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Curriculum Development And Analysis To Encourage Positive Environmental Attitudes In High School Students

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CURRICULUM DEVELOPMENT AND ANALYSIS TO ENCOURAGE POSITIVE ENVIRONMENTAL ATTITUDES IN HIGH SCHOOL STUDENTS

by

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Overview of Capstone Inquiry

Introduction

As a science teacher and department chair at a first ring suburban high school near a large metropolitan area in the upper Midwest, I am in a unique position of designing and delivering curriculum around the topic of ecology and resource conservation. Being in this position provides me a way of implementing new curriculum around the idea of conserving resources and developing individuals who are environmentally minded. This is important because according to United Nation's World Water Development Report (2015) the world faces some very large problems such as water security, growing energy demands, supplying food to all people and climate change. As the organization Climate Generation: A Will Steger Foundation (2013) has pointed out, science teachers are some of the most important communicators when it comes to informing the public on issues like climate change, habitat protection, resource and energy conservation. Given the scale and importance of these problem, science curriculum developed to address these issues takes on new importance in being part of the solution.

Since I have an interest in adding an elective course with a focus on conservation to our department's course offerings my capstone question investigates "How do the students, who are participating in a course on ecology and resource conservation, describe their understanding of ecology and conservation?" The curriculum will focus on the topics of ecology and resource conservation and is scheduled to start in the spring of 2017. After working at my high school for eight years I have observed a gap in students' understanding of ecology and the natural world. At the high school where I work there is

also a lack of curriculum aimed at addressing this gap. One of the primary goals of the curriculum being developed as part of this capstone project will be to give students a better understanding of ecology and develop a more environmentally focused mindset.

The course being designed will also explore the implications of climate change, overpopulation and how resources are shared. Students will explore these topics through experiments, research, observations and projects. While investigating each resource, students will be exposed to the ethical challenges related to each area and will gather and use evidence to propose and support possible solutions.

It is likely that there are many variables that may affect how students understand the topic of ecology and resource conservation. In the 2010 journal article Identity Formation in Adolescence: Change or Stability?, Klimstra, Hale, Raaijmakers, Branje and Meeus pointed out that during adolescence a person's identity is still being formed and factors that affect identity formation are wide ranging and variable from person to person. Since personal identity has an impact on the way a person behaves, (Hagger, Anderson, Kyriakaki and Darkings, 2006), the scope of this project will not be to determine if taking a course in ecology and resource conservation changes behavior. Rather, this project will simply seek to determine how students taking this course understand the topic of conservation and to determine if there is an attitude shift.

When students assess their understanding of ecology and resource conservation based on sound, scientific sources of information I can foresee three likely results. One possibility is that students will find that they really do not know much about the topics. A second possibility is that students may realize that they are misinformed or have based their understanding and opinions on inaccurate or nonscientific sources of information. A

final possibility is that students have an understanding of the issues based on sound, scientific research. Regardless of where students are on their continuum of understanding, there is room for growth. It is important for the teacher to understand what his/her students think prior to and during instruction then use that information to design learning opportunities that help students develop deeper conceptual understanding.

The remainder of Chapter One contains the following sections.

- Definition of terms
- Personal Importance of the Capstone Question
- Professional Importance of the Capstone Question
- Chapter Summary

Definition of Terms

Withgott and Bernnan (2009) consider resources to be physical materials used by people in their daily lives. The primary resources that will be explored in the curriculum developed for this capstone project are water, food, timber, metal ores and natural land to provide ecosystem services such as purification of water and air, nutrient cycling and waste treatment.

The term conservation has multiple scientific meanings. First, is the physical law of conservation of energy. In the chemistry textbook (Wilbraham, 2008) used at my high school, the law states that the total amount of energy in the universe is constant thus energy is conserved. The U.S. Department of Energy's guide Energy Literacy (Energy. Gov., 2014) considers conserving energy to be the decreased societal consumption of energy resources. In this discussion of energy conservation the latter meaning is intended. Likewise, the term resource conservation will refer to the decreased consumption of

resources. Ecology is commonly defined as the branch of biology dealing with the relationships and interactions between organisms and between organisms and their environment.

Personal Importance of the Capstone Question

For a long time, I have been interested in structuring my life in a way that helps the environment. For example, I use my bike to commute eight miles to and from school when the weather is good. My family has recently made the investment to install solar panels on our home in order to offset our electrical use. When it was time to purchase a new vehicle one of my primary considerations was how the vehicle was made and the gas mileage. I enjoy growing a garden each summer and shopping at local farmers' markets. My career choice has also allowed me to help the environment by educating young people about how our actions affect the environment and what we can do to improve things.

Currently, I teach chemistry at a suburban high school near a large metropolitan area in the Upper Midwest. The high school I work at has a rapidly growing student population which is diverse in both socioeconomic status and ethnicity. The growing student population creates a lot of opportunity for students and teachers within the district. Students at the school I work at come from many walks of life, including rural farm families as well as families that have recently immigrated from other countries. One of my professional goals is to ensure that all of my students leave high school with the education necessary to make informed decisions about the future of our community, our state, our country and our planet.

For many years our district has been working to expand the amount of environmental education students receive. In the fall of 2012, the high school I work at took a big step toward expanding environmental education by building an Environmental Learning Center (ELC). This building is detached from the main high school building and was designed to be a model of energy and resource conservation. Along with the addition of ELC, new curriculum has been incorporated that is intended to provide students with a better understanding of the natural world. This new curriculum, with an emphasis on such topics as climate change and resource conservation, is an opportunity to have an even greater impact by further increasing students' environmental awareness.

As a result of changes in our district, new classes are being designed to focus on issues faced by our community and our world. According the Environment and Natural Resources Trust Fund's final report (2010-2013) (Will Steger Foundation, 2013) educators have a unique and important opportunity to connect with their students and to raise their awareness about the changes happening in our world while providing them with the skills to mitigate and adapt to these change. My primary goal for this capstone project is to shed light on how students understand ecology and resource conservation. This capstone research is important to me because I believe this topic is an important part of young people's educational journey during which they can learn to recognize and solve the problems facing our planet.

Professional Importance of the Capstone Question

According to the organization Climate Generation: A Will Steger Legacy (2016) science teachers are some of the most important communicators when it comes to informing the public on issues including climate change, habitat protection and resource

and energy conservation. In the 2009 book, Never Work Harder than your Students & Other Principles of Great Teaching Robyn Jackson suggest that one of the basic tenets of good teaching strategy is knowing where your students are in their understanding of issues and concepts. This capstone project will provide tools and strategies that will help myself and the teachers with whom I work understand their students' level of understanding and allow the teacher to tailor instruction to meet students' needs. Throughout my career I have learned that taking the time to get to know the students I work with has been the most valuable tool I can use to help them grow and learn. When it comes to issues of great importance, such as ecology and resource conservation, knowing the students' level of understanding is critical.

The issues of ecology and resource conservation are not only scientific, but are also political issues. There is anecdotal evidence (Reardon, 2011) that science teachers often avoid discussing politically charged issues with their students. The article "Climate Change Sparks Debate in the Classroom" in the journal Science (Reardon, 2011) suggests one reason science teachers may not teach about issues related to climate change could be that they do not want to deal with parents and school administrators who are not in support of their instruction. However, Reardon (2011) suggest that by allowing students to describe their understanding of politically charged issues teachers can help students separate opinions from scientific facts so that students can engage in meaningful conversations with each other.

Summary of Remaining Chapters

Our world is changing and in order to adapt to these changes individuals need to be well informed of the issues. The International Energy Agency's report Worldwide

Trends in Energy Use and Efficiency (2008) states that energy demands continue to grow and it is increasingly important that individuals understand where their energy comes from and how they can use energy more efficiently. Every three years the United Nations releases its World Water Development Report, the 2012 report shows demand is growing for resources such as clean water, food, space to live and agricultural land. An understanding about how these resources are being used and abused is of the utmost importance because today's students are the individuals who will need to deal with the changes likely to occur within their lifetimes.

The goal of this capstone project is to reveal how students taking a course that focuses on ecology and resource conservation describe their understanding of the course topics including their attitude toward the environment and environmental issues. Chapter Two will review the research literature to describe the work that has been done in this area. Chapter Three will provide a detailed description of the methods used to collect information in order to assess students' understanding of energy and resource conservation and their attitude toward the environment and environmental issues. Chapter Four will describe and analyze results of the investigation. The final chapter will summarize the work done throughout the project, describe any shortcomings of the research and discuss possible areas for future research.

CHAPTER TWO

Literature Review

The purpose of this capstone project is to address the question, "How do the students, who are participating in a course on ecology and conservation, describe their understanding of ecology and conservation?" In order to have a better understanding of the work that has previously been done in the area environmental education I have reviewed articles from scientific journals, articles from teaching magazines and other publications. This chapter will review the literature to provide an overview of three areas; one is best practices in environmental education to support their use in the curriculum created for this capstone project. The next section provides examples of research-based curriculum design principles that were used to develop the curriculum. The inclusion of these research-based practices supports me in ensuring that I am making informed decisions. The last section examines strategies for assessing learners' science knowledge and understanding because one goal of this capstone was to document student reaction to the new curriculum.

While reviewing the literature in the area of ecology and conservation, I was forced to broaden my area of focus and consider environmental education (EE) as a whole. The reason for this decision is that ecology and conservation is a specific aspect of EE and there has not been a lot of research published in this specific area. A course in Ecology and Environmental Ethics can be considered an Environmental Education course since, according to the Environmental Protection Agency (EPA)'s website, environmental education is a process that allows individuals to explore environmental issues, engage in problem solving, and take action to improve the environment (EPA,

2017). The course which is being taught as part of this capstone project is intended to do those very things. Students' projects are focused on exploring environmental issues, identifying solutions and taking action to make their environment a better place.

Before elaborating on the best practices in EE, it is worth mentioning the importance of the teacher in a classroom focused on ecology and resource conservation. An important finding from Ernst in the 2007 article, Factors Associated with K-12 Teachers' Use of Environment-Based Education is that the teacher is the most important variable in determining the success of EE curriculum. There are several factors that impact a teacher's success in utilizing EE in the classroom. According to Ernst (2007), the main factor that motivates teachers to use EE methods in their classroom are their own understanding of the environment as well as their sensitivity and receptiveness to EE. Ernst (2007) also finds that training in EE has little influence on teachers' willingness or ability to implement. Similarly, in the 2006 article Issue-Specific Barriers to Addressing Environmental Issues in the Classroom: An Exploratory Study, Kim and Fortner (2006) found "If a teacher has a positive attitude toward teaching environmental issues, has enough knowledge on environmental issues, and knows how to teach the environmental issues, then he or she will teach the issues more often or more properly" (p. 16). As the principle investigator in this capstone project and the teacher of the course being taught I feel that I match the description offered by Kim and Fortner (2006) as a person with a positive attitude toward teaching environmental issues as well as being knowledgeable on the issues. I will use the rest of the chapter to inform my teaching practices and curriculum design.

