addressing a depleted area of ecological knowledge and thus not preparing our nation's students for their future. Cultural and ecological awareness go hand in hand for culture is based in ecology. Thus ecological justice is essential if not more important. Initiatives need to encourage the passing on of cultural knowledge in order to maintain these aspects of human existence and reproduction supported by nature. By not acting to prevent the

destruction of the commons, educators are not acting justly or morally. Public schools are the place for this education as well. Moral education cannot be divorced from public school as much as we would like it to be. With a focused attempt to revitalize ecological and cultural knowledge, there is a danger in not including moral and just choices in school for human behaviors may continue that are destructive to the cultural and environmental commons in spite of knowledge. So what is the recipe for behavioral change?

Consider that parents realize that children emulate the behavior of adults. At what point do adults realize that they are not only responsible for making choices that promote the preservation of the commons but also responsible for showing youth the way to do so also? Evolutionarily, and thus physiologically and behaviorally, the main purpose of humanity has been to reproduce and survive over the long-term; preserving the commons is necessary indeed.

Mueller (2008a, 2008b) has connected the need for responsible action in the face of uncertainty to humility (which is a non-arrogant stance towards the stories of others and Earth). By recognizing our strengths and limitations, humans are better prepared for ecological surprises (Mueller, 2008b; Mueller & Tippins, in press). It is with the recognition of humility that we also recognize our geography in relation with others' and the importance of the others in maintaining integrity of the whole. By realizing our place in the many relationships of the Earth, we realize our responsibility by better knowing ourselves. Perhaps, it is *humility* that is the mightiest word.

Orr's (1992, 1994) extension of ecological literacy specifically to science education is not necessarily present in words. It is, however, certainly alluded to in its essence. This essence was captured by John Dewey (1925) as well. Science, like nature, is ever-changing, cyclical and uncertain. It is open to contributions developed through our curiosity regardless of our backgrounds. Science stems simply from asking a question and addressing a problem. The

scientific processes encourage experience by way of inquiry through hands-on activities and an engaged thought process. It becomes stronger through collaboration and more life experiences. The scientific knowledge regarding nature that results from these questions is ancient and the process by which it is garnered is not limited to the human species. Science and education are embedded in experience. The experience of science reflects the structures, processes and relationships observed in nature. In the science classroom, the relationships among teachers and students encompass the collective experiences that compose each individual. As humans are a part of nature, to attempt to understand the relationships among humans is similar to understanding the relationships among other species. We are not that different from other species except for the capability humans have for making immoral and unjust choices. Or at least it has not been shown that nonhuman animals make immoral and unjust choices. Yes, we can also attend to *humility*.

Biophilia and ecojustice are explored as modes of extending Orr's ecological literacy. These perspectives have a basis in our understanding of genes, culture and morality, all of which are aspects of human life. Because of the significant relationships among all living things, and because humans are experiential learners, and because science education is based in experience, it is logical to assume that science education can be extended to include biophilia and ecojustice. For science and science education are human endeavors, stemming from human questions and our problems. Science is a human endeavor and with that are more than human choices embedded in morals and ethics. It follows that science education is morally reciprocal education.

4.4 Counterarguments

Although it is logically possible to create a pathway connecting science education and morals, it might be argued that due to the differences in their philosophical foundations, science and moral education are incompatible and that they lack parallelism and thus should remain disconnected.

The field of science is defined by generally accepted concepts, processes and scientific facts. Among modern scientists, or those who work in science fields, there is a general consensus of agreement regarding what defines science. Part of this definition pertains to what facts, concepts, and processes are relevant to one who participates in science. There are generally accepted and established sets of rules for attaining scientific facts, and generally accepted and established sets of rules for accepting evidence that are agreed upon by scientists worldwide. Despite the sociology of science and other philosophical literature that may claim otherwise, there is a large consensus about what professional scientists do which separates scientific work from other types of professional careers outside of science. Can the same judgments about "what is science" be made if the term 'morality' is substituted for 'facts, concepts, processes' and the term 'moralists' for 'scientists?' There is not nearly as much consensus about whether morals should be part of *science education*, and there is not as much consensus as there is in science about morality (by moralists) as there is a consensus about what scientists use to do their work.

In fact, there are long-standing, historical disagreements between moralists about what constitutes right and wrong. In comparison to science, there is far more ambiguity regarding the rules associated with arriving at a right or wrong answer. In other words, if the analogy of both fields of study with the construction of a building is made, both fields will involve a process that results in a structure for professionals. In morality, varying designs and building materials are acceptable, while in science, these designs and materials are generally restricted to what are the

most accepted and reliable methods. In a science classroom composed of unique individuals, many of whom that have moral foundations already constructed: where does an educator begin to address morality? Whose morality and by which moral processes should students be guided?

To avoid being misunderstood, I want to make clear that science is not in question, but that the narrower field of science education is being examined in this thesis. Likewise, it is not general morality in question, but a reciprocal morality regarding other than human species and the physical environment. As morality stems from shared individuals' value systems and emotional beliefs, it follows that morals regarding the natural environment can be deep-seated. These values and beliefs frame how we act in the world. Although it is generally agreed that lessons regarding values or values education can take place anywhere (e.g., classroom or home), or anywhere someone more experienced guides someone less experienced in establishing values that underlie behaviors, there are varying thoughts regarding the approach by which this education takes place. Values education may be deemed a transmission of a set of shared values that originate in a sect, or societal, cultural or religious milieu. Values may be deemed a process of self-realization regarding what constitutes good behavior and what effects that behavior has on one's self and surrounding community. Typically, morals extend from personal values shared by individuals and underlie intents of individuals, based on right and wrong. A system of morals or a more formalized set of "rules" generally accepted by a group of people is an ethic. To incorporate moral education as part of science education through ecological literacy involving, for example, biophilia and ecojustice simply means to incorporate more inclusive perspectives regarding the environment, which include other species and shared natural environments. Students will be better informed regarding the relationships of ecosystems, the place of humans within ecosystems and the responsibilities of humans for the conservation of ecosystems, and for

