January 2012

The Impact of Socioscientific Issues Based Curriculum Involving Environmental Outdoor Education for Fourth Grade Students

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by

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Dissertation submitted in partial fulfillment
Of the requirements for the degree of
Doctor of Philosophy
In Curriculum and Instruction with an emphasis in
Science Education
Department of Secondary Education
College of Education
University of South Florida

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ABSTRACT

There is a divide between what students are being taught within the science classroom and what they experience out in the real world. This study sought to explore possible relationships between a socioscientific issues embedded curriculum and outcome variables addressing environmental attitude and knowledge, oral and written argumentation and critical thinking skills. Both quantitative and qualitative methods were used to examine both within and between class differences as well as individual differences between the beginning and end of a semester of elementary school. Results indicated that socioscientific issues assist students in developing their critical thinking skills while also providing students the opportunity to be exposed to and participate in local and global environmental issues influencing the community at large. Statistical significance was found between groups in regards to attitude toward the environment, the qualitative interviews did indicate that some students provided more advanced argumentation skills by articulating alternate viewpoints on controversial environmental topics. Theoretical implications regarding the use of socioscientific issues in the classroom are presented.

CHAPTER 1: THE PROBLEM

Introduction

There is a divide between what students are being taught within the classroom and what they experience in the real world (National Research Council, 1996, 2000, 2009). The public acquires science information throughout their lives by which they construct their understanding of scientific information. A few studies have shown that schooling is necessary but not sufficient enough to support lifelong science literacy, emphasizing the necessity of alternative learning environments and approaches (Falk, 2009; Falk, Storksdieck & Dierking 2007). In Britain, Scotland and Wales the development of Forest School is becoming an exceedingly popular way to incorporate regular contact with woodlands or outdoor spaces for students. Forest School allows students to become more familiar with the open and green spaces, creating opportunities to learn and gain experience outside of the classroom (O'Brien, 2009). In England and Switzerland, educators are beginning to bring controversial environmental topics into the science classroom to allow students the opportunity to discuss issues-based science, connecting what they are learning to real world issues such as nuclear power and rainforest deforestation (Rickinson & Lundholm, 2008).

Socioscientific issues (SSI) allow students to view science realistically by integrating attitudes and ethics in making judgments about scientific information, similar to what is being introduced into the science curriculum in Europe. Although SSI are controversial by nature, not all controversial issues are considered to be socioscientific issues. The SSI framework makes use of informal discussions, formal debates and argumentative thinking as an important part in preparing students to use information in familiar and personally relevant contexts (Erduran, Monk, Osborne, Simon & Zeidler, 2003; Sadler & Zeidler, 2005; Sadler & Donnely, 2006; Zeidler, Howes, Sadler & Simmons, 2005; Zeidler, Sadler, Applebaum & Callahan, 2009). Students exposed to the use of informal discussions have the opportunity to learn that decision-making is complex. There are numerous social issues, such as stem cell research, water shortages and habitat loss, involved with solving scientific problems that can, in essence, prepare students to engage in argumentative thinking (Erduran, Monk, Osborne, Simon & Zeidler, 2003; Simmonneaux, 2001).

Socioscientific issues coupled with informal educational experiences have the ability to create scientifically literate citizens by enhancing students' understanding of how science works outside of the classroom. Zeidler & Sadler (2009) place emphasis on the quality of educative experiences leading to the quality of life within our society. If the goal of scientific literacy is for students to understand complex scientific issues and make decisions based on their knowledge, then it is imperative that they are exposed to SSI within informal learning environments (Zeidler, 2007). An SSI curriculum incorporates real world, ethically and morally debatable scenarios that are drawn from real world science issues that citizens are faced with daily. The three main characteristics of the SSI movement are their controversial nature, their open-endedness, and the inclusion of moral or ethical reasoning (Zeidler & Sadler, 2008a; Zeidler, Sadler, Simmons & Howes, 2005). Components of this approach allow students to engage in critical thinking and discussion of topics with others who may believe differently. It is a multi-faceted tool necessary in developing critically thinking students, hopefully creating meaningful dialogue and authentic learning.

It is important for children to begin the development of critical thinking at a young age. Research within the informal science education field has shown that adults who are more aware and involved with environmental issues were exposed to informal learning or alternative ways of learning as a young child (Dierking, Falk, Rennie & Williams, 2006; Falk, 2009; Falk & Heimlich, 2009). However, few studies have been done specifically focusing on using socioscientific issues as a base for the curriculum in children at the 5th grade level and younger (Dolan, Nichols & Zeidler, 2009).

There are a few programs set up to cater to younger learners within informal science education facilities. For example, WINGS (Winning Investigative Network for Great Science) is a program designed to inspire adolescent students' long-term interest, understanding and involvement in science through the study of butterflies (Dunckel, Malone & Kadel, 2008). This program focuses on student's ages 9-13 and promotes understanding of scientific inquiry through direct engagement with science, and by doing science outside of the classroom. One activity called "sort it out" has the students break into smaller groups and organize photos of butterflies into categories. Students discuss their reasons for their categorization through group spokespeople, loosely involving informal discussion. The students discuss with one another in a small group setting and then share their views and hear how other groups came to their decisions and what their thought process was for the butterfly categories (Dunckel, Malone & Kadel, 2008).

Splash, Flash, Crank, Slide, Alive Tour at a Discovery Center in Tennessee provides inquiry based science activities for students PreK-2 that include small group problem solving (Ervin & Sadler, 2008). While students get acquainted with splashing around a water table highlighting water cycles, students are asked about pollution problems and conservation. They also are able to create waves and experiment with small boats as a few of the hands on activities they do while in smaller groups, helping students develop problem solving skills (Ervin & Sadler, 2008). However in this project there is a lack of follow-up or reinforcement of specific issues highlighted during this experience. At this site, the educator at the informal facility only touches on such issues, missing an opportunity to delve deeper into investigating and facilitating how younger students think about issues connected to pollution and conservation. By using socioscientific issues as topics for informal science experiences to enhance students' ability to communicate, young students may be more inclined to think critically about issues dealing with the environment. Solutions do require choices and decisions based on the critical examination of information providing an opportunity to cultivate decision-making at an early age through the use of environmental issues.

The Norwegian Framework Plan for the Content and Tasks of Kindergartens emphasizes democratic values by recognizing the equal worth of all humans, respect for life, justice, truth and honesty. Research conducted in Norway has suggested that the best way to achieve these democratic values is through informal learning situations in the outdoors because it allows for positive development through participation with other children due to the fact they are learning to cultivate relationships with living things outdoors, which transfers over to compassion for humanity (Aasen, Grindheim & Waters, 2009).

By focusing on environmental issues, students will not only begin to think critically about such issues, they will become more environmentally literate as well. The Environmental Literacy Council (2002) determines that to become environmentally literate, students need to have a fundamental understanding of the systems of the world, both living and non-living, along with the analytical skills needed to weigh scientific evidence and policy choices. The "No Child Left Inside" initiative is a growing movement that promotes environmental literacy by reconnecting children with nature and has been supported by new national laws being developed to set forth guidelines to enhance environmental literacy (Louv, 2007). Environmental issues are multidimensional and include ethical and political dilemmas that align with the SSI framework. These issues put forth the idea that scientific knowledge is changing and evolving, and that there is critical importance placed on environmental literacy for our society and the environment around us. There is a growing need to connect environmental issues not only with the health of the environment but also to put it into context with larger societal issues that have been developing such as access to clean drinking water, human health and safety and social justice. The goal is to provide students with the knowledge and skills needed to make decisions about important environmental issues that they will be faced with in the future.