Curriculum Design Philosophies Used in Environmental Education

Several curriculum design philosophies emerged throughout the literature and will be elaborated on in this section. According to Gardiner (2000), a curriculum should be founded on a carefully thought-out philosophy of education and should be clearly connected to the goals of the course. The philosophies I will elaborate on and use while developing the curriculum for the course Ecology and Environmental Ethics include viewing EE with the big picture in mind, ensuring that the curriculum is student-centered, using project based learning and taking an interdisciplinary approach to EE.

Curriculum for the big picture. Scientists and scholars know what needs to be done in order to solve the many problems facing our planet, and education can serve a crucial role in passing that knowledge to the people so that action can be taken. I have noticed in my teaching experience that students are often unaware of many of the issues that will have an impact on their lives. When they become aware, I have also seen a shift in their thinking about how they can play a role in solving the problem. The 1986 article by M. Brennan, A Curriculum for the Conservation of People and Their Environment, points out that people have the ability to develop and use technology to manipulate, control, transform, preserve and destroy environments. Knowledge of how these things are done and possible consequences are critical aspects of the curriculum. Brennan (1986) states, "Our purpose is to construct a program of education that will lead to the development of a world culture that by its policies and practices will maintain an environment fit for life for all people in the global community" (p. 2). This viewpoint is that a principle goal of education is to have an informed community regarding environmental issues so that we can collectively make decisions that benefit everyone.

Developing curriculum that focuses on the big picture has as much to do with understanding how things are interconnected as it does with understanding the scale of the issues. It may seem a bit ironic that one way to help students understand the big picture of conservation may be to examine the specific field of chemistry. Jegstad and Sinnes (2015) point out that people need to have a working understanding of chemistry in order to understand the mechanisms behind issues facing our planet, such as climate change, production of goods and production of energy. To me this indicates that students must be able to understand issues at multiple levels in order to make the most informed decisions.

***Student-centered curriculum*.** The online Glossary of Education Reform (Student-Centered Learning Definitions (2014) defines the term student-centered curriculum as a wide variety of educational programs, learning experiences, instructional approaches, and academic-support strategies that are intended to address the distinct learning needs, interests, aspirations, or cultural backgrounds of individual students and groups of students. In one study done by Tomkinson, Engel and Tomkinson (2011) students were given specific problem scenarios and asked to work in groups to complete tasks within a given set of constraints. Teachers in this study were trained to serve as facilitators and further trained to not actively teach concepts with the intention that all learning must come from the endeavors of the students themselves. The result of this study "indicated that students felt more confident about their knowledge and skills . . . and the learning styles questionnaire showed an increase in the application of 'deep' learning" (p. 28). Giving students the opportunity to become knowledge producers rather and passive absorbers of information will have a long lasting impact.

Another example of a student-centered approach to curriculum design is the use of drama in the classroom. In a 2014 study, McNaughton found that using drama in the classroom provided participants meaningful ways in which concepts could be explored. The drama used in this curriculum is based on improvised role-play and other theater conventions. According to McNaughton (2014) this enables the participants to put themselves in the shoes of others, explore ideas, emotions, values and actions from different perspectives. The in-class dramatic productions also allowed a wide range of skills to be developed and practiced, encouraged the consideration of dispositions, attitudes and values necessary for positive environmental citizenship.

Student-centered curriculum design is one way to achieve the goal of increasing the level of student interest and engagement. In the course being taught as part of this capstone project students will be asked to become knowledge producers by choosing what topics they investigate and sharing their learning with others both in the classroom and outside of the classroom. Another approach to curriculum design that is often used in environmental education is project-based learning.

***Project-Based Learning Curriculum*.** Project-based learning provides students an opportunity to practice real-life problems solving skills and extend their learning beyond the walls of the classroom, this is according to a 2014 study done by Al-Balushi and Al-Aamri. The authors of this study, which was published in the journal International Research in Geographical and Environmental Education, showed that students who used project-based learning to investigate environmental issues have shown that there was enrichment in students' environmental knowledge and it also nurtured their interest in global environmental issues and prepared them to instigate environmental reform. The

course being taught as part of this capstone project also uses project-based learning. Student are given the opportunity to choose a project beyond the confines of the classroom walls with the intention of improving our community and creating a lasting impact.

A small school in Texas used project-based learning to get students involved in real-life science, enjoy the beauty of the local school grounds and to expand the common ecological thread throughout grade levels. The project was described by McEwen in a 2008 article. Students at the school became citizen scientist through a statewide program called Texas Watch; this program works with the EPA and the Texas Commission on Environmental Quality to collect environmental data on nonpoint source pollution issues. According to McEwen (2008) teachers at the school noticed the students had a sense of pride in being able to contribute meaningful scientific research and increase their understanding of biology, chemistry and ecology.

According to Reiss and White (2014), project-based learning is one way to shift the mindset of curriculum writers from what teachers should teach, to what students need in order to be successful in their lives as students and beyond. In order to address the complex, global scope of environmental issues, curriculum must be developed to focus on the big picture and allow students to have a positive impact that they can see and be proud of.

An Interdisciplinary Approach. Environmental education is generally thought of as a specific area of study within the larger field of science education, however as Welch-Devine, Hardy, Brosius and Heynen (2014) point out environmental issues are interdisciplinary in nature and cannot be packed neatly into one box or field of study.

Welch-Devine, et al. (2014) also comment on the practice in which science typically narrows the focus of study in order to achieve precision and clarity, however conservation and sustainability education requires students to understand many aspects of the problem and to recognize that solutions will come from many areas. In my experience, one of the most difficult things students have to do is accept that there may be more than one solution to an environmental problem and that a single solution to a problem may not solve the problem entirely. When coupled with the fact that different groups have different worldviews it makes if even more difficult for students to discuss solutions. Fenton, Long and Acharya (1995) point out that environmental education requires students to approach environmental issues from multiple disciplines including the science behind the issues facing the environment, the policies related to addressing those issues, the technology required to address the issues and the economics surrounding those environmental issues.

The conclusions of Welch-Devine, et al. (2014) are largely informed by the outcomes of the Advancing Conservation in a Social Context (ACSC) initiative, a four-year research initiative created by the MacArthur Foundation. ACSC participants develop a framework for decision making that requires the identification, analysis and negotiation of the trade-offs that occur when considering issues related to conservation and sustainability. Like the ACSC participants, students in my class will be required to analyze issues from multiple viewpoints. Fenton, et al. (1995) reiterate this sentiment, "Because environmental issues are frequently complex, involving not only science, but also technology and public policy, it is important to help science students develop skills in understanding problems and gain experience in examining issues from viewpoints

other than science" (p. 212). While it may be difficult for some students to examine environmental issues from multiple viewpoints, it is necessary.

In the 2007 article, Factors Associated with K-12 Teachers' Use of Environment-Based Education, Ernst pointed out that "There is a shared, primary emphasis on the following essential elements of environmental education: consideration of the environment in its totality, interdisciplinary, learner centered instruction, and the development of critical thinking and problem-solving skills" (p. 16). Instructing a student centered classroom that has students analyze real world problems from multiple viewpoints and does so with an action driven project based approach is the goal of this capstone.

Best Practices in Teaching Environmental Education

To effectively teach the topic of energy and resource conservation one must use the best available practices in Environmental Education. In one project that developed guidelines for best practices, Meredith, et al. (2000) says that good environmental education will effectively and objectively help learners develop into environmentally literate students while holding up against the charges of critics. After an examination of the literature several best practices emerged that will help in developing the curriculum for my Ecology and Environmental Ethics course. Those practices include engaging students in critical thinking as well as modeling sustainable behavior for students. Engaging students in critical thinking is a practice that I have identified because I have been trained as a science teacher and a hallmark of science is solving problems through critical thinking. In science we must analyze the problem and determine the best possible solution based on the evidence provided. The practice of modeling sustainable behavior

for students is something that I have learned is a best practice but I also feel that it is the right thing to do. The logic is simply that if I hope to see a change in my students I must also be the change I hope to see.

Engaging Students in Critical Thinking. As a teacher who is implementing many of the Next Generation Science Standards (NGSS Lead States, 2013) into my science class, I know it is important for students to have the interpretation skills and background knowledge to analyze information and draw evidence based conclusions. The Next Generation Science Standards (NGSS) (2013) are K–12 science standards developed by states to set the expectations for what students should know and be able to do. I find it troubling that in the 2011 article, Climate Change Sparks Battles in Classroom, Reardon, observes that there are individuals in positions of political power that do not understand the nature of science and see uncertainty as justification for requiring teachers to present opposing viewpoints.

As a mid-career teacher I agree with Rosenau (as cited by Reardon, 2011) who states that "Science is not about providing balance to every viewpoint out there" (p. 689). Like Rosenau (as cited by Reardon, 2011) I agree that students must have the skills and background knowledge to analyze information and draw evidence based conclusions. One way to do prepare students to face questions and even criticism from their peers and the community at large is to have them develop critical thinking and problem solving skills

One technique for allowing students to practice critical thinking skills is allowing students to engage in academic argumentation as described by Chowning and Griswold in the 2014 article, Beyond "My Opinion Versus Yours." Chowning and Griswold (2014)

describe a form of academic argumentation that involves justifying a position on a socio-scientific issue (SSI). These SSI "are often controversial; involve competing views; and draw from fields as diverse as biology, ethics, sociology, economics, politics, and law. SSI instruction often uses complex, real-world case studies that don't have easy answers" (p. 39). Students that engage in academic argumentation must use critical thinking in order to develop justifications for their position.

According to Chowning and Griswold (2014) there are four essential elements required for students to engage in academic argumentation: first, all students must have a clearly stated position, even if it is an assigned position from the teacher. For these authors a clearly state position is one that relates directly to the question being argued, often times the position will be either "for" or "against." When students state their position Chowning and Griswold (2014) recommend that the students should avoid connecting phrases such as "I think" or "I feel" to their position.