the protection of other species. Aforementioned is the larger picture that this ethic involves the development of care for others. Mere presentation of information regarding the profundity of ecological relationships carries inherent value with it. To choose not to present this information in order to not introduce values is to deny students of a complete and accurate larger perspective (which should rightly be called "the more informed ecological or natural systems perspective"). In response to the question of "whose morals" is whether this question is limited to humans, and shifting beyond anthropocentrism will require that morals of the learners upon which morality is built considers eco-pluralism. Biocentric pluralism is a morally defensible environmentalism for ecological literacy, as I have argued with others (Mueller, 2008b). This morality is school-specific and depends on the schools embeddedness in geographic location and cultural background and experience of learners. The key point is that this ethic already exists in nature. It should be drawn out and developed sensitive to ecological information and experience in the natural environment. We all know deep down that it is good to be kind and respectful to 'others.'

Another counterargument regarding moral development as part of science education is found in the logistics of today's schooling. If time and curriculum are constraints, and educators need to select some things over others (i.e., because not everything can be taught during a period of time), then what is most important in a class which is labeled "science?" To parents, teachers and administrators striving to provide the most fruitful opportunities to our nation's youth, and to students interested in constructing the best foundations for financial opportunity in a capitalist society, a significant concern is with regard to the importance of content conveyed and how well time is spent conveying content. In response to this concern, we are reminded by Dewey (1925) that knowledge does not exist without action. Scientific information that is provided in a way that is void of the promotion of value, results in actions limited to that of regurgitating concepts.

Historically informed, we know that the nature of science continues to evolve. Science exists because of actions put forward in an attempt to solve problems and answer questions that were originally deemed important by what is valued at a particular time period. The science classroom is a model of problem solving that is required of youth as they enter adulthood. But morals and values are already present as students walk through the doors of the science class. Inherent biophilia and an implicit value for living things (including human life) are not separate from the associated acts by which scientific information can be more deeply be appreciated and applied, which is built upon experience. Public and private values and morals give our science information meaning, while promoting actions and the ongoing development of our knowledge.

In recent decades in the U.S. education system, technology and engineering have been given additional merit and have been moved to the forefront of approaches to teaching science. Although technology and engineering are not "pure science" but "applied science," the case has been made that they are relevant for and should be included in the science classroom (e.g., Science-Technology-Society [STS]). This relevance for science education is based on our needs. In a competitive global economy, it is realized that youth need to learn how to apply science, and not just how to memorize scientific facts. This need led to a paradigm shift in the mid-1900s. In fact, STEM (science-technology-engineering-mathematics) is an integral part of science education now. That funding in the form of National Science Foundation (NSF) grants is based on STEM fields now more than ever is evidence of the recognized importance of applied science in science education along with the many programs that now exist to support its implementation. STEM now includes professional learning for in-service teachers, pre-service teacher training, and curriculum resources all aimed at guiding students towards STEM fields. The case for STEM can also be applied to an emerging environmental awareness. There is a rapidly

increasing environmental awareness amongst youth. The recognition of diminished resources and the need for an adjustment in how we go about using them is apparent. It is time for another shift, this time to recognize why morality is an integral part of humanity in science education.

Moral development in the science classroom is simply recognizing the morality that already exists with some cultural groups and how it can be applied to better understanding the evolving nature of science and science of nature. Understanding how relationships that exist in the ecological world support human life is "applied morality." This morality plays an important role as youth-becoming-adults begin to grapple with a rapidly increasing human population and natural habitats that could continue to be manipulated and destroyed. There are choices before us (Bowers, 2004; Mueller, 2008b).

An example of applied morality can be found in the following hypothetical situation. Let's say there is an area of expensive property surrounding a lake intended for bass fishing. And, let's say property and homeowners have formed an association with intentions of promoting bass fishing, and for that reason, favor the presence of a certain water plant that provides breeding grounds and habitat for food of bass. Researchers have discovered that a certain toxic bacteria, associated solely and specifically with this certain plant, is responsible for a fatal condition in bald eagles, a species that is not only a national symbol but also has only recently been removed from the endangered species list. The water plant also serves as a superior purifier of the fertilizer run-off from the homeowners' lawns and the additional nutrients from waterfowl that visit the lake. Eagle researchers are calling for action and want to remove the water plant before more eagles are lost to toxins. Adding more complexity, water quality analysts downstream are concerned with issues of eutrophism that will result from the removal of this plant. The homeowners want to continue to enjoy green lawns and sport fishing for which they

are paying top dollar in association fees. The complexity of this situation necessitates some ethical consideration along with the development of a scientific understanding of the ecology of the lake. How does one consider the needs of all stakeholders, including nonhuman species and physical environments, in order to make a choice that is the most just and right, and which is good for all? This scenario demonstrates one of many modern day cultural and environmental situations that will require humans to use humility to approach the larger picture and consider the best decision.

And there may be multiple decisions. Because of the increasing need for decisions and actions, there is more of a need for public understanding of ecology science and environmental ethics. Scientists realize they have been leaving out the general public by not conveying scientific information in a manner that can be understood and inform (e.g., Jordan et al., 2008). This is much like proceeding without explaining the rules and penalizing individuals for not abiding by them (e.g., Delpit, 1988). To recognize that the classroom can also lead to a lack of understanding of the ecology of Earth, and thus, a lack of proper preparation of students for being informed in a decision-making process regarding limited resources that are to support them, could be construed as an intentional attempt to keep those who are uninformed, unempowered and not included in the dominant culture of U.S. life, thus left out of the decision-making process. It also keeps some individuals dependent on those of the dominant culture, assumed unworthy of stakeholder status and left without a voice. It is these individuals of minority cultures who often live closest to the environmental issues, such as areas of poor water quality and toxic landfills and thus have first hand knowledge of.their detrimental effects on the health of ecosystems, including humans.