Some students are growing less involved and connected to the environment and outdoor spaces creating a lack of knowledge within the area of environmental topics (Falk, 2009). Students that are allowed the opportunity to discuss environmental problems and discuss possible solutions may become more aware of what is going on around them in their formative years. Exploring different views that are held on such topics as global warming, pollution, or invasive species introduction through the use of open discussions and debate may provide students with critical thinking skills that are needed to be a scientifically literate member of society.

The overall goal of this study was to design, implement and evaluate a socioscientific issues-based environmentally focused program used to enhance learning and critical thinking of elementary school students during outdoor environmental science experiences. The curricular content was taught using socioscientific issues focusing on environmental and conservation based content within an informal learning context. Issues dealing with speed reduction for the safety of local wildlife, beach and farmland erosion, seal culling and plastic pollution have been chosen as topics of discussion due to the growing concern over these environmental influences within the local and national community. A pre-test was administered to measure the students' knowledge and understanding of environmental and conservation issues, their attitude toward conservation before participating in outdoor hikes and the socioscientific modules, followed up with a post-test after the semester long experience. Along with the pre- and post-test instrument, students were asked to participate in a series of classroom debates designed to compliment their informal environmental experiences, while written and oral interviews that focus on argumentation and critical thinking skills were conducted.

Theoretical Context of Study Background

Informal Science Education

While classrooms provide a good contextual framework for scientific conversations (Kelly, 2000), informal learning atmospheres allow students to further explore environmental issues in an atmosphere that is conducive to hands-on learning (Dierking & Falk, 2004). These experiences are seen by many educators as important for students, but their integration into classroom curricula and contexts is difficult and often times it is this lack of cohesion that creates the loss of meaningful learning opportunities (Dewitt & Storksdieck, 2008; Kisiel, 2006). Teachers may tend to maintain their task-oriented focus by having students fill out worksheets while visiting these facilities, or as a follow-up activity once back in the classroom because of the need for accountability (Ratcliffe & Grace, 2003). This can result in learning for some students, but hinders learning for others by cutting down on opportunities to work in groups and share ideas. With the emphasis placed on standardized testing, with teachers and principals being accountable for their schools' performance, the value of informal experiences are coming under scrutiny based on the curricular demands that are set in place through the schools (Dewitt & Storksdieck, 2008).

Informal science is an asset and a tool that can be used to help students grasp how science can connect them to the real world (Evans, 2005; Miller, 2004). Gerber, Cavallo & Marek (2001) propose that students who participate in few informal learning opportunities may have less well developed schemata with which to relate formal science experiences compared to those that are exposed to numerous informal learning opportunities. According to the National Foundation for Educational Research, learning in outdoor environments, which is considered informal learning, can have varying positive impacts on cognitive development, affective, interpersonal, social and physical developments (Dillon, Morris, O'Donnell, Reid, Rickinson & Scott, 2005). For example, the Forest School approach being adopted by teachers in Britain is showing gains in conceptual understanding because a theory taught in the classroom is made explicit by "doing" in the outdoor environment, resulting in gains in student confidence and understanding (O'Brien, 2009).

Dierking (2004) has determined that informal facilities as zoos, aquariums, museums and science centers are striving to become centers for conservation education and environmental awareness by conducting scientific research, fostering dialogue about civic responsibilities, and offering engaging experiences to visitors with the hope of influencing the way people understand, care about, and participate in activities that help protect our global community. However, there is an incomplete understanding as to the influence of these programs, because this field is lacking in rigorous research-based studies related to the impact such programs have on the quality of students' reasoning, conceptual understanding, and personal connection to environmental issues. There is a need for more focused research, particularly about the impact of such experiences on young children.

Informal facilities have the potential to make a major contribution to its visitors' learning about science by providing information and offering opportunities for visitors to gain a clearer understanding about science as a process of building explanations about natural phenomena in ways that are contextualized by the prevailing culture. This type of understanding emphasizes more than knowing facts, it means knowing science as a way to think critically about information and using it to make rational decisions (Henrikson & Froyland, 2000; Rennie & Williams, 2006). Some science centers have taken on the task of improving cultural aspects of scientific literacy by displaying exhibits highlighting this; however, other facilities may not place importance on the civic and practical aspects of scientific literacy, thereby losing out on potentially creating citizen action.

Socioscientific Issues

Socioscientific Issues (SSI) incorporate moral and ethical components of scientific topics, done so through interaction and discussion of controversial issues that attenuate the topics. The open-ended nature of SSI allows students to think critically about issues with others who may hold opposing viewpoints (Simonneaux, 2008; Zeidler & Sadler, 2008). The SSI movement focuses on enabling students to understand how scientific issues and the decisions they make about these issues have moral and ethical outcomes. Extensive research has been conducted on the use of SSI within the science classroom to connect students to science issues that are occurring within the community at large, measuring their moral sensitivity and improving the understanding of scientific concepts (Fowler, Zeidler & Sadler, 2009; Zeidler, Sadler, Applebaum & Callahan, 2009; Zeidler, Applebaum & Sadler, 2011). However, it is important to note that there is a lack of empirical research examining the use of socioscientific issues within informal science learning situations.

According to Ratcliffe and Grace (2003), formal education should provide students with the skills with which to explore scientific issues that may be presented in the future. The use of socioscientific issues allows students to more closely examine the links between morals and ethics that are a part of scientific knowledge. This may ultimately lead to the goal of scientific literacy, which requires critical thinking skills

(Sadler & Zeidler, 2005; Norris & Phillips, 2002). The use of informal discussions using socioscientific issues exposes students to moral and ethical issues and diverging viewpoints, creating a richer experience for the student (Zeidler, Sadler, Applebaum, Callahan, 2009; Zeidler, Applebaum & Sadler, 2011).

Critical thinking should be considered an important aspect of science education because of the importance it ultimately has on quality of life. At the root, critical thinking is the analysis and evaluation of how one thinks and the knowledge that there is always improvement and growth to be had through thinking skills; it requires students to use higher order thinking (Sadler, 2002). Without the proper skills poor decisions can be made leading to economic, environmental or social chaos (Elder & Paul, 2009; Zeidler, Lederman & Taylor, 1992; Zeidler, 1997).

By allowing students to discuss real world problems they can begin to understand the complexities of science, breaking down the ideas that science is only what is learned in the classroom. Students may also see that science goes beyond that subject matter and can be linked to economic, political and moral issues as well and can help develop skills such as problem solving and decision making (Hodson, 2003; Zeidler, Sadler, Applebaum, Callahan, 2009; Zeidler, Applebaum & Sadler, 2011). This outcome may be reached by using socioscientific issues because of their all-encompassing nature and also by providing students with informal learning contexts to put these issues in context. Cox-Petersen & Spencer (2006) support the use of informal experiences toward the goal of scientific literacy because it allows for opportunities for discussion and interactions with other students, promoting brainstorming and the sharing of ideas and knowledge; exposing students to the reality that science is much more complex than a set of memorized facts. Although in recent years some research has focused on the impact and importance of informal settings as increasingly valuable learning environments, empirical data and documentation of such experiences is still lacking (Falk, Heimlich & Foutz, 2009).