A second element of academic argumentation identified by Chowning and Griswold (2014) is that, students must use scientific facts as evidence to support their stated position. Scientific facts are items that can be confirmed or refuted regardless of personal or cultural views. When students use scientific facts in their academic arguments Chowning and Griswold (2014) state that students should be prepared to cite the source.

The third requirement described by Chowning and Griswold (2014) states that because students are forming arguments using often controversial SSI, it is important for students to make reference to ethical considerations. Ethical considerations may include describing how the stated position maximizing benefits and minimizing harm.

The last requirement for academic argumentation described by Chowning and Griswold (2014) is that regardless of each student's stated position, all arguments must consider how other people will be impacted by the decision. There are a variety of views and interests in the decision, and more than one individual or group will be affected by the outcome. No one decision will satisfy all parties therefore a thorough justification considers strengths and weaknesses of various positions.

Griswold and Chowing (2014) describe one technique for allowing students to engage academic argumentation called “The Silent Debate.” This is a technique in which pairs of students are given a question or topic and engage in the argumentation process by writing on a piece of paper that they pass back and forth. Every student participates in the activity and because it is in the written form there is documentation of all points made throughout the argument. At the end, students work in pairs to review the paper, they could review their own argument or partners could exchange and review other arguments. Reviewing the written argument allows students to identify the strongest arguments and justifications, and analyze what makes arguments noteworthy.

According to Chowning and Griswold (2014) as a result of participating in argumentation activities, “Students showed highly significant gains in the following self-reported areas: interest in science content, ability to analyze socio-scientific issues, ethical issue awareness, ability to listen to and discuss differing viewpoints, and understanding of the relationship between science and society” (p. 44). One of the goals of the class that will be taught as part of this capstone project will be to increase students interest and awareness of environmental issues, using academic argumentation should be an effective strategy to achieve that goal.

Modeling Sustainable Behavior for Students. As noted earlier, by Ernst (2007) and Kim and Fortner (2006), teachers can have a large impact on students' attitudes and behaviors, but to take students' knowledge of environmental issues to the next level, as well as illustrate potential solutions, teachers and schools need to be very explicit in the way they model sustainable behaviors. According to Higgs and McMillan (2006) sustainable behaviors include;

> a) driving a hybrid car, carpooling, biking, or walking to school, b) eating organic, local food with minimal disposable packaging, c) wearing second hand clothes, d) participating in community service, e) composting, recycling, and reusing, f) picking up litter, g) turning off lights when leaving a room, h) promoting democratic, equitable classroom environments, i) using appropriate conflict-resolution strategies, and j) encouraging diverse and divergent opinions. (pp. 41-42)

If students in my class see the behaviors listed above as common place and typical, perhaps they will be more likely to engage in the behaviors themselves.

In their article Teaching Through Modeling: Four Schools' Experience in Sustainability Education Higgs and McMillan (2006) did an extensive study of four schools that explicitly model sustainability. One important finding was that modeling sustainable behavior can considerably shorten and improve learning, particularly when students are exposed to multiple models. In other words, students need to be able to see resource conservation in action. Higgs and McMillan (2006) point out that sustainability role modeling does not have to, and perhaps should not be limited to, the teacher modeling for the student. "Observations revealed students modeling sustainable practices

to other students, teachers modeling for other teachers, and students even modeling to teachers" (p. 42). In other words, the goal of modeling is to create a culture where sustainable behavior becomes the norm.

Another important finding from Higgs and McMillan (2006) is that the buildings that house the school can teach students as much about sustainability as the actual courses because students see the concepts in action. The school facilities may have design features such as solar panels and wind turbines for producing energy, rain barrels and rain gardens for managing water runoff. Other design features may include sustainable building materials and passive solar design to allow for minimal use of energy for heating and cooling. According to David Orr (as cited by Higgs & McMillan, 2006), a principle at a school studied, "Buildings have their own hidden curriculum that teaches as much any course taught in them . . . we have not thought of academic buildings as pedagogical, but they are" (p. 45). The building where I teach the course used in this capstone project does have many environmentally friendly design features. We use solar power and a wind turbine to provide power to the building, as well as using a large rain barrel for watering our plants.

Modeling sustainable behavior, as described by Higgs and McMillan (2006), allows schools to foster learning about sustainability and adopt those behaviors rather than simply telling students how they need to change. My students learn behaviors by observing the people and institutions they respect, as a teacher I can see how modeling (Higgs & McMillan, 2006) is likely to help students adopt sustainable behaviors.

The final section of the literature review will focus on the assessment of students understanding and attitude toward environmental issues such as energy and resource

conservation. It will be important to assess students understanding and attitude toward environmental issues in order to determine if taking the class has caused any change in their understanding and/or attitude toward environmental issues.

Strategies for Assessing Learners' Science Knowledge and Understanding

According to Boyes et al., (2014) an important objective of environmental education is to motivate people to behave in a more environmentally friendly way. Likewise, in the course that I am teaching as part of this capstone project will have a similar objective of helping students to gain a better understanding of the environmental issues we are dealing with as a community and motivate students to engage with those issues in order to help solve the problems. In order to measure success or failure in meeting that objective, one must have an effective tool that assesses individuals' attitudes toward environmental issues and the propensity of students to act in environmentally friendly ways.

From my review of the literature I have found two general strategies for assessing students' science knowledge and understanding. One strategy is designing and administering a closed-response survey, which aims to determine attitudes or measures knowledge about specific topics/issues. Closed-response surveys have questions or statements to which students must select a response (Walonick, 2010). A second strategy is to create an open-ended assessment in which students' responses come in a variety of forms including, writing, drawing and discussion.

Designing a Survey Tool. In order to design an effective survey tool, the researchers must have a clearly defined objective. One example is the Monitoring the Future study (MTF) used by Wray-Lake, Flanagan and Osgood (2009). The MTF is a

closed-response survey that is given annually to high school seniors across the country. The objective of the study was to analyze changes in young people's environmental views over a long period of time. To meet this objective, Wray-Lake, et al. (2009) selected specific questions related to environmental issues from the annual MTF. The responses from surveys given between 1974 - 2005 were analyzed to determine trends over the period of three decades. According to the results of this study, "trends in adolescents' environmental concerns showed declines through the 1980s as well as the 1990s and beyond" (p. 78). The MFT study was used for the purpose of analyzing how the environmental attitudes changed over a period of decades. In my capstone project I will be focusing on how attitudes change as a result of being in a class dealing with environmental issues over the course of one semester or a period of about 4 months.

Other assessment tools have been designed for wide ranging use in assessing attitudes toward environmentalism. One such tool is the New Environmental Paradigm (NEP) survey. The NEP survey was originally designed in 1978 by Dunlap to measure adults' attitudes toward environmentalism. The survey has been refined and modified slightly over the years (Dunlap, Van Liere, Mertig & Jones, 2000). The NEP now contains 15 items intended to reflect critical aspects of environmentalism including limits on growth, balance of nature and anti-anthropocentrism. The NEP has become one of the most widely used measures of environmental worldview as cited by Lee (2008) and the use of the instrument in the 2008 study Environmental Attitudes and Information Sources Among African American College Students.

Open Ended Assessment. An alternative to using a survey to measure students' attitudes and understanding of environmental issues is to design opened ended

assignment. This strategy was used by Jordan, Gray, Demeter, Lui, and Hmelo-Silver. in the 2009 article An Assessment of Students' Understanding of Ecosystem Concepts: Conflating Ecological Systems and Cycles. Students first built a model ecosystem in their classroom, then were they asked open-ended questions and were asked to draw their model showing interactions. Students' responses were coded according to their level of sophistication using a rubric developed by the researchers. Open-ended questions and the opportunity to draw allows the students to demonstrate their true level of understanding. The open-ended nature of this assessment also allowed the researchers to find out what misconceptions students had.

Chapter Conclusion

Based on this review of the research literature, it is clear that a course in Energy and Resource Conservation needs to use an interdisciplinary approach, allow students to think critically, and model sustainable behavior. The curriculum should be student-centered, incorporate project-based learning and allow students the opportunity to focus on the big picture. The success of the course can be assessed in at least two ways; using a survey tool designed to assess the objectives of the course and creating open-ended assignments that allow students to demonstrate their true level of understanding. Chapter Three describes the research design for this project.

CHAPTER THREE

Capstone Methodology

Allowing students to engage and learn about the important topics of ecology and energy conservation has been the inspiration for this capstone project which is exploring the question of, "How do the students, who are participating in a course in ecology and energy conversation, describe their understanding of ecology and conservation?" This project has two primary components; one is developing curriculum that allows high school students to learn about ecology and energy conservation in meaningful ways, the second is assessing how well the curriculum accomplished the goal of engaging students in this content. Being the primary curriculum writer and the individual who was responsible for delivering the content to the student group puts me in a unique position to develop curriculum and explore how students engage with this challenging area of study.

The remainder of this chapter will outline the methodology that was used to collect data for my research. This capstone project used a qualitative research design to address my question. The chapter begins with a rationale for the use of a qualitative research design. Next I explain my decision to use the New Environmental Paradigm (NEP) (Anderson, 2012) survey to gauge student attitudes toward environmental issues, I describe this survey in detail as well as provide a rationale for using it. To assess student understanding I used student journals, this chapter describes the format for the student journals as well as a structure for assessing understanding using student journals. Next, I provide an overview of the course and describe demographics of the student group. This chapter also elaborates on the structure of the teaching journaling used during the project and how it was analyzed. Finally, the chapter concludes with a description of the

potential limitations of the study. The next section explains my rationale for selecting a qualitative research design for this project.

Rationale for the Research Paradigm

This research used qualitative methods for collecting data. Qualitative research is typically used when exploring how individuals or groups understand social or human problems (Cresswell, 2014). In this capstone project I explored how a group of high school students enrolled in an elective ecology course engaged with the main concepts of conservation and environmentalisms. Another feature that makes my research qualitative is that I taught the course used in my capstone project therefore I am an invested participant which according to Cresswell (2014) makes my research qualitative in nature. Also, because the sample size was small, 15 students, and nonrandom a quantitative approach was not possible. As qualitative research methods were used, the data analysis was also qualitative. For example, I completed text analysis of student journals to identify any emergent themes. The next section elaborates on the nature of the specific data collection tools used to collect the data and how data from each tool was analyzed.

Data Collection Tools

For this capstone project I used student journals as a primary source of information to answer my capstone question. I also kept a record of my own experiences and reflections in a teacher journal. In addition to student and teacher journals, I used a pre- and post-course environmental attitude survey called the New Environmental Paradigm survey (Anderson, 2012).