4.5 Summary

Morality is part of what constitutes science education. Morals cannot be separated from students, or the teachable moments grasped by the teacher. They are present in the ethical treatment of the class rat, and in the one point of a lesson or one lesson of a school year that finds a suitable environment for germination within a child's mind to grow, framing future choices and actions. Morality reciprocation also exists in nature, and nature is a most certainly well suited for science. Science education that recognizes morality is more familiar and welcoming to children than high status science knowledge claiming to "prove" the ecological crisis. Science education that nurtures a child's sense of wonder, and draws on the underlying biophilia of individuals in relation to nature lends to the development of moral consideration for diverse ecosystems. It is time to recognize that love and justice cannot be separated from science education and that humility is an essential part of what it takes to participate in a scientific understanding of Earth. By extending ecological literacy with ecojustice and supporting it with biophilia, a unique perspective is established that is comprised of interrelationships, just choices, and a moral consideration that extends beyond humans to ecosystems. This literacy perspective recognizes responsibility in the conservation of the cultural and environmental commons in good teaching. But it will be the continuing development of ecological literacy through practical application and sustainable education that takes it beyond the crisis suggested by Orr and other environmental philosophers. Ecological literacy is our means towards a sustainable future. In the continuing evolution of our Earthly existence, the favored feature of natural selection will be sustainability.

5 Recommendations

5.1 Introduction

The previous chapters analyze, amend and extend David Orr's theory of ecological literacy to advance his theory in science education and provide fruitful directions for school-wide reforms. Through philosophical analysis and a lens of American pragmatism, ecological literacy is understood as a holistic and experiential approach to education drawing on the environment and particular backgrounds of learners. Analysis of Orr's three literary works assists in the development of a thorough definition and clarification of ecological literacy and of the human view of nature. Biophilia and ecojustice strengthen ecological literacy and further advance it. My theory of ecological literacy encompasses pragmatic experiences, cultural tradition, community, morality, ecological knowledge, and the acknowledgement of ecological relationships. Based on my work, I will now provide some possible applications and envisioned implementation of ecological literacy theory and how it enhances models of middle school learning communities.

5.2 Fruitful Directions for Science Educators

Although all stages of education will benefit from the incorporation of biophilia and morality as part of ecological literacy, there is no stage in greater need of a focus on ecological literacy than during the middle school years. Students of this age are completing a passage from childhood to adulthood, a critical age in preparing future decision-makers. They are but a few years away from driving, working, voting, paying taxes and parenting. Educators serve as guides to our nation's youth in understanding the ecological foundation of the resources our youth will inherit.

Education in middle school requires more than teachers and students. Parents, siblings, grandparents, neighbors, preachers, mentors, school staff and faculty are all vital to middle school learning. These community members all share some responsibility in the learning process of today's youth in addition to learning reciprocally from one another. Each of the above possesses valuable knowledge and skills, beliefs and values, culture and experiences to offer in the learning process. Sharing these knowledges and experiences enhances the development and understanding of differences across languages, cultures, behaviors, learning styles, and family values (McCaleb, 1997). Sharing also helps students to recognize the support that is available to them in these influential years. Youth need to recognize that there are many people who are involved in their education and that they are part of this expanded community. "A community is the mental and spiritual condition of knowing that the place is shared, and that the people who share the place define and limit the possibilities of each other's lives" (Berry, 1969, p. 61).

My theory of ecological literacy is communal. Ecological literacy theory reflects the repeating cyclical and systematic patterns observed in the natural environment. It follows that the implementation of ecological literacy is communal as well. The community immersion model (Tippins et al, 2008) although usually applied in pre-service teacher training could also be applied to middle school science education in the United States. It is an effective method for including outdoor education and community action, harnessing the energy of middle school students while nurturing their sense of wonder and strengthening social skills and community. The community immersion model incorporates service with a field component in combination with community and cultural activities. What follows will outline a plan for implementation.

Students can begin the school year by mapping their schoolyard (cultural and environmental aspects). During this activity they get to know their place at school. Teachers will

have prior knowledge of the site and be able to point out interesting areas for more intensive investigations. Students can be encouraged to choose a reflection site. Time must be dedicated by the teacher for students to reflect solitarily in their spot weekly, biweekly or monthly. Orientation of the site through collaboration with scientists will enhance the teachers' effectiveness and could be provided for teachers as professional learning days and workshops during which teachers will earn professional learning units or the equivalent according to each school district.

Students can vote on a project for the school year or semester. These projects provide opportunities to do a larger ongoing project. For example, the students of one school year may be involved in the building of raised beds for a vegetable garden and the amending of soil to fill them. This project fits into a larger plan of eventually having multiple gardens such as pollinator or water gardens. Additional projects might include students building benches for an outdoor classroom, or a stage for presentations. Being part of a larger constructivist-oriented project is important for middle school aged students because these projects provide hands-on experiences. Other projects can include making pathways to connect the gardens or even clearing pathways to connect separate and adjacent schools with "greenways." A connection between different aged students serves as an opportunity for older and younger students to be assigned "work buddies". Students of all ages gain from having the opportunity to talk to others, especially students of a different peer group, and will find the opportunity to help others empowering and the chance to talk with new friends enlightening. Still other projects can include building birdhouses or other habitats and habitat features, or the construction of water ponds, or tool sheds. There are so many activities and curricula already available to guide teachers in teaching outdoors. Some of these curricula include Project WET, Wild, Wild Aquatic, Flying Wild, Learning Tree and The State Botanical Garden of Georgia's Garden Earth Naturalist Program, to name a few in Georgia.

Traditionally indoor activities can be adjusted for the outdoors without losing an emphasis on what needs to be taught as part of working within the framework of the state's standards. Most important is getting students outdoors and engaged in a project with an adult there to guide them.