While classrooms using SSI provide a productive contextual framework for scientific conversations, a possible key to connecting students further with science may lie in the use of informal experiences to help students understand their role in science. SSI can be used as a tool to provide students with the opportunity to explore ethical issues and moral dilemmas related to stewardship and environmental responsibility, presenting topics that address fallacies learned over the years related to such scientific issues (Zeidler, Sadler, Applebaum & Callahan, 2009). According to Brewer (2001), one of the biggest challenges facing the scientific community is demystifying the process of science and translating the results for nonscientist citizens. The teacher's responsibility is to get students motivated to do science and understand how it connects to the real world. Students need to be presented with issues that not only stimulate learning but also raise awareness. This point is supported in work done by Sadler and Donnelly (2006) in which moral considerations that students are faced with when discussing socioscientific issues are emphasized.

By allowing students to discuss and debate about real world scientific issues, students are exposed to the reality that science that has many layers of complexity. Students may also see that science goes beyond that subject matter and can be linked to economic, political and moral issues as well (Hodson, 2003; Zeidler, Osborne, Erduran, Simon & Monk, 2003; Zeidler, Sadler, Applebaum & Callahan, 2009; Zeidler, Applebaum & Sadler, 2011).

Scientific Literacy

There are several understandings of scientific literacy. They range from being able to read newspaper and magazine articles about scientific topics with a reasonable level of understanding to acquiring the skills necessary to pursue a career as a professional scientist (Hodson, 2003; Roberts, 2007). Through extensive research examining 17 groups and organizations, Norris & Phillips (2003) found several uses of scientific literacy ranging from the ability to think scientifically to the ability to use science knowledge in problem solving. Scientific literacy has been defined and used in many different ways, from meaning the understanding of science and its applications to how one uses science to solve problems. However the underlying fundamental thread of scientific literacy is “literacy”, having the ability to read and write (Norris & Phillips, 2003). Scientific literacy consists of students using scientific information to solve problems and make decisions for the health of their community at large. Zeidler (2007) argues that scientific literacy needs to incorporate moral and ethical reasoning in order to fully encompass what it means to be scientifically literate, enabling students to reflect on issues and look closely at how certain issues directly influence the health of their community (Zeidler & Sadler, 2011).

Roberts (2007) suggests two separate visions of scientific literacy. Vision I focuses on the process of “doing” science and the outcomes, highlighting nature of science, basic concepts and ethics. Vision II emphasizes the interrelationships of science and society, how science may be seen in the real world and what students may encounter in the future. The use of SSI to enhance learning and scientific understanding relates directly to Vision II, pushing students to become critical thinkers and decision makers when faced with real world scientific issues.

International assessments such as the Program for International Student Assessment (PISA), define scientific literacy as the ability to use scientific knowledge, "identify questions and draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity, along with being able to understand environmental, medical, economic and other issues that confront modern societies (OECD, 2003 p. 295)." Results from the 2006 PISA indicate that students from the United States are falling further behind in Science, ranking 21st out of 30 in science. While PISA raises concerns dealing with the poor performance of students in science from the United States, Sadler & Zeidler (2009) have additional concerns about PISA, which will be discussed at more length in chapter 2.

Scientific literacy is identified by the National Research Council (1996, 2000, 2009) as providing students with the opportunity to become proficient in skills used by scientists, such as communication, critical thinking and decision making with desired outcomes to promote scientific inquiry leading to scientific literacy. Scientific literacy means not only having an understanding of a range of scientific concepts and processes, but also being able to apply these understandings together with ones' own experience and values to a range of science-related matters in private or civic life (Henriksen & Froyland, 2000).

The goals of scientific literacy include creating students into citizens that can:

- Ask, find, or determine answers to questions derived from curiosity about everyday experiences
- Read or view with understanding, articles or video about science in the popular press and engage in conversations about the validity of the conclusions
- Identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed
- Have the capacity to pose and evaluate arguments based on evidence and apply conclusions from such arguments appropriately (National Research Council, 1996, p. 105).

This type of understanding emphasizes more than knowing facts. It means knowing science as a way to think critically about information and using it to make rational decisions (Henrikson & Froyland, 2000; Rennie & Williams, 2006).

To become scientifically and environmentally literate, students need to have a fundamental understanding of the systems of the world, which includes knowledge of:

- Force and Motion
- Nature of Matter
- Processes that Shape the Earth
- Energy
- Earth and Space
- Processes of Life
- How Living Things Interact with the Environment
- Nature of Science

An important aspect of science education is to provide students with the analytical skills needed to weigh scientific evidence and policy choices, however, the inclusion of environmental issues within the science classroom can offer a robust view of how all things are connected. Environmental issues are multidimensional and include ethical and political considerations, which recognize that scientific knowledge is changing and evolving, and that there is critical importance placed on environmental literacy for our society and the health of the environment. One of the goals of science education is to provide students with the knowledge and skills needed to make decisions about important environmental issues that they will likely face in the future. Chepesiuk (2007) furthers this goal by supporting the civic and practical ideas of scientific literacy to prepare children earlier on to become environmental stewards. Environmental literacy can prepare students for these responsibilities, develop and expand children's critical thinking skills, prepare them for citizenship and develop an appreciation of the natural world.

Encompassing the view of children becoming engaged in the world around them is the concept of ecoliteracy, which at the root promotes the awareness of the earth as our life-support system. However, to become ecoliterate, one requires the basic knowledge and understanding of how the systems of the world that have been described above. This paradigm highlights the interconnected relationships between humans and the earth. Central beliefs of ecoliteracy include social justice, and moral and ethical environmental issues. The necessity of ecoliteracy is to better educate students about their place in the world and highlight the relationships they have with their local community and how future decisions influence the health of the earth (Mueller & Zeidler, 2010). This allows students to view the environment with "fresh" eyes, a new perspective on their place in the world, with focus on not just human-centered environmental health, but the health of all living things.

Statement of Problem and Research Questions

Statement of Problem

The overall goal of this study was to, design, implement and evaluate a socioscientific-issues-based-program that was used to enhance learning and environmental literacy of elementary school students during outdoor environmental experiences. The curricular content was taught using socioscientific issues that focus on environmental and conservation-based content within the informal learning experience. Functional scientific literacy is based on the understanding that science education needs to include moral and ethical based inquiry to present students with a fuller understanding of how scientific decisions and their potential consequences may impact the health of the community at large (Mueller & Zeidler, in press). Controversial issues dealing with speed limit changes to protect local wildlife, beach and farmland erosion, seal culling and plastic pollution have been chosen as topics of discussion. The four topics were chosen for this study due to several factors that allow them to be seamlessly integrated within the environmental education curriculum:

1. Physical science and Life science are taught in the Fall semester and all four chosen topics have elements of both
2. Topics align with Sunshine State Standards
3. Each topic is controversial in nature, open-ended and allows for moral and ethical discussions and debates

4. Informal learning experiences can be easily applied to each topic, creating a richer learning experience for the students
5. Each topic has the possibility to connect students to scientific issues that are occurring within their local community and international community

To this end, using a curriculum embedded with SSI that expose students to science in a hands-on authentic environment, will possibly reveal different levels of understanding about environmental and conservation issues that young students will be faced with in the future. To address the overall goal of the study, the following research questions are offered.