The goal of this capstone project was twofold. First, I wanted to develop a curriculum that was engaging and meaningful to students. As a high school science

teacher I take on the professional responsibility for ensuring that my students learn about ecology and energy conservation. In my role as a high school teacher this content is incredibly important for my students to understand. Unfortunately, in the school where I teach this content is not included in the non-elective science courses as much as it could be. The stand-alone class that I developed is focused on these issues, filling a gap for my students, with the goal of making them more aware of the issues. Growing this program of study and building student interest at the school I work at, required a well thought out curriculum to meet the students' needs and allow them to pursue their interest.

Student journals were used to assess whether or not I was meeting students' needs and engaging them in the curriculum. According to Al-Rawahi and Al-Balushi, (2014) journals are a place where students can freely respond to and reflect on what is happening in the course and provide a timely, authentic account of what they are learning. The authors also note how self-reflection through journaling also allows students to think back on the activities during the lesson, reveal their judgments and feelings about these activities, suggest alternative methods for conducting these activities, and note questions for further exploration. With this in mind, the student journals and teacher reflections were selected to be appropriate tools to analyze the strengths and weaknesses of the curriculum.

The second goal of this capstone project is to assess student understanding of ecology and conservation. As a high school teacher, I have had many casual conversations with my students about how they use energy. For example, when students plug in their cell phone they have trouble explaining where the electricity is coming from beyond knowing it comes from the outlet. I have even heard students confuse the

electricity in the outlets with the internet, thinking that the wires in the outlet also provide internet access. Therefore, it is important to my capstone project to have an authentic source of information to assess students understanding of energy and energy conservation as well as the use of resources. Student journals were selected to be this authentic source of information and the next section describes the format of the student journals used in this capstone project.

Format for Student Journals

According to DeFelice, Adams, Branco and Pieroni (2014) student journals can be a valuable source of information in regards to how students learn science. As DeFelice, et al. (2014) point out, when students write in journals they are able to express themselves in an authentic way. In the course, Ecology and Environmental Ethics, the research design was for me to introduce the use of journals to my students as a way for them to track their own learning throughout the semester as well as reflect on specific lessons and experiences.

Student were given a hardcover blank book that was referred to as a Student Journal. In these journals students were asked to record their observations, class notes, recorded notes for their projects and kept track of resource, and their reflections. All students were required keep a student journal. Students were also informed that their student journal was a factor in their overall grade. Fifteen students enrolled in the course all of whom maintained the journal. All 15 journals were included in the data analysis as each of their students returned a consent form signed by a legal guardian.

The Ecology and Environmental Ethics class was divided into several themes, each had the same essential journaling components. The themes included, Personal

Environmental Identity, Vested Interests, Environmental Issues Identification and Solutions, Action Driven Projects. The original research design was to have each student to complete a journal entry describing how they currently feel about the topics at before and after learning experiences. Instead, as the course included many field trips, it was logistically easier to have students complete a reflection the following day. The journal prompts used were specific to the activities that took place in class and classroom experiences. Some examples of those prompts are:

1. After listening to the speaker on climate change, how do you feel about the topic and do you have additional questions.
2. After visiting the wildlife refuge, what is the value to you personally and to society of having natural places and are you willing to pay for such places?
3. After reading Aldo Leopold's essay, do you think nature is something that we own or do we belong to it? Explain.

Another important curriculum aspect of the course was the Action Driven Project. The inclusion of this project was to promote active student engagement. When students have the opportunity to choose a project that is important to them and will have an impact on their community they are more likely to be actively engaged, this notion is supported in the work of McEwen (2008). Each student's project required an in depth study of a topic followed by the student working to solve a problem. The purpose of the projects was to give students the opportunity to engage in the content in meaningful ways. Students completed journal entries throughout their Action Driven Project to reflect on their progress.

Analyzing Student Journals

My goal in analyzing student journals was to determine the depth of students' understanding of ecology and conservation, however the reality of classroom instruction was that it became mainly a place for my students to reflect. Analysis of the student journals did provide me with a window in what my students knew about the topic and whether or not their understanding was based on misinformation or nonscientific sources of information. My analysis was based on reading all journal entries and identifying and recording emergent themes while reading.

Format for Teacher Journal

As the teacher of the Ecology and Environmental Ethics course and the researcher of this capstone project it was important to maintain a record of my experience with the course. This record was used to track my own experiences throughout the semester with the intention of comparing my perceptions as the teacher to the attitudes and experiences of the students. This record could also be used to make future improvements to the course.

The format for the teacher journal was free form entries written at the teacher's convenience, with the goal of one entry per week. The free form entries were dated and written in a notebook kept by me. The entries primarily included reflections on the effectiveness of the lessons and how I perceived students' achievement.

The primary objective of the teacher journal was to determine if the curriculum was effective from the teacher's point of view. The goal of the capstone was to determine how students understand the topics of energy and resource conservation, reflecting on the

effectiveness of the lessons provided insight on if students were progressing in their understanding of the curriculum.

Like the student journals, to analyze the teacher journal I used an emergent theme strategy. As suggested by Creswell (2014) the emergent theme strategy should be used when the data does not have a predetermined outcome, which is the case in the teacher journal. The key idea behind the emergent theme strategy is to learn about the problem or issue from the participants and to address the research to obtain that information. After all teacher journals were written I read the set and noted important topics and thoughts then categorize those into themes. Finding themes in the teacher journal gave me a better understanding of how students were responding to the curriculum. In addition to student and teacher journals I used the New Environmental Paradigm (NEP) survey (Anderson, 2012) to measure student attitudes at the beginning and end of the course in order to determine if any change has occurred as a result of the curriculum.

Pre- and Post-Course Student Attitude Survey

The survey tool that I chose to use for this capstone project was the NEP scale (Anderson, 2012). The NEP scale measures individuals' attitudes toward the environment and environmental issues. It is important that the scale measures attitudes rather than behaviors because as Alkan and Ogurlu (2014) mentions, environmental attitudes are changed in a shorter period of time than environmental behaviors. It would be unreasonable to expect that high school students could make dramatic behavioral changes in their lives such as installing solar panels, buying an electric vehicle or purchasing energy efficient appliances for the house they live in. Therefore, while it was ultimately a

goal for students to shift toward positive environmental behaviors, for the purpose of this study I was interested in looking for changes in attitudes toward environmental issues.

A second reason I chose to use the NEP scale as a pre- and post-course survey tool was because the NEP has been used in a wide variety of settings with many age groups in multiple countries. Hawcraft and Milfront (as cited by Dulap and Liere, 2008), performed a meta-analysis of the NEP and found that the results have a very good internal consistency. Meaning that the NEP scale can be used to compare sample groups to national and international populations.

The NEP is designed to measure the environmental concern of groups of people using a survey instrument constructed of fifteen statements. Using a Likert scale respondents are asked to indicate their strength of agreement or disagreement with each statement (strongly agree, mildly agree, unsure, mildly disagree, strongly disagree). The fifteen statements are listed below:

1. We are approaching the limit of the number of people the Earth can support.
2. Humans have the right to modify the natural environment to suit their needs.
3. When humans interfere with nature it often produces disastrous consequences.
4. Human ingenuity will insure that we do not make the Earth unlivable.
5. Humans are seriously abusing the environment.
6. The Earth has plenty of natural resources if we just learn how to develop them.
7. Plants and animals have as much right as humans to exist.
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.
9. Despite our special abilities, humans are still subject to the laws of nature.

10. The so-called “ecological crisis” facing humankind has been greatly exaggerated.
11. The Earth is like a spaceship with very limited room and resources.
12. Humans were meant to rule over the rest of nature.
13. The balance of nature is very delicate and easily upset.
14. Humans will eventually learn enough about how nature works to be able to control it.
15. If things continue on their present course, we will soon experience a major ecological catastrophe.

According to Anderson (2012) agreement with the eight odd numbered statements indicates a positive attitude toward environmental issue and general acceptance of the notion that humans are impacting natural systems. Agreement with the seven even numbered statements indicates a negative attitude toward environmental issues and the general acceptance of the notion that humans are separate from natural systems. The NEP was scored on a five point Likert scale as directed by Anderson (2012) see Table 1. The ordered response options are; Strongly Agree, Mildly Agree, Unsure, Mildly Disagree, Strongly Disagree. I have coded the responses on a scale from one to five. Agreement with the odd numbered items received the higher value, while agreement with the even numbered items received the lower value. The maximum positive score would be 75, indicating a strongly positive environmental attitude. A score less than 45 indicates a negative environmental attitude. The NEP was given to the students in the form of a paper and pencil survey. Students were given time during class to respond to each of the survey items.

Table 1. Shows the value assigned to each statement on the NEP survey

Item number	Positive/Negative Attitude	Strongly Agree	Mildly Agree	Unsure	Mildly Disagree	Strongly Disagree
1	Pro-environmental	5	4	3	2	1
2	Anti-Environmental	1	2	3	4	5
3	Pro-environmental	5	4	3	2	1
4	Anti-Environmental	1	2	3	4	5
5	Pro-environmental	5	4	3	2	1
6	Anti-Environmental	1	2	3	4	5
7	Pro-environmental	5	4	3	2	1
8	Anti-Environmental	1	2	3	4	5
9	Pro-environmental	5	4	3	2	1
10	Anti-Environmental	1	2	3	4	5
11	Pro-environmental	5	4	3	2	1
12	Anti-Environmental	1	2	3	4	5
13	Pro-environmental	5	4	3	2	1
14	Anti-Environmental	1	2	3	4	5
15	Pro-environmental	5	4	3	2	1

Demographics of Student Group

As mentioned in chapter one, the high school I work at is a large suburban high school with a total population of about 1600 students in grades 10-12. According to information available to anyone who can access the website for the school district in which I teach, the school has a diverse student population with about 35% qualifying for free or reduced lunch prices and in 2015, the student population consisted of 63% Caucasian, 13% Asian, 13% Hispanic, 9% African American and 2% American Indian.

The pool of participants for this capstone were students enrolled in the science elective titled, "Ecology and Environmental Ethics." On the first day of class there were 16 students enrolled. At the end of two weeks one student dropped the course. The research was based on data from 15 students with five females and ten males, who all completed the course. All students in this course are seniors.

Human Subjects Committee Approval and Limitations of the Study

In August of 2016 my application to the IRB was approved. The research was initially scheduled to take place in the fall of 2016. As a result of the resignation of a teacher at my school I was forced to adjust my teaching schedule and was not able to complete the research during that time period. The research was completed in the spring of 2017.