Larger projects will require more planning, and may require the procurement of new tools and materials, and the involvement of volunteers from the community. Generally there are volunteers in every community, that is, people who are happy to share their skills, tools, supplies, and time. Many sources for funding education projects such as the ones described are provided every year through organizations such as the North American Association of Environmental Education (NAAEE) and the US National Park Service. My theory of ecological literacy for middle school reform should involve a change in priorities from inside the school building towards the outdoors. This change will require district level planning and teachers should be included as part of the planning process. Moreover, parents and other community members can play an active role in the development of outdoor classrooms that surely set the stage for cultivating ecological literacy. Regardless of how many adults become involved, we should not forget that the students must remain an important part of this decision process too.

The community immersion model, dubbed a "dialogue of life" (Tippins et al, 2008, p. 15), can be compared with Henry David Thoreau's "dialogue with place" (as noted in Orr, 1992, p. 126) which refers to the contexts that build authentic conversations with people in the community and embeddedness in one's natural surroundings. These ideas are a sweet reprieve from the consumer filled world of billboards, bumper stickers and computer screens that we are accustomed to in our society. The consequences of being embedded in the community will include changes in shared attitudes, personal health and increasing communication between community members: students, teachers, administrators, staff, parents, mentors, and so forth.

Some teachers do not choose to teach outside (Cutter-MacKenzie, 2003; McAuley, 2009). Often those who do not choose the outdoors have based their choice on their lack of knowledge regarding the environment (or time/curriculum constraints). In order to increase these teachers' comfort outdoors, they can be provided professional development opportunities and trained in outdoor settings, including methods of classroom management in the outdoors and student involvement and preparation for going outdoors. Teachers ought to be trained in grant writing specifically designed for fostered ecological literacy. Professional learning days are more likely to transition from stressful events to days of relaxation for teachers because they are able to spend time outdoors benefiting from nature. It must be remembered by all involved that teachers are role models and their treatment and perspective of environments is crucial. Teachers are individuals too and should not support the bulk of the responsibility. The efforts teachers make to include students and their individual experiences and backgrounds can also be extended to teachers. Teachers are all learners and we are all teachers. As was noted by the principal at MLK Middle School in Berkeley aforementioned in Stone and Barlow (2006), "the teachers have to want to do it," but given the support and training that is needed, they most likely will want and will select what to do to make changes in the direction of healthier students and a healthier Earth.

Administrators are likely to have concerns regarding safety and liability. For this reason, there are great success stories of similar situations from which to learn. Administrators can be reminded that events involving even greater risk occur daily. Planning and training is the key. Time may be a limiting factor for teachers. Perhaps a more interdisciplinary schedule can be discussed such as a block schedule combining subjects, for example science and social studies, or sciences from different grade levels. One intention of my theory of ecological literacy is to dissolve the walls of disciplines, and outdoor areas must be welcoming to students of all subjects

and classes, for English Language Arts students to read poetry on the constructed stage, or for Math students to create graphs of data collected from outdoor observations and investigations.

One example of a project with deeply meaningful results for students stemming from teacher interest and leading to student care is found in a middle school Habitat Club in Georgia, where a seventh grade life science teacher makes a vision a reality through the transformation of a barren field into a certified wildlife habitat. This restoration began by providing the opportunity to students to plant donated tree seedlings. Five years later, the head-high trees have newly constructed paths among them, habitat features for different species, and an outdoor classroom area, all constructed by students. Moreover, a pavilion is now used for events such as staff meetings and mock student elections. The pavilion too was built as a result of the imaginations of teachers, students, parents and neighbors working together in action. Although this middle school teacher originally met concerns from her school's administrators regarding safety, the willingness of involved students accompanied with their increased interest in science, as well as the development of a sense of environmental kinship continue to prove ways for the project to be not only safe but also successful.

Science classes can include lecture components and indoor labs along with outdoor projects. I am not advocating that teachers abandon the indoors. Some experiences are neither practical nor feasible outdoors. However, a connection between the outdoors and indoors can be developed in the classroom, such as doing labs that involve extended observation and data collection of live animals, for example. More specifically, a laboratory activity involving the observation of reproduction rate of *Ceriodaphnia dubia*, a species of zooplankton found in freshwater with an extremely fast cycle could be used to determine chemical toxicity. But the use

of an animal to determine environmental health requires ethical considerations, responsibility and concentration.

Another example of education based in experience and led by student interest, is set in Arizona (Mueller & Valderrama, 2006) where a teacher's enthusiasm for promoting interest in earth science led to an in depth study of the planet Mars where high school students work side by side with NASA researchers collecting data to make analyses of images of Mars. In addition to fostering a sense of scientific ability, this project involves students in planning, managing and teaching their peers about the project, building social skills along with scientific process skills. This project eventually led to the construction of a new science computer lab along with an inspired sense of science while promoting throughout students involved a confidence and different perspective of themselves and their place on Earth that is carried into the future. What can be used to foster ecological literacy to curriculum is not limited to the Earth. There are also good examples of teachers using the 'cosmos' to cultivate ecological literacy.

Scientific investigations outdoors and in can involve citizen science projects, or students acting as the "eyes and ears" for scientists in other places, assisting scientists to better understand the big picture of how things work in nature, or students investigating problems in their own community. Community components in addition to working alongside community members in larger outdoor projects might involve interviews of neighbors or family members regarding observed changes in land use or customs, recollection of childhood activities, and sharing of traditions and skills. In learning to change the oil in a car, for example, or baking a favorite dish, a student learns physics and chemistry. These examples of sharing knowledge and skills in a manner that supports conservation of the natural environment and resources are morally

reciprocal activities. Science learning does not have to always take place in traditional ways and should include value.