Research Question 1

What is the impact of SSI based unit developed for use during outdoor environmental science experiences by fourth grade students on their ability to use critical thinking when faced with controversial and emotive environmental issues?

Question 1 Rationale

Allowing students the opportunity to visit an informal science facility may be helpful in exposing students to a range of science topics. However, connecting students to science in meaningful ways through these experiences with conceptual understanding of subject matter has historically been a challenge to science education (Dierking &Falk, 2004). By using socioscientific issues as the tool, these informal experiences have the potential to be pedagogically meaningful for students to develop conceptual understanding and connect the aesthetics of their experience to learning. Unfortunately, informal education programs situate sciences within the context of a single lesson or experience instead of the real world of the learner (Falk, 2008). A socioscientific-based curriculum implemented within informal science education programs has the possibility to connect the students with real world issues within the local community. Formal education can be enhanced to ensure scientific literacy in a world where ideas and technology are changing rapidly. Hands-on science is needed in order for students to grasp how science can connect them to the real world. Learning about the local environment may translate into tangible participant action on a local scale by visiting local facilities and understanding how our communities' wildlife can be accessible and within reach to our students as well as what issues are causing harm to the health of their communities' possibly becoming an important part of the science curriculum by inspiring and emphasizing our connection to the world.

Research Question 2

What differences in critical thinking exist between the treatment and comparison groups of fourth grade students after being exposed to SSI and informal science experiences?

Question 2 Rationale

As Walker & Zeidler (2007) highlighted, our goal as science educators is to promote environments where students think for themselves to promote opportunities for their engagement with informal reasoning. By exposing students to alternate views of science through outdoor environmental education experiences, and then applying these experiences to the concepts and context within this experience, educators may be closer to this goal. Research dealing with the impact of SSI-based curriculum focusing on elementary school students is limited and should be explored further to gain a more complete understanding as to how young children think critically and make decisions about environmental issues. To move forward with educational reform, research into how young students think, their capacity for thinking critically and their moral sensitivity to environmental issues will help determine how to shape curriculum and learning modules to best suit the needs of the students. By examining the critical thinking processes of elementary school students with environmental issues, we can gain a richer perspective of the differences and similarities in how young children think about controversial issues. Socioscientific issues invite students to explore science that is multi-faceted and rich with ethical queries. With continuing emphasis being placed on standardized testing students are quickly becoming adept at regurgitating facts. Some science educators feel that this is only exposing students to a limited view of science (J. Schubel, Monroe, K. Schubel & Bonnenkant, 2009; Zeidler, Sadler, Applebaum, Callahan, 2009). Science is generally represented as separate from the world outside, divorced from social, political, ethical consideration and debate. Topics' dealing with environmental issues present opportunities to expose students to things occurring outside their window, reconnecting them with science and real-world issues. The use of SSI may have the potential to make students utilize their critical thinking skills so they can analyze and synthesize scientific information they need to uphold their arguments about the moral and ethical dilemma they are faced with. This will create a learning environment that not only exposes students to new methods of comprehending science information, but also enhance their scientific knowledge, promoting critical thinking at a young age, a skill that is a necessary component of truly becoming educated and scientifically literate (Dolan, Nichols & Zeidler, 2009).

Research Question 3

What differences in students' conservation knowledge and attitude exist between the treatment and comparison groups of fourth grade students after exposure to SSI and informal experiences?

Question 3 Rationale

Kuhn (1993) points out that young children are naturally curious about the world around them, but that their curiosity should be guided toward scientific argumentation and scientific thinking. Science instruction tends to focus more on facilitating the development of argument and critical thinking skills in older students through the use of moral and ethical issues, leaving a gap in the literature particularly dealing with young students. Moral issues are an embedded part of environmental and conservation topics; therefore, it is possible for informal experiences to be effective and contextually reinforcing experiences when brought back into the classroom successfully (Falk & Dierking, 1992; Falk, 2009). It is also possible that the pairing of conservation issues and SSI will help to cultivate students into informed and scientifically literate citizens (Burek & Callahan, 2005). This experience may lead to an embedded sense of environmental stewardship by offering students a glimpse at how action can lead to change and that decisions made today can have a strong influence on the future. Informal science centers need to take their role seriously within the scientific community, emphasizing the practical and civic part of scientific literacy. Falk, Dierking, Rennie & Williams (2006) focus on science centers as places that explore science as a process rather than science as a product, hopefully influencing the way visitors think about science.

Significance of Study

This study has the potential for practical and theoretical significance within the field of not only science education but informal science education and environmental education as well and will provide a framework for the quality of programs used by informal facilities as a relevant way to get students motivated and connected with science. The main practical outcome would be to create socioscientific-based curriculum that could be used during informal science experiences, specifically focusing on young students, lessening the gap that is apparent between formal classroom settings and informal science settings. By allowing the students the opportunity to think critically about important environmental concerns facing their local habitats and creating solutions to these problems is significant development within the science education field. This has the potential to provide much needed data dealing with elementary school students and their capacity for thinking critically about controversial issues.

This was an exploratory study, aiming to examine young students' reasoning and thinking when confronted with ethical and moral issues dealing with environmental and conservation issues. This information will be important to the future of the SSI movement, providing further growth in the field to extend to informal science education and its impact on students by studying the effects of the SSI and informal combination creating a much needed link between the fields. This study will also provide the opportunity to gain insight into how younger students think about moral and ethical dilemmas that deal with significant environmental problems facing their local community. How students respond to these issues using their critical thinking skills and problem solving skills is of significant importance for the development of curriculum at this grade level.

CHAPTER TWO: LITERATURE REVIEW

Introduction

The central argument underlying the theoretical framework is that socioscientific issues and informal science experiences have positive effects on students' understanding of environmental issues and their critical thinking skills. To this end, a brief introduction to the framework guiding SSI will precede arguments providing evidence that the use of a socioscientific based curriculum would be beneficial to elementary school students. There are links made to informal science education, argumentation and discourse and critical thinking coupled with scientific literacy.

Socioscientific Issues

Socioscientific issues (SSI) focus on the inclusion of science issues within the current science curriculum that are rich with social relevance. These issues incorporate values, attitudes and ethics that students need to consider when making judgments about scientific information (Sadler & Zeidler, 2005). Through the use of SSI, students are presented with issues that include social and moral dilemmas, which force the students to utilize critical thinking skills to analyze the data they are presented with (Dolan, Nichols & Zeidler, 2009). Current issues that have been used to promote critical thinking include genetic engineering of food, stem cell research, global warming and cloning. Although controversial in nature, there are no correct answers for such topics, engaging students in sociomoral discourse with their peers, promoting problem solving and reflective thinking. However, the issues used need to be personally and socially relevant to the students involved with the discussion otherwise such exercises are lost on students and do not enforce the learning outcomes. The use of socioscientific issues within classroom discourse allows students to more closely examine the links between morals and ethics that are a part of scientific knowledge (Sadler & Zeidler, 2005; Sadler, 2011; Zeidler, Applebaum & Sadler, 2011). The use of inquiry, argument and connectedness to content, students develop skills to construct knowledge and solve problems; students do not learn these skills by being told, they learn by immersing themselves into the process (Kuhn, 2007).