The conclusions from this research are limited because the sample size of the research subjects is small and non-random. Chapter Four presents the results of my data analysis.

CHAPTER FOUR

Description of Data

This chapter will describe the results of the data analyses for my research study. My research was designed to explore the capstone question, "How do the students, who are participating in a course on ecology and conservation, describe their understanding of ecology and conservation?" The research design was qualitative and conducted in Spring 2017 with a group of high seniors enrolled in Ecology and Environmental Ethics. Date collected included a pre- and post- assessment using the New Environmental Paradigm (NEP) survey (Anderson, 2012). The NEP survey was administered to students at the start of the course and the end of the course, a comparative analysis will be described. Students also kept personal journals throughout the semester, several themes from an analysis of the journals will be described. In addition, I kept a teacher journal which was analyzed, the themes from this teacher journal will also be described.

New Environmental Paradigm (NEP) Survey Results

The NEP survey was completed by 16 students on the second day of second semester, January 18th, 2017 and again on the final day of class, May 19th, 2017. The May copy of the survey was completed by 14 students. Two of the original 16 students did not complete the survey. One student was absent and one student who took the survey in January was no longer enrolled in Ecology and Environmental Ethics in May.

The purpose of the second survey was to ascertain if students' beliefs or attitudes regarding the environment had changed as a result of taking the Ecology and Environmental Ethics course. Students were informed that the researcher was interested in knowing where they were in their thoughts about the environment and were asked to

complete the survey. Since Ecology and Environmental Ethics is a one semester class the students were not exposed to specific environmental education during the first half of the school year.

The survey consists of 15 statements that are agreed or disagreed with on a five point Likert scale. A maximum score of 75 would indicate the highest level of pro environmental attitude. A minimum score of 15 would indicate the lowest level of environmentalism. The overall data shows that there was a gain in the total average score on the survey, the January average was 53.50 while the May average was 54.36.

The survey is arranged so that agreement with odd numbered items indicates a positive attitude toward the environment and agreement with even numbered items indicates a negative attitude toward the environment. The pre- to the post-NEP revealed a drop in the negative score indicates that students agreed with the statements that reflect a negative attitude toward the environment more often when taking the May survey compared to the January survey. Table 2 and 3 shows the breakdown of the agreement with both the positive and negative statements.

Table 2. January 2017 Pre-NEP Average Scores for Positive and Negative Survey Statements

January Data	Positive	Negative	Average Quiz Total
Student Average	31.06	22.44	53.50
Maximum Possible	40	35	75

Table 3. May 2017 Post-NEP Average Scores for Positive and Negative Survey Statements

May Data	Positive	Negative	Average Quiz Total
Student Average	32.93	21.43	54.36
Maximum Possible	40	35	75

In addition, it was helpful to examine the pre- and post-results for each of the individual statements in the NEP survey. Table 4 compares the January results to the May results for each individual statement.

Table 4. Pre and Post Average Score for Each Statement on the NEP Survey

	Statement on the student survey	Jan. Average	May Average
1.	We are approaching the limit of the number of people the Earth can support.	3.88	**4.14***
2.	Humans have the right to modify the natural environment to suit their needs.	**3.44**	3.21
3.	When humans interfere with nature it often produces disastrous consequences.	4.0	**4.14**
4.	Human ingenuity will insure that we do not make the Earth unlivable.	2.5	**3.0**
5.	Humans are seriously abusing the environment.	4.25	**4.64**
6.	The Earth has plenty of natural resources if we just learn how to develop them.	1.88	**2.21**
7.	Plants and animals have as much right as humans to exist.	3.5	**3.71**
8.	The balance of nature is strong enough to cope with the impacts of modern industrial nations.	**3.69**	3.64
9.	Despite our special abilities, humans are still subject to the laws of nature.	3.88	**4.21**
10.	The so-called "ecological crisis" facing humankind has been greatly exaggerated.	**3.88**	3.5
11.	The Earth is like a spaceship with very limited room and resources.	3.56	**4.0**
12.	Humans are meant to rule over the rest of nature.	**3.81**	3.07
13.	The balance of nature is very delicate and easy to upset.	3.75	**3.93**
14.	Humans will eventually learn enough about how nature works to be able to control it.	**3.25**	2.79
15.	If things continue on their present course, we will soon experience a major ecological catastrophe.	**4.25**	4.14

* The bold values are the higher average when comparing January results to May result

To better discuss the trends in the survey results it is worthwhile to analyze some items individually. In the following section I elaborate on the statements with the most significant change between the pre- and post NEP survey averages. For this study I chose to define a significant change as one that had a change of +/- 0.40 or greater.

Individual Statement Analysis

There were four statements that had a change of +/- 0.40 or greater. I selected two statements that had a positive change and two statements that had a negative change. These statements were selected because they were either specifically addressed by the curriculum or because the change in survey results contradicted statements from student journals.

Survey statement number four had an increased average score of 0.5, from 2.5 to 3.0, meaning more students on the May survey were unsure if human ingenuity will ensure that we do not make the Earth unlivable. One explanation for this result is that throughout the semester a significant amount of class time was focused on how natural systems behave and emphasizing to students how restoring natural systems can improve ecosystem health. For example, we spent time discussing the use of buffer strips to maintain and improve water quality. In addition to discussing buffer strips, we spent three hours planting native plants on the banks of a local stream and learned from experts what those plants will do for water quality. The NEP survey results support the idea that as a result of completing the course students learned that natural systems often do a better job than human ingenuity when it comes to ensuring that the planet remains livable.

The idea that nature can do a better job than humans at maintaining quality habitats was also seen in journal entries. For example, one student wrote the following in their journal,

> During the trip I learned that . . . creek has one of the highest sediment rates out of all the tributaries . . . A good way of stopping that is by planting these native species to help capture the sediment and hold it in place before it enters the creek and makes it worse. These native plants have root structures of different lengths and over time should out compete the non-native plants and thrive in that area for a long time to come.

The student who wrote this entry was not enthusiastic about doing physical work to improve the buffer strip at this site, however this student's journal entry is evidence that this student learned the benefit of restoring natural systems. Another area of the survey that had a significant positive change was the statement addressing the Earth's resources.

Survey statement number 11 had an increased average score of 0.44, from 3.56 to 4.0, meaning more students agreed on the post-NEP assessment that the Earth has limited resources. Throughout the semester we discussed renewable energy vs. fossil fuel energy, these discussions often centered around the idea that the use of fossil fuels is hurting our planet and these resources will eventually run out. The observed change in survey scores support the idea that the curriculum did have an impact on how students view the use of resources. Additional support that students internalized the idea that fossil fuel energy can run out was found in the following journal entry. After one discussion a student wrote,

> I would change the demand for gas and oil, because if people quit wanting it, the big energy tycoons in the Middle East will go out of business. That will solve our energy crisis, and a lot of political unrest. The way to shift demand would to make something else, like green energy CHEAPER than gas and oil, so the population demands more of that, and less "dirty energy."

This entry exemplifies the notion that fossil fuels are causing harm to the planet and that there is a cleaner way to produce energy.

Survey statement number 12 had a decreased average score of 0.74, from 3.81 to 3.07, meaning more students showed agreement with the statement that humans are meant to rule over nature. The reason for this change is difficult to explain since the curriculum did not spend a lot of time discussing an individual's right to rule over the land. However, early in the semester we did read some excerpts from the naturalist and author Aldo Leopold. One excerpt we read from Leopold focused on the question of owning the land versus belong to it.

After reading the expert students were asked to create a journal entry in response. I analyzed the responses to this journal prompt and placed them into three generalized categories; "We belong to nature," "We own nature," "Unsure." The results are as follows, nine students responded with an answer that stated we belong to nature, one student responded that we own nature, one student responded with uncertainty and four students did not respond the journal prompt. The journal responses do not correlate with the survey responses. Figure 1 shows the distribution of responses to statement 12 on the NEP survey in January and May. While Figure 2 shows the responses to the student journal prompt regarding owning land vs. belonging to it.

Figure 1. Pie charts of the overall results of the survey in both January and May.

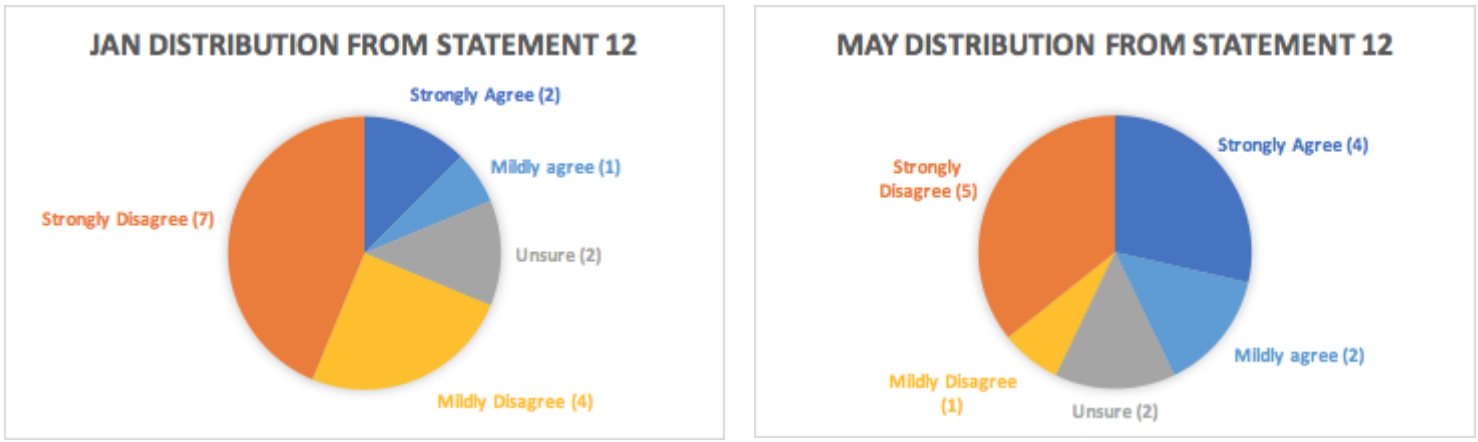
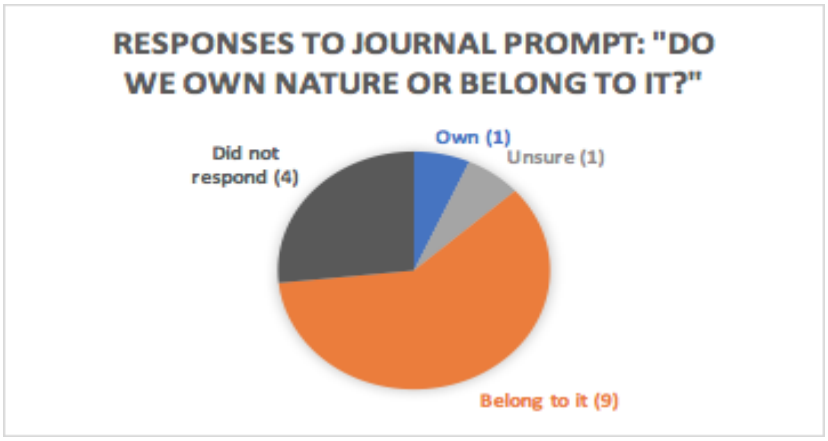


Figure 2. A pie chart of the distribution of student responses to the journal prompt "Do we own nature or belong to it?"