This vision provided here is one of many that may be developed by focusing on the particular cultural and environmental commons where students share knowledge and experiences. Learning about the environment and humanity, or place and community, is part of what is encouraged to become ecologically literate, and ought to preserve natural and cultural commons. It should foster an inherent affiliation for living things and incorporate one's hands, head, and heart. Most importantly, the meaningful purpose of enacting a plan that works towards cultivating ecological literacy is in the diversity, humility, and the recognition of planning details that will be engaged with as part of working as part of a middle school learning community. The essence of this community depends on care and social coordination as well as communication. These projects must be conceived in "terms people understand" (Stone & Barlow, 2006, p. 136) and include the input of diverse stakeholders who are involved in promoting a patient and trusting atmosphere where people feel they can safely express their ideas. The point is to promote the development of young people who know that their voices count, and feel empowered such that they will participate more fully in community decisions. These lessons of ecological literacy will carry over into the future with citizens who know their geographic, cultural, and ecological place in the world and know humility in the face of uncertainty, or what seems to be ecological crisis. We must remain humble by approaching the Earth as a voice and do the best we can to hear what it has to say, and act upon what we know.

5.3 Summary

The above description is a sample plan for cultivating ecological literacy in science education. Ecological literacy embodies biophilia and ecojustice requires more investigation from scholars. Moral education differs depending on context, but moral development is inseparable from any plan to foster ecological literacy in science education as I have argued. Places are unique as are their students, teachers and all other members of a learning community. The experiences shared in the learning process as part of context are unique as well. In spite of the multifaceted distinctiveness of its many parts, moral education is embedded within the natural environment and within the human spirit that sustains our world. Science educators should have faith in the longer-term potentiality of the human spirit and sustainability of ecological literacy and benefits that follow. My theory of ecological literacy provides an opportunity for these longer-term effects in schools.

6 Final Remarks

We have come to be comforted by knowing that the lights are always on and that work continues around the clock. Money is made, resources are procured, production and consumption continue, and we humans are ahead of schedule, except that we are always trying to make up for lost time.

Meanwhile, nature's processes continue as they always have. Trees photosynthesize and exchange gases with us. Earthworms and fungi decompose, making death into nutrition for new life. Seeds and insects are triggered to wake with warmth; leaves emerge and fall with changing light. Birds, butterflies, turtles, whales and more and more somehow know to migrate and communicate without and in spite of cell phones. Although it seems like the Earth is constantly busy, even plants rest at night. There are lessons to be learned here. If we were to begin to see the Earth similarly to how we see ourselves, we may begin to take a little more care. We realize that we need time to rest, to reenergize. The Earth does too. The Earth will be able to decrease the abundance of toxins accumulated within animals with time. The dust in the polluted air will be deposited to the soil where remediation can begin as plants and other biological species disassemble toxins into elements of nutrition. The chemistry of Earth's water will be restored to purity. The Earth will change to meet the challenge of repair if we just will allow it time to sleep.

We are living during an age when a congressional bill is being reviewed that will require teachers to teach part of their lessons outside. What a great idea! But something is definitely wrong with this picture. The children we want are over weight and diabetic, and they have swollen lungs from dirty air -- so they sit inside. All the while, we are continuing to deforest the

planet and burn fuel, increasing our greenhouse gases, heating the Earth unnaturally, and sucking out its insides to get more "juice." Humans are a large part of the global degradation of the Earth.

However, that statement, although warranted by the evidence that we see in nature, sounds as if it could actually be possible that humans have greater power than the Earth itself. And this is where the answer to all of this lies, in the knowledge that that idea is preposterous. Humans are not great enough to change the laws of matter or thermodynamics. There is still a molecule of rain for every one of vapor. But in many ways we do not conserve water; the conversion of state cannot keep up. The Earth is greater and will heal itself eventually, ridding itself of its "pesky" parasite infestation unless there is a change of how we frame the Earth. Humans need to revisit their relationship with the Earth with ethical-moral considerations in science education. We need to change our view of the Earth and take responsibility for our actions, learn to be nice and share, to treat Earth the way that we WILL want to be treated.

In an effort to refresh my memory about what middle school science was like to me, I conducted an informal survey among friends, all adults but of various ages and backgrounds, several of them scientists. The survey consisted of one question, "What do you remember about middle school science?" Answers include the smell of formaldehyde when dissecting frogs and the pain felt upon burning one's hand with a Bunsen burner, for examples. These memories are based in shared experiences and remembered through the senses, like my pond experience at the beginning of this thesis. Interestingly, the memories of those that I surveyed about science were placed *inside* of a classroom. Many answered that they did not remember anything at all. What would they have remembered if they had only experienced science through ecological literacy?

Classroom science does not often promote care in middle school students because youth of this age are still learning what is standardized and examined. Yet they are learners of many

different types of senses: visual, kinesthetic, technological, logical, verbal and so on. They have the energy of puppies and are often held captive in a classroom. Middle school science students need to be able to experience earth, life, and the physical sciences of the Earth as it occurs before them. By not allowing students to experience ecology as part of their personal and shared experiences in nature, we are leaving out the most invisible standards to be tested by Earth. These experiences translate into the rules for living sustainably. Many students are not being given ecological literacy opportunities to learn science. It is time we evened the playing field.

Ecological literacy is more than incorporating the environment as "subject matter." It is the immersion of students in the study of natural systems and patterns, giving them practice in personal and shared responsibilities and empowering them in decision-making. It is not the result of incorporating an environmentally-based activity in science class, or even an entire curriculum unit. It is a lifestyle of relating; it is a shift in perspectives. As in the ancient Chinese proverb: "Give a man a fish, and you feed him for a day. Teach a man to fish, and you feed him for a lifetime" (author unknown), the sustainable ecological knowledge that our youth gain from experiences goes beyond comparison with those gained by mere expressions and written words. Ecological knowledge gained through shared experiences will be carried forward. This is ecological literacy. Sharing and caring are an integral part of this model for ecological wellbeing in which we move beyond crisis to sustainability. Morality associated with science, imagine that!

Glossary

Belief: the psychological state in which an individual holds something to be true (Schwitzgebel, 2008)

Biophilia: an inherent human trait of affection for life (Wilson, 1984)

Coevolution: the change of a biological object triggered by the change of a related object (Yip et al, 2008)

Community: A group of interdependent organisms inhabiting the same region and interacting with each other, or a group of people living in a particular local area (WordNet, 2006)

Cooperation: an act or instance of working or acting together for a common purpose or benefit, or in ecology, mutually beneficial interaction among organisms living in a limited area (cooperation, n.d.)