Components of SSI include moral and ethical characteristics, the use of social discourse and class discussion, which were included within the units created for this study. This framework transcends the notion of science-technology-society (STS) and emphasizes the interrelationships among subject matter with the goal of creating scientifically literate citizens. The moral and ethical threads that SSI encompass separate it from STS and creates scientific learning that is personally relevant to the students which promotes growth and development of character (Zeidler & Nichols, 2009). The use of discourse as an instructional tool allows students the opportunity to research a topic from multiple points of view, and then discuss the issue using their research and background science knowledge, knowledge of economics, political science, religion, and sociology. This method presents the science as an integral part of society, rather than the traditional idea that science is separate from society (Zeidler, Sadler, Applebaum &

Callahan, 2009). The use of socioscientific issues in the classroom is not to focus solely on economics and politics, however environmental issues such as global warming allow students to view controversial issues that are cross-sectional in nature and that our world is being faced with presently (Sadler & Klosterman, 2009). Offering the opportunity for students to use their critical thinking skills will develop their literacy skills and create a culture of learners that have the ability to make thoughtful and informed decisions about moral and ethical issues (Kolstø, Bungum, Arnesen, Isnes, Kristensen, Mathiassen, Mestad, Quale, Tonning & Ulvik, 2006).

Driver, Newton & Osborne (2000) state that students engaged in this type of discourse are exposed to other students' viewpoints on topics and faced with the reality that others may not believe the same things. Ratcliffe & Grace (2003) explain that socioscientific issues are open-ended topics that involve forming opinions and making choices on a personal or societal level, reinforcing the ideas of Zeidler, Applebaum & Sadler (2006) that these issues also involve values and ethical reasoning. Socioscientific issues have come to represent controversial social issues, conceptual, procedural or technological ties to science (Sadler & Donnelly, 2006). The very fabric of SSI is aiding students in the developmental abilities to reason and discuss science from a personally relevant standpoint. Socioscientific issues allow teachers to engage students in discussions with differing viewpoints about scientific topics. Because there can be several views to scientific questions raised, the students are exposed to and hopefully opened to a broader spectrum of science topics. Hopefully this exposure will lead to deeper understandings of how to form legitimate, supported arguments and the realization of a weak argument when faced with one. Within these scenarios, the teachers become a guide for the students, rather than providing straight facts without the discussion of possibilities and differing viewpoints. Students will be provided with the prospect that science is not static and is ever changing and developing as the world around us changes.

One study (Dolan, Nichols & Zeidler, 2009) investigated fifth grade students' understanding and engagement of science concepts through the use of socioscientific issues based curriculum. Prior to including any SSI based issues and activities into the curriculum, the instructor made sure that students had solid comprehension of the science concepts that would be discussed. Three units were developed and implemented into a single fifth grade class located in Tampa, Florida. Students were asked to think critically and utilize their analysis, synthesis and evaluative skills throughout these activities which included debate and continued dialogue about controversial issues ranging from beach erosion to harp seal harvesting. Students showed enthusiasm and deeper understanding as to the richness of science concepts and how they influence the health of their lives and the environments and communities in which they live. Although SSI may seem too advanced for younger students, the effectiveness of these units on younger learners cannot be denied. The students' enthusiasm and creativity that was brought to these scenarios bolsters learning and understanding of controversial topics and socioscientific issues. With few studies focusing on elementary aged students and the use of SSI, their capacity to think critically, solve problems and understand the complex nature of scientific issues is a wide open field of study that can provide much needed growth and reform within science education. This approach to learning enhances the progressive movement of SSI based instruction, focusing on students at a younger age, hopefully planting the seeds early so that they nurture and grow their understanding of scientific concepts and the connection to real-world contexts.

Within the informal education field, research focusing on the intellectual and emotional challenges visitors face while attending informal facilities such as science centers includes the use of socioscientific issues to provoke thinking and learning within an informal environment. Critical thinking is encouraged at certain facilities that have designed issues-based exhibits that promote different views of science while effectively teaching the public about environmental issues that are of concern locally and nationally (Pedretti, 2004). Two specific exhibitions, *Mine Games* and *A Question of Truth*, were closely examined to see how well visitors were challenged emotionally and intellectually while observing the exhibitions. Both *Mine Games* and *A Question of Truth* were studied over a ten-year period by the researcher to gain a better understanding and robust evidence that issues-based exhibits assist in the publics' knowledge that scientific issues are far reaching.

Both exhibitions used socioscientific issues to provoke critical thinking, argumentation and debate and moral and ethical considerations. *Mine Games*, an exhibit featured at Science World, is categorized as an STSE exhibition that engaged visitors in deciding whether or not a mine should be built in a fictional town. *A Question of Truth*, an exhibit featured at the Ontario Science Centre, has a strong nature of science connection exploring the socioscientific and epistemological issues in relation to how history has shaped science through bias and changing knowledge (Pedretti, 2003).

During the mine exhibition, visitors are led through a computer simulation where they meet different towns people from the fictional community of Grizzly, British

Columbia where the proposed mine is to be built. Visitors hear different viewpoints about whether or not the mine should be built and then are asked to participate in a discussion with other visitors led by a mediator to come to a decision about the most economical, safest and environmentally acceptable way to build the mine.

Questions dealing with the moral, ethical and social repercussions that have occurred throughout history in the science field are posed to visitors at the *A Question of Truth* exhibit. There are three main sections of the exhibit, the first is considered to be the Frames of Reference, which attempts to put a human face on science through the discussion of alternative medicines and non-Western practices of science. The second section explores the Bias in Science and Society by asking visitors to consider concepts of race, slavery, sterilization and intelligence testing that have added to oppression and marginalization of certain groups of people. The third and final section of the exhibit promotes critical thinking about Science and Community by promoting the ideas that the future of our environment and community depend on an informed and scientifically literate citizenship (Pedretti, 2004).

Pedretti (2004) found that visitors did think more critically and seemed to be emotionally and intellectually influenced by these specific exhibitions. Teachers also described these exhibits as a way to bring controversial socioscientific issues back into the classroom where they continued the conversations and debate with students in the formal classroom setting. However, expanded data collection, including follow-up after the visits and how exactly teachers integrated the information learned into their classroom was not detailed. While the study was longitudinal in nature, covering a ten-year time span, the researcher indicated that more follow-up and future studies based on how information learned within these contexts is applied outside of the science center visit is needed.