The discrepancy between the survey and the journals raises the question of which data is more reliable. As was mentioned in chapter three, DeFelice, et al. (2014) point out, when students write in journals they are able to express themselves in an authentic way. Therefore, I am more include to believe the student journal responses that shows a majority of students believe that we belong to nature.

Survey statement number 14 had a decreased average score of 0.46, from 3.25 to 2.79, meaning more agree that humans will learn how nature works and be able to control

it. One possible explanation for this decrease might be that students see advancements in scientific understanding as an advantage and see the potential for positive changes in the environment as a result new technologies. When our curriculum focused on climate change we often discussed that there are solutions to this problem.

For example, on one occasion we invited a speaker form an organization called Citizens' Climate Lobby which exists to create political will for climate solutions by enabling individual breakthroughs in the exercise of personal and political power. After the speaker talked to the class, students were asked to reflect in their journal about how they felt about climate change and what additional questions they had. One student wrote, "Clean energy is possible but it's very hard to get society and government to give up things that use oil and coal and replace them with things like electric cars." This student seems to acknowledge that we have the technology to improve the environment, but we are lacking the willpower to do it.

Statement 14 on the survey says that *eventually* humans will learn enough about how nature works to control it. Perhaps students in my class see this as meaning that we will eventually have the willpower to make the changes necessary to solve our global climate problem, hence the survey data shifted toward agreement of that statement. The next section will focus on the analysis of student journals and describe the themes that emerged as well as provide examples of student responses.

Interpretation of Student Journals

Students were given a hardcover paper journal to keep and use throughout the semester. Students were told that they could write whatever they like related to the course in their journal. At least once a week throughout the semester specific journal prompts

were given and students wrote their response. At the end of the semester the journals were collected for analysis.

All fifteen journals were analyzed including the ones completed by the students who did not complete the post- NEP survey. The journals were analyzed using the emergent theme analysis technique described in Chapter Three. In order to determine the themes, I re-read all journal entries and wrote main ideas from each journal entries on post-it notes. I then categorized the main ideas into similar topic areas. Finally, I grouped those topic areas into themes. After reading all the journal entries and interpreting the meaning I discovered four major themes; positive engagement with the outdoors, skepticism about environmentalism, desire for environmental action, and realization about something. My interpretation of each themes will be described and examples from the students' journals will be provided.

Positive Engagement with the Outdoors. This theme could best be described as a feeling of connectedness with nature. Throughout the semester students had many opportunities to get outdoors in order to learn and explore. On several occasions students described the experience of going outdoors with feelings of appreciation, humility and surprise. The following quote was taken from a student journal on an abnormally warm day in mid-February and captures the essence of this theme.

The assignment given by myself and my teaching partner was to have students spend 15 minutes outside, we challenged them to observe something they had not observed before. One student watched the bees behind our Environmental Learning Center. This student wrote,

> Today I stood behind the ELC and watched the bees. It was crazy to see them playing around everywhere. One thing I learned is this isn't good. They're looking for food and there is none. It made me look at things in a very different perspective and realize that we need bees to survive.

I read this quote to mean that the bees were not going to find any food because it was still winter and there were no flowers around and therefore categorized it as an example of what it meant to my students to be connected to the outdoors. For me, this entry was a good example of a student connecting with nature in a new way, appreciating what nature can do for us by stating that " . . . we need bees to survive." The next quote was taken from a student the day after our class visited a National Wildlife Refuge visitor center and was categorized by me as another example of one of my students having a positive engagement with the outdoors.

During this field trip, students had a chance to listen to a Refuge employee and we went on a short nature walk into the valley near the river. The student wrote:

> When I'm at a place like the National Wildlife Refuge, the main value I take from it is the beautiful views. It takes me some time to really think about the impact these places have on us, but it just doesn't come to me in a moment. . . . the simplest and most beautiful things in nature are priceless.

Again as a researcher this entry was another good example of how students who spend time outdoors gain an appreciation for their surroundings and can be humble about their own place in the world. From what I have observed as the teacher of this course it is important to get students outdoors as a way of supporting students in developing an appreciation for nature as way of seeing it as something of value that is worth protecting.

In my experience, high school students are naturally skeptical and question much of what adults talk with them about. This skepticism was apparent in some of the journal entries I analyzed and I created the theme skepticism about environmentalism to capture it.

***Skepticism about Environmentalism*.** The theme could be described students questioning the importance of nature in our modern world or as questioning the validity/importance of environmental changes. It is important to remember that when students arrived in our classroom they have had 17 years of influence from their parents, peers and previous teachers so I consider it perfectly natural to be skeptical and question ideas from different points of view.

To begin to illustrate this skepticism about the environment the first quote I chose is from the day after our class visited a power plant that burns biomass rather than fossil fuels. Students had an opportunity to ask the plant manager questions about how the facility operates and see how they turn wood chips and oat hulls into electricity. After the visit we asked students to think about green energy in a broad sense and write about the feasibility of our country transitioning to green energy. One student wrote, "I think green energy is a great idea, however as of our financial state in the U.S., we need to continue to produce as much profit as we can to pay off our debt so that we can then invest in a better power source." My interpretation of this comment is that the student seems to imply that profit is a higher priority than reducing pollution but also acknowledged that green energy is important and that it will be used more in the future. Another example of skepticism about the environment came after our class had the guest speaker from Citizens Climate Lobby.

The Citizens Climate Lobby is a non-profit, non-partisan organization that encourages citizens speak to their local and national legislators about climate issues for the purpose of advocating for policies that address climate change (Citizens Climate Lobby, About, Core Values, 2017). One of the things the speaker talked about was the advancement of the electric car, specifically Tesla's vision for a clean energy future. The day after the presentation one student wrote the following reflection, "I think it is weird how easy people from Tesla think it could be to create a better, more clean world. My question is, if all this seems so fool-proof and beneficial to our Earth, what is stopping it from happening?" My analysis of this quote along with knowing the student throughout the semester leads me to believe that this student was wondering about if economic factors should be the primary way of making decisions about the environment. My interpretation was also influenced by the fact the throughout the semester several students have maintained the need for "economy first, environment second" philosophy. Additional examples of journal writing on different occasions also suggested the importance "economy first" for other students.

On this journal writing occasion students were asked if they see the world primarily from a social viewpoint, an economic viewpoint or an environmental viewpoint, a student responded with this, "I would say I am mainly economic because I care a lot about money, I am not saying I don't like the environment, but I like the concept of money and business growing and making more money." My interpretation of this journal entry is that for this student, environmentalism is not a priority.

Becoming aware of some students separation of economic and environmental benefit has caused concern about my instruction and curriculum. It was not my intention

that students would see the need to choose money or nature; in my opinion making choices that are good for the environment will ultimately pay off financially as well. However, as some students did seems to make this separation, in Chapter Five I will describe some potential revisions to my instruction and curriculum to address this. While there were some students who wrote about the economy being the priority other students in the course reflected in their journal that they wanted to see change and wanted to be part of the change. The next section explores this desire for action and provides a few examples of student journal excerpts illustrating this desire for action.

Desire for Environmental Action. One of the goals of the course, Ecology and Environmental Ethics, is for students to take action, get involved in their community and have a positive impact. Throughout the semester our class participated in several community improvement projects, such as planting native species to improve the buffer strip near a local stream, picking up trash at the local park and teaching fourth grade students about the environment and stewardship. When I read and analyzed the student journals, one of the themes I recognized there was a desire for action. I would consider this theme to be students' desire for society to act in a more environmentally friendly way and/or a desire to change one's individual actions to be more environmentally friendly.

One of the first journal entries students were asked to complete was a personal environmental philosophy statement. Some students just wrote about enjoying the outdoors while other students wrote about their desire for change. An example of this theme can be found in this quote from one student's environmental philosophy statement,

> I am EXTREMELY passionate about the environment and I want to dedicate my life to preserving it. I don't do it for anthropocentric reasons – I don't think we

> should just protect earth for human's sake, although that is important too – think us as humans have a duty to protect the natural world. Our actions are destroying it, and it's too wonderful and beautiful to deplete from the earth. I am often frustrated with people who choose economic benefits over protecting the environment.

The expression of frustration over how others make decisions and the desire to protect the environment are the deeply rooted in this student's mindset.

Analyzing the journals showed growth in this desire for change. As I previously mentioned, when students begin this class they have already had many experiences that shape who they are and what they would like to become. It is unclear to me at this time how much of an influence the curriculum had on those students who already had a positive view of environmental issues. Additional information is required to better understand the impact on students of reading many essays and articles that were used in the curriculum. But the analysis of the journals did reveals students making connections between the readings and other aspects of the course. For example, one student made a connection between the readings and the project and wrote,

> I read Aldo Leopold's book this semester, and I have to say that it made a lasting impact on me and my environmental philosophies. I think the passage that means the most to me was, "None were shy of getting out in the woods, rain or shine, to see what was to be seen, to notice, observe and ask questions, eventually to make discoveries and challenge conventional ideas." I think this fits perfectly because you two [the reference is to me and my teaching partner] always stressed the idea

> of doing what we were passionate about, and not being afraid to go out and experience. I think this will stick with me.

My interpretation of this excerpt is that the student has come to the realization that doing something you are passionate about benefits the community and the person who is taking action. Seeing growth in the desire for action gives me confidence that the curriculum did accomplish the goal of shaping students' environmental philosophies to make them more positive. Other examples that supported the creation of this theme were found in a journal prompt that asked my students to reflect on how they will influence the future.