Culture: an integrated pattern of human knowledge, belief, and behavior that often involves shared attitudes, values and practices that characterize a group (culture, 2009)

Ecojustice: justice in the social order and integrity in the natural order (McGraw-Hill Online Learning Center, 2003)

Ecology: the scientific study of the distribution and abundance of life and the interactions between organisms and their natural environment (Begon, Townsend, & Harper, 1996)

Economy: a social system of production, exchange, distribution, and consumption of goods and services of a geographic area (economy, n.d.)

Ecosystem: a natural unit consisting of all plants, animals and micro-organisms (biotic factors) in an area functioning together with all of the non-living physical (abiotic) factors of the environment (Christopherson, 1996)

Environment: all of the biotic and abiotic factors that act on an organism, population, or ecological community and influence its survival and development. Biotic factors include the organisms themselves, their food, and their interactions. Abiotic factors include such items as sunlight, soil, air, water, climate, and pollution. Organisms respond to changes in their environment by evolutionary adaptations in form and behavior (environment, n.d.).

Ethic: the principles of right and wrong that are accepted by an individual or a social group (WordNet, 2006).

Monoculture: the cultivation of a single, homogenous crop without diversity or dissension (monoculture, n.d.)

Moral: of, pertaining to, or concerned with the principles or rules of right conduct or the distinction between right and wrong (moral, n.d.)

Motivation: expectancy x value, i.e. the expectations that a student has of success in a decision-making process crossed with the value that the student places on the outcome (Knapp, 2002)

Mutualism: a biological interaction between two organisms, where each individual derives a fitness benefit (Begon, Townsend, & Harper, 1996)

Natural Selection: a natural process that results in the survival and reproductive success of individuals or groups best adjusted to their environment and that leads to the perpetuation of genetic qualities best suited to that particular environment (natural selection, 2009)

Parasitism: the relation between two different kinds of organisms in which one receives benefits from the other by causing damage to it (WordNet, 2006)

Pragmatism: the philosophy of considering practical consequences or real effects to be vital components of meaning and truth (Hookway, 2008)

Reciprocal altruism: a form of altruism in which one organism provides a benefit to another without expecting any immediate payment or compensation. However, reciprocal altruism is not unconditional. Firstly the act of altruism must give rise to a surplus of cooperation, in the sense that the gains to the beneficiary must be perceived to be meaningfully larger than the costs to the benefactor. Secondly the act of altruism should be reciprocated by the original beneficiary if the situation is later reversed (Trivers, 1971).

Science: knowledge attained through study or practice, or knowledge covering general truths of the operation of general laws, esp. as obtained and tested through scientific method [and] concerned with the physical world (science, 2009)

Society: a particular community of people living in a country or region, and having shared customs, laws, and organizations (society, n.d.)

Sustainability: the ability of an ecosystem to maintain ecological processes, functions, biodiversity and productivity into the future (Regional Ecosystem Office, 2008); extends from a balance among the ecological, economic and sociocultural aspects of human existence (Pezzey, 1992)

Traditional Ecological Knowledge: knowledge of the conservation and sustainable use of an environment gained from generations of living and working within that environment. This knowledge includes an intimate and detailed knowledge of plants, animals, and natural phenomena, the development and use of appropriate technologies for hunting, fishing, trapping, agriculture, and forestry, and a holistic knowledge or "world view" that parallels the scientific discipline of ecology (Ecological Monitoring and Assessment Network, 2000)

Utility: a measure of the relative satisfaction from, or desirability of, consumption of various goods and services, as based in utilitarianism, the idea that the moral worth of an action is determined solely by its contribution to overall utility (Brink, 2008)

Value: a principle, standard, or quality considered worthwhile or desirable (value, 2003)

Virtue: conformity to a standard of right; a particular moral excellence (virtue, 2009)

References

Akinbami, L.J. (2006). The state of childhood asthma, United States, 1980–2005. *Advance data from vital and health statistics*, 381. Hyattsville: National Center for Health Statistics.

Begon, M.; Townsend, C. R., Harper, J. L. (2006). *Ecology: From individuals to ecosystems. (4th ed.)*. Cambridge: Blackwell.

Berry, W. (1969). *The Long-Legged House*. New York: Harcourt.

Berry, W. (1989, September). The futility of global thinking. *Harper's,* pp.16-22.

Bloomgarden, Z. T. (2004). Type 2 diabetes in the young: An evolving epidemic. *Diabetes Care, 27*, 998-1010.

Bowers, C.A. (1996). The cultural dimensions of ecological literacy. *Journal of Environmental Education, 27*(2), 5-10.

Bowers, C.A. (2004). Revitalizing the commons or an individualized approach to planetary citizenship: The choice before us. *Education Studies, 36*(1), 45-58.

Brink, David, "Mill's Moral and Political Philosophy", *The Stanford Encyclopedia of Philosophy (Fall 2008 Edition)*, Edward N. Zalta (ed.), Retrieved April 9, 2009, from http://plato.stanford.edu/archives/fall2008/entries/mill-moral-political

Brownell, B. (1950). *The human community*. New York: Harper Brothers.

Capra, F. (2006). How Nature Sustains the Web of Life. In M.K. Stone & Z. Barlow (Eds.), *Ecological literacy: Educating our children for a sustainable world.* San Francisco: Sierra Club Books.

Carson, R. (1984). *The sense of wonder.* New York: Harper.

Center for Ecological Literacy Home Page. Retrieved March 20, 2009, from http://www.ecoliteracy.org

Christopherson, R.W. (1996). *Geosystems: An introduction to physical geography*. Upper Saddle River: Prentice Hall Inc.

cooperation. (n.d.). *Dictionary.com Unabridged (v 1.1)*. Retrieved March 25, 2009, from http://dictionary.reference.com/browse/cooperation

culture. (2009). In *Merriam-Webster Online Dictionary*. Retrieved March 25, 2009, from http://www.merriam-webster.com/dictionary/culture

Cutter-MacKenzie, A., & Smith, R. (2003). Ecological literacy: The 'missing paradigm' in environmental education (part one). *Environmental Education Research, 9*(4), 497-524.