In a broader sense, socioscientific issues should be a part of the science curriculum because students deserve the opportunity to explore important issues that challenge their understanding of science concepts. To be a scientifically literate citizen, one needs the ability to analyze claims and make decisions based on evidence with ethics and reasoning (Chowning, 2009). Environmental issues such as climate change, swine flu and pollution issues are hot-button topics that students will be faced with in the future and should be prepared to make informed decisions about. The real-world problems used within curriculum embedded with SSI are multi-dimensional and promote critical thinking because they go beyond just science into cultural, political and economic spheres, engaging students in moral and ethical discussions. Students need to recognize that the more clearly they can articulate their positions on socioscientific issues the better prepared they are to take on the decision making process that no doubt will influence their own livelihood and the health of the community in the future (Chowning, 2009).

The Program for International Student Assessment (PISA) is a project of the Organization for Economic Cooperation and Development (OECD) to provide feedback on literacy in three competencies; Reading, Mathematics and Science, providing much needed information as to how students apply what they learn to real world contexts. Science was assessed in three different domains:

1. Scientific Concepts: students are not asked for recollection of concepts but the application of concepts to real-world problems.

2. Scientific Processes: students need to have recognition of scientific questions, identify evidence, draw conclusions, communicate the conclusions and demonstrate the understanding of science concepts.
3. Scientific Situations: students need to be aware of situations in the "everyday" not just within the classroom, acknowledgement that science is all around.

This assessment focuses on 15 year-old students from 30 industrialized countries and occurs every three years to measure if students have the knowledge and skills to become a literate member of society. According to Sadler & Zeidler (2009), PISA gauges how well students of this age group are prepared for future challenges, whether or not they can analyze, reason and communicate effectively and if they have the capacity to continue to learn throughout life. Because PISA does not ask for students to regurgitate facts but to move beyond sheer application of knowledge into analyzing the problem and thinking critically to solve the problem, this supports progressive movements such as SSI-based instruction where emphasis is placed on real-world application, interpretation, decision-making, solving problems and argumentation (Sadler & Zeidler, 2009).

Citizens faced with a situation containing scientific components should be able to identify the scientific issues, explain the phenomena scientifically and use scientific evidence to respond to the situation (Bybee, Fensham & Laurie, 2009). PISA is meant to measure not the passive "stores" of knowledge that a student has, but to examine their ability to actively use the knowledge when faced with new situations. This has renewed the need for science curriculum reform by integrating the use of real world contexts into teaching science in a greater and more robust manner (Fensham, 2009).

Sadler & Zeidler (2009) identify four fundamental features of the PISA definition of scientific literacy:

1. "Scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena and to draw evidence-based conclusions about science-related issues
2. Understanding of the characteristic features of science as a form of human knowledge and enquiry
3. Awareness of how science and technology shape our material, intellectual and cultural environments
4. Willingness to engage with science-related issues and with the ideas of science as a reflective citizen" (OECD, 2007b, p.35)

Sadler & Zeidler (2009) point out that PISA and SSI share several consistencies when analyzing the features previously mentioned. The first point emphasizes the "application of scientific knowledge in socioscientific contexts," the second point "addresses the significance of understanding about science," the third point highlights the need for "complex interactions between science and society" and how this relationship shapes various social domains and the final point emphasizes the need to understand a students "disposition toward personally engaging in science-related issues" (Sadler & Zeidler, 2009 p.917). Although these points support the SSI movement, the PISA assessment only goes so far. There are alternative ways to conceptualize and assess SSI within the classroom curriculum. Using scientific evidence competently is featured within PISA and can be more thoroughly examined through the use or misuse of scientific argumentation, something that has been successfully assessed in small-scale research studies (Zeidler & Sadler, 2010). Although PISA moves beyond traditional assessments in that it does not ask students to regurgitate information, it does have limitations in that if cannot take into account various aspects of learning experiences. Because of the push for accountability, assessments such as PISA may not be supporting "progressive" aims of science education, which promote more context-based real world application of scientific knowledge (Ratcliffe & Millar, 2009; Sadler & Zeidler, 2009).

Critical Thinking

By providing students the opportunity to discuss or debate controversial scientific topics presented within the SSI curriculum, students have the potential to develop skills associated with critical thinking. Critical thinking by broad definition is a form of reflective thinking that ultimately helps one decide what to believe or do (Ennis, 1992). Skills such as analysis, inference, evaluation and interpretation are nurtured and developed through the use of SSI embedded curriculum creating an environment that is conducive to developing critical thinking skills. The aim of socioscientific issues is to instill the skills needed to be a functioning member of a democratic society, which requires critical thinking. Critical thinking is embedded within SSI curriculum because the topics are multi-faceted and address real world issues promoting thinking critically about these issues and how they influence the everyday life of the student (Ennis, 1997). The incorporation of SSI units within elementary education enables the students to become more open-minded, analytical and confident in their abilities to reason and solve problems (Zeidler & Nichols, 2009). However, it is ultimately the teacher that needs to create an environment that will stimulate and promote critical thinking (Carr, 1988). The ability for students to engage in active dialogue and apply critical thinking processes, participating in informal discussions and formal debates are important elements in creating a scientifically literate student and should be fostered at a young age (Zeidler, 1995). By integrating argumentation, critical thinking and discourse into the elementary school classroom, students may be faced with their own fallacious reasoning, exposing them to alternate ways of viewing topics and perhaps realizing that there are other ways of examining evidence (Zeidler, 1995; Zeidler, Lederman & Taylor, 1992).

Critical thinking has many functions including evaluating the arguments of others, evaluating ones own argument, resolving conflicts and understanding resolution. The promotion of critical thinking within the curriculum is to teach students to use these skills beyond the actual classroom, applying the strategies in practical situations (Allegretti & Frederick, 1995). The goal behind promoting critical thinking is so that children become habitually used to analyzing information correctly within the classroom and in the real world (Burke, Williams & Skinner, 2007).

In a more general sense critical thinking is a skill needed throughout life and should be cultivated at an early age to provide children with necessary tools to navigate through scientific information. The approaches to life which characterize critical thinking include:

- Inquisitiveness with regard to a wide range of issues
- Concern to become and remain well informed
- Alertness to opportunities to use critical thinking
- Trust in the processes of reason inquiry
- Self-confidence in one's own ability to reason

- Open-mindedness regarding divergent world views
- Flexibility in considering alternatives and opinions
- Understanding of the opinions of other people
- Fair-mindedness in appraising reasoning
- Honesty in facing one's own biases, prejudices, stereotypes or egocentric tendencies
- Prudence in suspending, making or altering judgments
- Willingness to reconsider and revise views where honest reflection suggests that change is warranted (Facione, 2007 p10).

Ennis (2011) incorporates similar ideas into a general definition of what critical thinking entails; open-mindedness and mindful of alternatives, desire to be well informed, judges the credibility of others, asks appropriate questions, judges the quality of arguments and reasoning, draws conclusions and can defend positions regarding a belief or action. These processes should be cultivated throughout all levels of education, reinforcing that there are multiple perspectives and aiding the students in finding their own position on issues that they will no doubt be faced with outside of the school environment (Sadler & Zeidler, 2004). However, as students get older, educational success may be more focused on test scores than on fully developed literate students who can reason and think critically about subject matter and how it relates to their own lives, especially in times of educational accountability. Elementary school curriculum lends itself to the all-encompassing nature of SSI allowing for a cross-curricular experience for the students and sparking their interest and promoting their skills as critical thinkers (Nichols & Zeidler, 2009).