Near the end of the semester we asked students to reflect on the semester as a whole and write about how they will have an influence on the future. One student wrote,

> . . . the unintended consequences of fossil fuels are no longer unintended or acceptable. . . . I feel like I am one of the few people at my school who has realized this. If more millennials had a similar mindset it would be extremely powerful.

This student is one who participated in many other environmental outreach programs at our school and beyond, this student even participated in the Youth Climate March in Washington, D.C.

From knowing this student, it is clear that this student has a personal goal of spreading a message of environmentalism and has a strong desire to see the change in the actions of their peers. This student started the semester with a positive environmental mindset, however I feel that the quote from the end of the semester is evidence that the course did have an influence because now this student is more likely to be share this positive environmental mindset with others.

During my teaching career I have realized sometimes that the things students learn in my classroom are not the primary objectives of the lesson or curriculum. The next section describes some examples of journal entries that fall into the category of unintentional lessons and comprise the theme I named realization about something.

Realization about Something. Although classroom lessons are designed to meet certain educational/instructional objectives, I am always pleased that my students have learned something. The course used in this capstone project is unique because it gives students an opportunity to experience new things and hopefully come to realizations about things that they would have otherwise not have experienced.

One of those experiences involved tapping maple trees to collect sap then process it into syrup. Some students had not thought about where maple syrup comes from or how it is made. One student wrote,

> I learned a lot from going to tap maple trees. Before doing this I am not sure I could even identify what a maple tree looked like. We also saw that the sap from the tree is practically clear, like water and you need a lot of sap to make a little bit of syrup. We also talked about how the temperature affects the flow of the sap through the trees. I didn't realize how serious it is when they are boiling it down, there are actually a lot of steps in the process.

For me this quote documents the value of my students experiencing things and is a good way of making students think about things. Some people might consider an activity like tapping maple trees to be better suited to younger students, however I would argue that any activity that gets students thinking is worthwhile. Another experiential pedagogical strategy used in this course was having students participate in community service

projects, such as the planting of native species to enhance the buffer strip of a local stream.

It is my sense that some of these students would not choose to participate in such an activity unless it was course requirement. However, when they were asked to reflect on the experience most realized they enjoyed it. One student wrote,

> In the beginning I thought it was going to be boring and stupid because we were just planting plants for someone, but once they told us why we were doing it, it was actually kind of interesting. I didn't know why they were planting plants next to the creek, but I found it interesting after we learned that they do it so that the creek banks can become more strong. . . . I found this really interesting that they are preventing water erosion from the river bank naturally through plants. They could dump rocks or pour cement along the banks, but they have found a better way to do the same thing. . . . It is awesome to know that there are groups like the ones that put on this event in our community doing something that . . . benefits our environment and water sources around us greatly. This was definitely a good thing to experience because I had no idea the impact that planting small little plants can do for our environment.

When planning for our class to attend this planting event I was somewhat apprehensive because I was worried that students would use the occasion to socialize and we would leave the work unfinished. This entry is further evidence that when students in my class were given the opportunity to participate in meaningful activities they learned from those experiences. Another activity that students in our class participated in was our Outdoor Learning Day in which we invite fourth grade students to come to the high school.

For the Outdoor Learning Day students in our class organize and taught lessons about sustainability and environmental stewardship for the fourth graders. Some students expressed concerns and were nervous about the event beforehand, however afterwards the reflections about how the day went typically revealed that the day was better than expected and many students even wrote that they were surprised that they learned somethings as well.

For example, one group of students set up their lesson around the honey bees kept behind the ELC and taught the fourth graders about the importance to pollinators and how we can help pollinators by planting native flowers, a student in this group wrote,

> . . . the day taught me a lot about the younger generation and about speaking to groups. I realized that young kids care a lot more about bees than high schoolers. Most of the children were genuinely surprised about the decline in the bee population and asked many reflective and inquisitive questions.

This student is describing what for them was an important realization about the difference between how young kids and adolescents view the world. The opportunity to teach the younger students provided this student an opportunity to experience a different and unexpected point of view and learned that children can be surprisingly good at questioning.

My analyses of the student journals revealed four major themes; positive engagement with the outdoors, skepticism about environmentalism, desire for environmental action, and realization about something. Throughout the semester a teacher journal was also kept by me. The next section will discuss the analysis of the teacher journal entries and the themes that emerged.

Interpretation of Teacher Journal

The entries in the teacher journal were free format entries, meaning I wrote about topics related to the class that were most present in my mind at the time. On average, one entry was completed per week. In re-reading my journal and completing an emergent analyses two main themes emerged, anxiety about student work and pride in student performance. For the purpose of answering the capstone question, "How do the students, who are participating in a course on ecology and conservation, describe their understanding of ecology and conservation?" the teacher journal did not provide as much insight as I had initially hoped. Therefore, the analysis of the teacher journal will remain brief and starts with the anxiety about student work.

Anxiety About Student Work. Throughout the semester I found that I was worried about both the level of participation in class activities and assignments and the quality of the work that was completed. As the instructor of this course one of the measuring sticks that I use to determine the success of the course is the amount of participation in specific assignments.

Early in the semester students were asked to write their personal environmental philosophy statement. The assignment was intended to be a reflection for each student about how they feel about the environment and their relationship with nature. During the class period when the assignment was described some students gave both verbal and nonverbal cues that they were not interested in doing reflections. I reflected on this in my teacher journal and wrote;

> Two weeks into the semester, I can see there are some students who have views that are very different from my own. My hope for this week is that I can build

> relationships with those students and encourage them to be open minded. I am worried that some students view the reflection and journal writing as pointless acts and will not participate fully.

The students who I was worried about at the beginning of the semester did not fully buy into the journal writing. Throughout the semester these students often only wrote a short paragraph or a couple of sentences. Another event that induced anxiety for me was in preparation for our Outdoor Learning Day.

This day required a lot of organization and preparation by me. I needed to coordinate with 22 fourth grade classroom teachers about dates and times for the event, contact outside vendors to bring in canoes for the fourth grade students as well as an educational trailer from a local recycling center. In addition to working with other elective teachers at my high school to coordinate lessons for the younger students.

The days leading up to the event I felt my high school students were not seeing the importance of the event and were not adequately prepared. In my teacher journal I wrote,

> My first time organizing fourth grade day will be a real test. Students seem to be not nearly as concerned as I am, I hope they take this seriously and do a good job. This is one of the most stressful things I have done because so much of it is out of my hands. The weather forecast looks good but I am not 100% sure I can count on these kids.

I think the challenge with authentic learning experiences, such as our Outdoor Learning Day, is that the teacher hands over control to the students and needs to take on a coaching role rather than an instructional role. As a teacher in this role failure by the student is a

scary thing because it means that many people will be affected and the students failure would reflect poorly on the teacher and classmates. Another area of concern came from the progress, or lack of progress, on student's semester projects.

For example, I found myself struggling with my role in these projects. Some students were able to take the general outline and requirements of the project and run with it, while other students struggled to even begin. On more than one occasion I asked myself how to support the students who struggle without dictating the topic to them. A journal entry from mid-April read,

> We are all over the map on these projects. Some are looking fantastic and need no help, while other kids have yet to begin. This is supposed to be student driven work! If I tell them what to do doesn't that defeat the purpose?

The majority of my teaching career has been centered around using traditional, teacher-centered instruction, changing to the student-centered approach required me to have more trust in my students and develop stronger relationships with students. The anxiety I felt throughout the semester was balanced by the pride I felt with the achievements of my students. The next section will provide some examples of student successes that were experienced throughout the research period.

Pride in Student Performance. An important take away for me this semester was that when students are given authentic learning opportunities they will usually rise to the occasion. Throughout the semester we took several field trips to experience environmentally friendly practices in the community. One of these trips was to see the green roof on an ice arena. My reflection from that visit was,

> We went to visit the green roof yesterday. It was very cold and windy, next year I know to schedule the visit in May. Despite the cold weather, I thought the kids did a good job asking intelligent questions and they seemed genuinely interested. I was impressed by [one of my male students whose name is not included to protect confidentiality] questions about the lifespan of the roof and the cost vs. benefit of this design.

The student referenced in this journal entry was typically not engaged in our lessons and not interested in environmentally friendly practices so to see him interested and engaged was rewarding.

Another example of feeling proud of student performance came following our Outdoor Learning Day. As I mentioned previously, I was worried that students were not prepared to teach their lessons to groups of fourth grade students. This anxiety was compounded when I learned that the day which had been scheduled for this event coincided with "senior skip day." All of the students in my class are seniors and I was convinced that several of them were going to choose to take the day off rather than teach lessons about sustainability and environmental stewardship to fourth grade students. However, 15 of the 15 students, all of whom were high school seniors, participated in Outdoor Learning Day even though it was Senior Skip Day. After a successful day I wrote,

> Wow! They came through big time! The fourth graders had a great day, their teachers said the high school kids did a great job and the weather turned out perfect. I guess when the kids know people are counting on them to perform they actually do.

In my professional opinion, this is powerful evidence that creating authentic, student-centered learning opportunities is more effective than the traditional, teacher-centered approach.

The end of the semester also revealed success in the approaches used throughout the research period. One of the last events of the semester is an evening where student work is showcased at our school for other students, parents, teachers and community members. After the showcase event, the final entry in the teacher journal read,

> When all's said and done, I feel good about the semester. There were lots of ups and downs, but more ups. It was great to see the semester's work on display at the showcase and I was happy with the comments I heard from the other adults who were there. I hope the students look back on the semester and are equally proud of the work they did.

One of my goals in teaching this course was to increase students level of awareness for environmental issues and their shift their attitude to respond positively to environmentalism. During the semester I was unsure if I was making any progress toward these goals however at the conclusion of the semester I ended with a feeling of pride and satisfaction with the progress made by my students.

The final chapter will summarize the conclusions of the capstone project and discuss what was learned. Limitations of the study and ideas for future research will also be discussed.

CHAPTER FIVE

Conclusion

We all make decisions every day that have an impact on the environment. Rachel Carson (1962) was an early leader in environmentalism and in her book "Silent Spring" she states that,

> We urgently need an end to these false assurances, to the sugar coating of unpalatable facts. It is the public that is being asked to assume the risks that the insect controllers calculate. The public must decide whether it wishes to continue on the present road, and it can do so only when in full possession of the facts. (p. 13)

One of the underlying goals of this research was to help my students be in full possession of the facts and to think about how their decisions impact the environment. In addition, I wanted to gain a better understanding of how my students respond to a curriculum that is student-centered and driven by authentic learning experiences around the environment. This chapter will use the information collected during the research period to address the capstone question, "How do the students, who are participating in a course in ecology and energy conversation, describe their understanding of ecology and conservation?" The chapter will also discuss how the research has impacted me professionally, how others can use this research and the limitations of the study.