Delpit, L. D. (1988). The silenced dialogue: Power and pedagogy in educating other's people's children. *Harvard Educational Review, 58*(3), 280-298.

Dewey, J. (1897/1981). *The philosophy of John Dewey*. (J. McDermott, Ed.). Chicago: University of Chicago Press.

Dewey, J. (1909). *Moral principles in education.* Boston: Houghton Mifflin Company.

Dewey, J. (1916). *Democracy and education: An introduction to the philosophy of education*. New York: The Free Press.

Dewey, J. (1925). *Experience and nature.* Chicago: Open Court.

Dewey, J. (1938). *Experience and education*. New York: Collier Books.

Diamond, J. (1992). *The third chimpanzee.* New York: Harper.

Ecological Monitoring and Assessment Network. Centre for Traditional Knowledge, personal

communication, 2000. Retrieved March 25, 2009, from http://www.eman-rese.ca/eman/reports/publications/rt_biostrat/cbs28.htm

economy. (n.d.). *WordNet 3.0*. Retrieved March 25, 2009, from http://dictionary.reference.com/browse/economy

environment. (n.d.). *The American Heritage Science Dictionary*. Retrieved March 25, 2009, from http://dictionary.reference.com/browse/environment

Ferre, F. (1993). Persons in nature: Toward an applicable and unified environmental ethics. *Zygon, 28*(4), 441-453.

Handa, V., Tippins, D., Bilbao, P., Morano, L., Hallar, B, Miller, K, & Bryan, R. (2008). A dialogue of life:Integrating service learning in a community immersion model of pre-service science teacher preparation. *Journal of College Science Teaching, 37*(6), 14-20.

Hardin, G. (1968). The tragedy of the commons. *Science, 162*(13), 1243-48.

Hookway, Christopher, "Pragmatism", *The Stanford Encyclopedia of Philosophy (Fall 2008 Edition)*, Edward N. Zalta (ed.), Retrieved April 9, 2009, from http://plato.stanford.edu/archives/fall2008/entries/pragmatism/

James, W. (1901). *Talks to teachers on psychology and to student's on some of life's ideals.* New York: Henry Holt and Company.

Jordan, R., Singer, F., Vaughn, J., & Berkowitz, A. (2009). What should every citizen know about ecology? *Frontiers in Ecology and the Environment, 7*, doi:10.1890/070113

Kellert, S.R. & Wilson, E.O. (1993). *The biophlia hypothesis*. Washington, D.C.: Island Press.

Knapp, N.F. (2002). Tom and Joshua: Perceptions, conceptions and progress in meaning-based reading instruction. *Journal of literacy research, 34*(1), 59-98.

Kuo, F. E,. & Taylor, A. F. (2004). A Potential Natural Treatment for Attention-Deficit/Hyperactivity Disorder: Evidence from a Natural Study. *American Journal of Public Health, 94*(9), 1580-1586.

Leopold, A. (1949/1987). *A Sand County almanac.* New York: Oxford University Press.

Lopez, B. (1989). "Renegotiating the contracts in Thomas J. Lyon (ed.) *The incomperable lande: A book of American nature writing*. Boston: Houghton Mifflin.

Lord, T. (2008). If You Go Down to the Woods Today… *Journal of College Science Teaching*, 37(4), 90-93.

Louv, R. (2005). *Last child in the woods: Saving our children from nature-deficit disorder.* Chapel Hill: Algonquin Books.

McAuley, J. (2009). Personal communication. Wildlife Habitat, Jefferson City Middle School, Jefferson, GA.

McCaleb, S. P. (1997). *Building communities of learners: A collaboration among teachers, students, families, and community*. Mahwah,: Lawrence Erlbaum Associates.

McGraw-Hill Online Learning Center. Retrieved March 25, 2009, from highered.mcgraw-hill.com/sites/0070294267/student_view0/glossary_e-l.html

Martusewicz, R.A. (2007). Toward a "collaborative intelligence ″: Educating for the cultural and ecological commons in Detroit. In M. McKenzie, H. Bai, P. Hart, B. Jickling (Eds.), *Fields of Green: Re-Storying Education*. Cresskill: Hampton Press.

Mitchell, D.B., & Mueller, M.P. (2008). The role of ecological literacy in middle school learning communities. *Tennessee Association of Middle Schools Journal, 39*, 1-9.

monoculture. (n.d.). *The American Heritage Dictionary of the English Language, Fourth Edition*. Retrieved March 26, 2009, from http://www.answers.com/topic/monoculture

moral. (n.d.). *Dictionary.com Unabridged (v 1.1)*. Retrieved March 25, 2009, from http://dictionary.reference.com/browse/moral

Morrison, R. (1999). *The spirit in the gene: Humanity's proud illusion and the laws of nature.* Ithaca: Cornell Univeristy Press.

Mueller, M.P. (2007). Integrating ecojustice in middle school science education. *Tennessee Association of Middle Schools Journal, 37*, 7-13.

Mueller, M.P. (2008a). Ecojustice as ecological literacy is much more than being "green!" *Educational Studies, 44*(2), 155-166.

Mueller, M.P. (2008b). Educational reflections on the "ecological crisis": Ecojustice, environmentalism, and sustainability. *Science & Education,* doi: 10.1007/s11191-008-9179-x

Mueller, M.P., & Bentley, M.L. (2007). Beyond the "decorated landscapes" of educational reform: Toward landscapes of pluralism in science education. *Science Education, 91*(2), 321-328.

Mueller, M.P., & Tippins, D.J. (in press). Rethinking an education from nowhere: Citizen science, ecojustice and science education. In K. Tobin (Ed.), *2nd International handbook of science education.* New York: Springer.