One study conducted by Burke, Williams & Skinner (2007) focused on the use of thinking skills in elementary school education within the Scottish curricular guidelines. Most curriculum areas were found to incorporate some type of thinking skills to promote problem solving in young children. Specifically in environmental studies, teachers emphasized the need to ask questions, design, solve problems and sort and categorize things, all promoting critical thinking. The study examined how teachers perceive the teaching of thinking skills within the curriculum. All forty-eight primary schools in a region of central Scotland were surveyed with thirty-six returning the survey for a total of 127 completed surveys to analyze. Teachers were asked to rate how frequently they perceived each of six main thinking skills (searching for meaning, critical thinking, creative thinking, metacognition, decision making and problem solving) were utilized within the classroom curriculum. Specifically focusing on critical thinking skills, teachers were asked to rate how regularly they taught the skills of making predictions, formulating hypothesis, drawing conclusions, giving reasons, distinguishing fact from opinion, determining bias, the reliability of evidence, being concerned about accuracy, relating causes and effects and designing a fair test. Responses were scored by using a Likert-scale; 1 indicating that they did not use that in their classroom and 5 indicating they use it all the time. Teachers believed that the critical thinking skills of drawing conclusions and giving reasons were most promoted within their classroom curriculum and that designing a fair test and determining bias were the least promoted. Within subject matters, critical thinking skills were taught most in the subject areas of science and technology with little difference between age levels. The researchers found this result particularly interesting due to the fact that they believed the higher order thinking needed to determine bias and relating cause and effect would be too advanced for children in the early years of elementary school. The study concluded that thinking skills are integrated more successfully into certain areas of the curriculum and completely left out of others, and awareness needs to be raised as to how the use of thinking skills can be applied within elementary school curriculum as a whole. A real concern is that children in the upper level of the elementary schools are not being exposed to or being asked to utilize critical thinking skills more frequently than at the lower level, which suggests perhaps the teachers are unaware of the "developmental abilities" of the students within their classroom. However, a major downfall noted is teachers self-reported on their use or lack thereof when dealing with critical thinking within the classroom. This study did not take into consideration different understandings of critical thinking held by the teachers and whether or not their introduction of critical thinking into the classroom was effective.

An experimental study was conducted by Yang & Chung (2009) in a Taiwanese Junior High School focusing on the effectiveness of teaching critical thinking in a civic education class. Two classes of 8^{th} grade students were examined; one being the comparison and the other the treatment, pre- and post-test were administered before and after a 10-week unit that included various critical thinking activities for the treatment group. The comparison group was taught in the traditional manner at this school, which included teacher-centered and lecture-based instruction. The treatment group was taught using debate and informal discussions when learning about current events and students were able to interact with one another in a small group environment. The students in the treatment group far exceeded the comparison group on the development of critical thinking skills based on the different teaching methods in this study and reportedly fostered students' active listening skills, respect for different ideas, they learned to tolerate divergent views and examine their own ideas for possible bias. Some of the quieter and more reserved students reportedly improved their speaking skills and confidence in the ability to express themselves. However, there is a need for a longitudinal study to confirm the change in students thinking skills are nurtured and replication is needed to provide stronger evidence that this treatment is continuously successful in promoting such growth in the students.

In the general sense, critical thinking can be defined as reasonable reflective thinking that is focused on what to believe or do (Ennis, 1989) and incorporates higher order thinking (Ennis, 1985). These studies provide evidence that there is so much more that schools can do to promote literacy, conceptual change and critical thinking skills and that this type of teaching needs to be introduced to younger students so that they can carry these skills, continuously developing them throughout their academic career so that they may apply them when they are faced with making decisions as adults (Zeidler & Sadler, 2010). To take part in a democratic society and to be a responsible citizen able to make decisions about scientific information and understand the outcomes of such decisions is based on how well one can think critically about information (Reis &Galvao, 2009). The use of SSI within the classroom can create a context where critical thinking skills are exercised in preparation for life outside of the academic setting.

Contextualized Argumentation and Discourse

Argumentation, critical thinking and reasoning are important to formal and informal learning, allowing students to understand and explore different aspects of science. Brewer (2001) highlights the notion that one of the most important responsibilities educators have is helping students learn to make defensible judgments about scientific problems. However, consensus has not yet been reached on the most influential ways for students to learn how to integrate this knowledge and to develop the skills and rhetoric necessary to make intelligent arguments dealing with scientific issues. Argumentation is key in promoting critical thinking, reflective thought, reflective judgment and purposeful thinking; all skills needed in order to develop into a scientifically literate citizen. In order to be a part of a democratic society, students need to acquire skills of reasoning and decision-making so that when faced with community issues they are well equipped to take action (Zeidler & Sadler, 2011). By using the SSI framework within the science classroom, it will enable students to not only develop an understanding for content knowledge, but nurture problem solving skills and the curiosity that comes from self-directed learning and exposure to open-ended relatable problems. Not only does it bring to light issues that are happening within the community at large, but it also can challenge students' moral reasoning (Zeidler, Applebaum & Sadler, 2011).

Argumentation within Informal Environmental Science Education

One of the main objectives of environmental science is to develop students into informed citizens who make ethical decisions in adulthood, using their constructed knowledge to do so. Jimenez-Alexaindre (2008); Osborne, Erduran & Simon (2004) believe that decision making and argumentation go hand in hand when dealing with science education. One study conducted by Jimenez-Alexaindre (2008) involved eleventh grade students and their knowledge of a local environmental issue. The students were given pertinent information to make ethical and value based decisions about this specific issue and were then allowed to argue their stance with the rest of the class. They not only had to consider how the environmental issue would influence human health, but also the health of the ecosystem in the area, including the wetlands and the local flora and fauna. This allowed students to explore different angles of the issue and see how their decisions would influence the health of others. This exercise allowed the students to understand the role that values play in making environmental decisions by allowing the students not only to apply conceptual knowledge but values as well. Since the environmental issue used for this simulation was based on situations that were occurring in the students' community, the students were able to see how their decisions in the classroom could be applied to real life. This allowed for the connection between classroom discourse and real scientific issues that connect students to the world (Jimenez-Aleixandre, 2002; 2008).

Environmental issues allow students to examine how real world issues that are local or national influence their well-being. By using these issues as a springboard for students to understand their connection with science, students will also begin to see that their separation from the environment is strictly artificial (Dillon, 2002). Environmental issues facing communities today include water shortages, encroachment, animal population decline, destruction of habitat and global warming. These are modern and challenging socioscientific issues that can influence the way that students think about science and their place within the world. Without the opportunity for students to further examine and question environmental issues that are influencing human and environmental health they will not know when and how to take action to solve these issues (Mueller & Zeidler, 2010).