Addressing the Capstone Question

As I previously mentioned, when students begin this course they have already had many experiences that shape who they are and what they would like to become. The course, Ecology and Environmental Ethics, which was used in this capstone research is a

one semester (18 weeks) elective, co-taught by the science and social studies department, open to students in their senior year. This course is designed to provide students with a system of thought, through the application of the scientific method, service learning, ethics and classical logic, to evaluate human interaction with the environment. The mission of the course is to assist students in developing an understanding of the direct footprint humans leave on the natural world and to explore methods for diminishing the impact of humans on the environment. As the teacher of this course I hoped to encourage those who already have a positive view of environmental issues and expose others to new ways of thinking about the world. Based on the data collected for this capstone, pre- and post New Environmental Paradigm (NEP) survey (Anderson, 2012) and student and teacher journals, there is support that students in the course experienced a small but significant positive growth in their environmental awareness.

The NEP survey results did indicate a small positive change in the environmental attitudes of the class participants and I saw additional evidence in the journals. However, there is also anecdotal evidence, not included in the research design, that show students in the class experienced a small but positive growth in their environmental awareness. The two sources of anecdotal evidence were one, teacher observed behavior of students and two, teacher heard conversations among students.

During the semester I was able to observe students doing things that demonstrated their positive engagement with the environment. Early in the semester, we had an assignment that asked students to take pictures that document an example of how people fail to protect a shared outdoor space. After this assignment and the subsequent discussion, the class choose to visit one park documented by several students to pick up

trash littered on the ground. Another student who came into the semester with a positive environmental mindset also demonstrated a change in behavior. This student helped organize a group of his peers to attend an environmental lobbying event at our state's capitol. He also joined a group of youth activists on a trip to the Climate March in Washington D.C. It is difficult to say that this student was inspired to do these things because of this class, however being part of the class help this student recognize the importance of environmentalism. Students also talked about issues related to the environment and I recall some of these conversation I overheard.

For example, at the end of the semester when students share their work at our school's showcase night, I heard a student from my class talking with a school board member and one of his comments to the school board member was that he would never have thought composting was so interesting and easy to do. As the teacher of the class and the capstone researcher I felt that this captures the essence of what this capstone project was aiming to accomplish and that is exposure to new ideas and a shift in mindset. On another occasion, after our class participated in planting native plants near a local river, I heard students discussing the landscaping around our school. They were talking about the fact that there is no natural landscaping and how they would like to that change. Hearing students talk about the landscaping at our school after the experience of restoring habitat near the river supports the idea that the experience did influence these students view about how we impact the environment. Along with the observed changes in students' attitudes and behaviors I recognize that this capstone project has had an impact on my professional life as well.

Impact on me Professionally

The majority of my teaching career has been centered around using traditional, teacher-centered instruction, changing to the student-centered approach required me to have more trust in my students and develop stronger relationships with students. I have recently completed my ninth year teaching. The teacher-centered approach I used during the first several years of my career was a reflection of my own educational experience. A colleague of mine, who also teaches environmental science, encouraged me to take a student-centered approach for the Ecology and Environmental Ethics course. Throughout the semester I felt anxiety about the shift in responsibility from teacher to student however I found that on most occasions the students met the challenges they faced and exceeded my expectations. To illustrate this, I will describe one instance from the semester stands out in my mind.

During our Outdoor Learning Day, a meeting for students graduating with honors had been scheduled. I was particularly worried about a special education student who was going to be left alone to lead a station for about a half an hour. When I went to check in at that station, the teacher of the fourth grade class commented to me that the student leading the station was doing an excellent job. This convinces me that giving students meaningful and authentic experiences is the best way to ensure they are engaged and able to demonstrate their best work.

Changing to the truly student-centered classroom did require me to take risks and put a lot of faith in my students. I found that developing relationships with students was an extremely important element to the success of the student-centered instruction. For this capstone project I used students in the course “Ecology and Environmental Ethics” as

my test group, however I also teach chemistry. As a result of this capstone project I plan to use more student-centered teaching strategies in my chemistry class.

Environmental education was the focus of this capstone project, however the environmental class I teach accounts for a small portion of my total students. Most of my student contact hours are in my chemistry classroom. Giving students the opportunity to engage in content in a way that is authentic and meaningful to them should not be limited to environmental education. In my chemistry classroom authentic learning will take the form of hands on lab experience and group work to solve problems. The challenge in chemistry is that many students do not continue their study of the subject and therefore they do not see the value in learning the content. To make the experience authentic and meaningful in chemistry the process of learning and the practice of solving problems becomes the emphasis. Although the process may look different in different subject areas and with different teachers, all teachers should incorporate authentic learning as much and as often as possible.

My Emerging Sense of Self as a Researcher and Scholar

Before I began this capstone I did not consider myself to be a researcher. As with many other teachers, the beginning of my career was focused on learning the teaching trade and doing my best to deliver content. Now that I have become more comfortable in the day-to-day aspects of teaching I have been able to think about how I can contribute to the profession. This capstone project has given me the opportunity to learn how others who teach environmental science approach the content and incorporate these best practices into my own classroom.

Through this capstone project I have benefited from the intense reflection required in doing this type of research. I have always thought of myself as a reflective practitioner, however doing qualitative research in my own classroom has put my teaching under greater scrutiny and forced me to think about how I can approach the other courses I teach to make them more student centered. As a result of completing this is project I have learned a lot about environmental education however I do realize that it may be difficult to generalize the results of this study and apply the same techniques to different areas of education.

Limitations of the Study

The course used in this capstone project is unique in many ways, hence it may be difficult to replicate the setting and obtain the same results in other classrooms. The course is co-taught with a social studies teacher, meaning that there are two teachers working with fifteen students. It would be difficult to manage the variety and scale of student projects if we were working with a typical student teacher ratio of one teacher for 30 or more students.

Another aspect of the course that is unique is that all students are seniors. This gives us a lot of flexibility in our planning because students have their driver's license which enables us to plan field experiences without the need for bussing. Since this class is composed of students in their final year of high school they enter the class with a wide variety of previous course work. Students with different backgrounds in science tend to take away different types of meaning from the class. Given that there are many variables which are difficult to control the outcome of the class will be unique for each student. Qualitative research is not meant to be generalized, however there are aspects of this

research that can and should be viewed broadly when making decisions about how to approach science education.

Possible Impact of My Research on Secondary Science Education

Although this capstone project was completed in the spring of 2017, I began the background work and conducted the literature review at the start of 2016. During this time period I was part of the curriculum development team that was tasked with examining how we teach science at the secondary level in my district. My school district has chosen to adopt the Next Generation Science Standards (NGSS) (2013) to guide our curriculum development. The NGSS provide a framework for teaching science that focuses on learning science through doing science (NGSS, 2013). The recommendations from the NGSS align well with the work of my capstone project because both focus on finding ways to increase student engagement. I would recommend that other districts examine the NGSS and make revisions based on these standards. Another part of the NGSS that I like is that about one third of the standards are “Earth and Space Science” which contains many aspects of environmental education.

In addition to incorporating NGSS, I recommend that the exposure to environmental education is earlier in a child's schooling and more frequent. Through this capstone project it has become clear that students don’t get enough environmental education. Some of my favorite moments teaching have been when students are outside and interacting with nature. I have become firmly convinced that when students have positive experiences in nature they are more likely to want to protect it and will make more environmentally friendly decisions.

In my experience teachers are naturally outgoing individuals who usually like things well planned. I understand that transforming from a teacher centered teaching style to a student centered classroom means taking risks. In science that may means giving students the freedom to design and conduct their own experiments, make mistakes and ultimately draw their own conclusions. While these things may be intimidating and uncomfortable, I encourage secondary science teachers to take chances and going beyond their comfort zone to make the classroom experience more authentic and to motivate students. This capstone project has answered many questions for me and has given me insights into different teaching strategies, however I do have some questions that remain unanswered and will require more research.

Recommendations for the Future

Teaching students about the environment will continue to be important as our society attempts to deal with the impacts of global climate change. Hence, finding the most effective strategies for teaching students about the environment will be necessary. One area that I would be particularly interested in examining is how to best expose students who live in large urban settings respond to environmental education. An organization called Appetite for Change is one initiative that aims to teach youth to grow food in urban settings in order to develop a closer relationship with the land and the community (Appetite for Change, 2017). The income level of students' families is another factor that I did not analyze in my research and I would be interested to learn how students in different income brackets experience environmental education.

Another variable not address in my current research design is how my students experienced spending time outside to learn about the environment something I

incorporated into the curriculum used as part of this capstone project. I am also curious about the relationship between students' attitude toward the environment and the strength of their science education background. For example, do students who take accelerated science classes have a more favorable attitude toward environmental issues? Although my capstone project did not answer every question that I had about environmental education, I certainly gained a lot from the experience of developing student-centered curriculum focused on environmental education and the analysis of student surveys and journals.

Closing

It is my hope that the reader of this capstone will be able to take some insights I have had and apply them to their work. For me, completing this capstone project has definitely impacted how I approach environmental education and will also influence my work as a chemistry teacher. One big take away for me is that when I provided my students with authentic learning experiences they learned more and were fully engaged. Providing students with authentic learning experiences will increase engagement in the environmental education setting as well as other educational settings. In the "Ecology and Environmental Ethics" course my students are given the freedom to choose a project based on their personal interest, while it may not always be possible to do this in other courses, I would favor student selection when there is room for it. Another big takeaway to how I will approach environmental education moving forward is that getting students outdoors as much as possible increases their engagement. Sometimes even simple outdoor activities can reveal gaps in student knowledge.

For example, early in the spring 2017 semester I organized a nature scavenger hunt. I selected items that I thought would be easy to identify and find. One item was a branch from a maple tree, I was surprised to learn that most of the students could not recognize a maple tree in the forest setting. This revelation let me to teach the class some basics of tree identification and how to use a dichotomous key.

The last big take away for me from this work is that teaching students about the environment should be continuous throughout their educational career. The students in my class did demonstrate a slight positive change in their attitude toward the environment, however if they had experienced similar exposure to the topics earlier and more often the shift could be more significant. In my professional opinion, environmental education should be ubiquitous and should not come to an end.

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