Mueller, M.P., & Valderrama, P. (2006). Crater appeal. *The science teacher, 73*(5), 22-25.

National Research Council (1996). *National science education standards.* Washington, DC: National Academy Press.

natural selection. (2009). In *Merriam-Webster Online Dictionary*. Retrieved March 26, 2009, from http://www.merriamwebster.com/dictionary/natural selection

Nixon, R.M. (1970). President's Message to the Congress of the United States. In *Environmental Quality, the First Annual Report of the Council on Environmental Quality, together with the President's Message to Congress.* Washington, D.C.: U.S. Government Printing Office, S/N 0-389-110. ED 062-109, p.11) Retrieved April 9, 2009, from http://eelink.net/pages/Perspectives-+Foundations+of+EE

Odum, E.P. (1971). *Fundamentals of ecology, third edition,* New York: Saunders.

Odum, E.P. (1984). Engraving on bust in the entry hall of Odum School of Ecology, UGA, Athens, GA.

Odum, E.P. (1997). *Ecology: a bridge between science and society*. Sunderland, MA: Sinauer Associates.

Orr, D.W. (1989). Ecological literacy. *Conservation Biology*, *3* (4), 334-335.

Orr, D.W. (1992). *Ecological literacy: Education and the transition to a postmodern world.* Albany: State University of New York Press.

Orr, D.W. (1994). *Earth in mind.* Washington, D.C.: Island Press.

Orr, D.W. (2004). The learning curve. *Resurgence, 226,* pp.11-12.

Orr, D.W. (2006a). Place and Pedagogy. In M.K. Stone & Z. Barlow (Eds.), *Ecological literacy: Educating our children for a sustainable world.* San Francisco: Sierra Club Books.

Orr, D.W. (2006b). Recollection. In M.K. Stone & Z. Barlow (Eds.), *Ecological literacy: Educating our children for a sustainable world.* San Francisco: Sierra Club Books.

Peirce, C. (1958). *Values in a universe of chance: Selected writings of Charles Sanders Peirce (1839-1914).* P.P. Wiener (Ed.), Garden City: Doubleday & Co, Inc.

Pezzey, J. (1992). Sustainability: An interdisciplinary guide. Environmental Values 1: 321-362.

Prakash, M.S. (1995). Ecological literacy for moral virtue: Orr on [moral] education for postmodern sustainability. *Journal of Moral Education, 24* (1) 3 – 19.

Regional Ecosystem Office (U.S.) REO Information Center Definitions. Northwest Forest Plan (NWFP) definition of sustainability. Retrieved March 10, 2009, from http://www.reo.gov/general/definitions_r-s.htm#S

Schwitzgebel, Eric, "Belief", *The Stanford Encyclopedia of Philosophy (Fall 2008 Edition)*, Edward N. Zalta (ed.). Retrieved April 9, 2009, from http://plato.stanford.edu/archives/fall2008/entries/belief/

science. (2009). In *Merriam-Webster Online Dictionary*. Retrieved March 26, 2009, from http://www.merriam-webster.com/dictionary/science

society. (n.d.) In *Compact Oxford English Dictionary*. Retrieved March 25, 2009, from http://www.askoxford.com/concise_oed/society?view=uk

Snyder, G. (1990). *The practice of the wild*. San Francisco: North Point Press.

Sobel, D. (1996). *Beyond ecophobia: Reclaiming the heart in nature education*. Great Barrington, MA: Orion Society.

Sterba, J.P. (1995). From biocentric individualism to biocentric pluralism, *Environmental ethics 17*, 191-207.

Sterba, J.P. (2001). *Three challenges to environmental ethics: environmentalism, feminism, and multiculturalism.* New York: Oxford University Press.

Stevens, W. (1971). Theory. In Author (Ed.), *Collected poems of Wallace Stevens.* NY: Alfred A. Knopf.

Stone, M.K., & Barlow, Z. (2006). *Ecological literacy: Educating our children for a sustainable world.* San Francisco: Sierra Club Books.

Story of Stuff. Tides Foundation and Funders Workgroup for Sustainable Production and Consumption. Retrieved July 25, 2008, from http://www.storyofstuff.com/index.html

Thayer-Bacon, B., & Moyer, D. (2006). Philosophical and Historical Research. In K. Tobin and J. Kincheloe (Eds.), *Doing Educational Research: A Handbook* (pp. 139-156). New York: Sense.

Thayer-Bacon, B. (2000). *Transforming critical thinking: Thinking constructively.* New York: Teachers College Press.

Thomas, D. (2007). Teaching technology in low socioeconomic areas. *Technology teacher, 67*(3), 4-8.

Trivers, R.L. (1971). The evolution of reciprocal altruism. *Quarterly Review of Biology*. 46: 35-57.

value. (2003). In *The American Heritage Dictionary of the English Language* (4th ed.). Boston: Houghton Mifflin Company. Retrieved March 25, 2008, from http://www.thefreedictionary.com/value

virtue. (2009). In *Merriam-Webster Online Dictionary*. Retrieved March 26, 2009, from http://www.merriam-webster.com/dictionary/virtue

Wilson, E.O. (1984). *Biophilia*. Cambridge: Harvard University Press.

Wilson, E.O. (1992). *The diversity of life*. Cambridge: Harvard University Press.

Wilson, E.O. (2002). *The future of life.* New York: Vintage Books.

Woolhorton, S. and Bennell, D. (2007). Ecological literacy: Noongar way. *Every Child, 13*(4), 30-31. Retrieved February 20, 2009, from http://www.earlychildhoodaustralia.org.au/index2.php?option=com_content&do_pdf=1&id=989

WordNet 3.0 (2006). Princeton: Princeton University. Retrieved March 25, 2009, from http://wordnet.princeton.edu/perl/webwn?s=word-you-want

Yip et al (2008). An integrated system for studying residue coevolution in proteins. *Bioinformatics 24* (2): 290–292. doi:10.1093/bioinformatics/btm584