Scientific topics explored at informal facilities and used within the science education curriculum help students to conceptualize real world issues influencing local environments. By using these experiences and issues in the science classroom, teachers will be using modern and challenging SSI to teach their students about the world. Ratcliffe & Grace (2003) explain that SSI are open-ended topics that involve forming opinions and making choices on a personal or societal level, reinforcing the ideas of Zeidler, Applebaum & Sadler (2006) that these issues also involve values and ethical reasoning. Socioscientific issues have come to represent controversial social issues with conceptual, procedural or technological ties to science (Sadler & Donnelly, 2006). The very fabric of SSI is aiding students in the developmental abilities to reason and discuss science from a personally relevant standpoint. Utilizing argumentation within socioscientific issues content allows teachers to engage students in discussions with differing viewpoints about scientific topics. Argumentation can be used in the form of open discussion, unstructured debate, however, students are expected to be respectful of opinions, listen and respond with pros and cons that address the topic being discussed. Because there can be several views to scientific questions raised, the students are exposed and hopefully open to a more broad spectrum and different aspects of science topics, hopefully leading to deeper understanding of how to form legitimate supported arguments and realize a weak argument when faced with one. Within these scenarios, the teachers become a guide for the students, rather than providing straight facts without the discussion of possibilities and differing viewpoints. Students are provided with the prospect that science is not static and is ever changing and developing as the world around us changes.

By using informal or open discussion in the science classroom, specifically to highlight informal experiences, students identify what information and arguments support their point of view, which can then lead students to identify strong counter arguments within SSI. Students have the opportunity to learn that decision-making is complex, and there are numerous social issues involved with solving scientific problems. Science is driven by debate and disagreement, and therefore it is a needed part of learning science (Simmonneaux, 2001). This offers the students an opportunity to take a critical approach to scientific issues.

Simmonneaux (2001) conducted a research project with students in his classroom based on an environmental issue dealing with feeding hormones to farm raised salmon. The salmon were described as living in a natural pen, surrounded by a net but located in the ocean, providing as close to a natural habitat as possible. Based on information given to students by the instructor, the class was divided into different groups. Each group was responsible for representing a particular viewpoint on the controversial topic detailed in the classroom. The student groups represented real people influenced by this environmental issue such as farmers, conservationists, local and national consumers and native members of the Alaskan community used in the simulation. Each group was instructed to conduct research and be able to adequately defend their stance on the issue during a structured debate. The researcher found that students were extremely excited by the project and did in fact produce well thought out and intelligent arguments on the environmental issue. This simulation offered students the opportunity to explore all sides of an environmental issue, producing cognitive change and social awareness. Issues such as hormone alterations can be viewed as strengthening a students' connection with how science can be applied outside of the classroom and also that there are several sides to scientific dilemmas.

Osborne, Erduran & Simon (2004) and Simonneaux (2008) agree that the introduction of argumentation within the science classroom challenges teachers to change their discourse and forces them to try new things that may be out of their comfort zone. Hodson (2003) enhances this point by stating teachers who allow open discussion or debate may feel as if they are losing control of the classroom and the traditional sense of science learning that is memorization of facts with little discussion of topics. Introducing argumentation into the science classrooms requires teachers to believe in the importance of discourse taking place within their classroom (Osborne, Eduran & Simon, 2004; Zeidler & Sadler, 2008; Zeidler, Applebaum & Sadler, 2011).

Debate and argumentation are excellent ways to teach students how to become more engaged in the scientific community, however, not many teachers know exactly how to conduct structured debates or even informal discussions dealing with controversial issues and shy away from ethical dilemmas because they are sensitive in nature. Gayford (2002) conducted a study with teachers that currently used global climate change in their science curriculum in middle school science in an effort to teach students about pertinent environmental issues. Most teachers chosen for this study did not consider using argumentation to teach students about the richness of the environmental issue and were more concerned about teaching the proper information for testing. The teachers chosen for this study were broken up into groups and asked to discuss the role of global climate change within their curriculum. Most teachers were able to determine that they were teaching a socially relevant topic and began to understand how to discuss the issue within the classroom to enhance their students' understanding of environmental issues and how these issues influence the health of the world. Most teachers believed that they needed to keep the topic of global climate change within the relevance of the class because it was such a controversial topic and could lead to uncomfortable conversations. However, this only highlights the issue that teachers do not adequately know how to incorporate controversial scientific topics into the curriculum and also make it meaningful and cohesive with what is being taught in the classroom.

Kelly (2000) suggests that within the science classroom, science is presented as a set of facts that are discussed in collaboration with the textbook but that a real life connection where students apply pedagogical knowledge is rarely seen (Zeidler, Applebaum & Sadler, 2006). This could be due to how the current science teachers were themselves taught science, influencing how they do science in the classroom and how their attitudes impact student perception and interest in the subject. While classrooms provide a good contextual framework for scientific conversations, informal learning atmospheres allow students to further explore these issues in an environment that is conducive to hands-on learning.

Issues discussed at informal science facilities allow for the use of socioscientific issues and argumentation to be used onsite. SSI can be used as a tool to provide students with the opportunity to explore ethical issues and moral dilemmas related to stewardship and environmental responsibility, presenting topics that address fallacies learned over the years related to such scientific issues (Zeidler, Applebaum & Sadler, 2006; Zeidler, Sadler, Applebaum & Callahan, 2009). According to Brewer (2001), one of the biggest challenges facing the scientific community is demystifying the process of science and translating the results for nonscientist citizens. The teacher's responsibility is to get students motivated to do science and understand how it connects to the real world; using environmental topics pulled from informal experiences can aid in this connection. Students need to be presented with issues that not only stimulate learning but also raise awareness. This point is supported in work done by Sadler and Donnelly (2006) in which moral considerations that students are faced with when discussing socioscientific issues are emphasized. Moral issues are also an embedded part of environmental and conservation topics, therefore, it is possible for informal experiences to be effective and contextually reinforcing experiences when brought back into the classroom successfully (Falk & Dierking, 1992; Falk, 2009).

It is also possible that SSI, particularly dealing with conservation and environmental concerns during informal science experiences will help to cultivate students into informed, critically thinking and scientifically literate citizens (Burek & Callahan, 2005). This experience may lead to an embedded sense of environmental stewardship by offering students a glimpse at how action can lead to change and that decisions made today can have a strong influence on the future. Engaging young people in SSI has far reaching influences and can expose them to issues that force them to make choices about the health of their community or environment showing them their civic responsibility as a citizen of a democratic society (Mueller, Zeidler & Jenkins, 2011).

Informal discussions and formal debates play an important part in preparing students to use the information gained through argumentative thinking through the use of socioscientific issues (Sadler & Zeidler, 2005; Sadler & Donnelly, 2006; Zeidler, Osborne, Erduran, Simon & Monk, 2003). Argumentation can be used as a tool to examine how students think about certain topics; ultimately students' preconceived notions and learned fallacies will be revealed and can therefore be addressed. Argument can encompass debate or open discussion in the science classroom providing the potential to help students identify what information and arguments support their point of view and helping students identify strong counter arguments within socioscientific issues. Students exposed to the use of informal discussions or debate in the classroom have the opportunity to learn that decision-making is complex and there are numerous social issues involved with solving scientific problems (Simonneaux, 2001, 2008).

Informal Science Education

Informal science environments and experiences play a crucial role in the interests and involvement of children and science. The National Research Council (2009) states that there is abundant evidence that informal programs and settings, and even the experiences of everyday life such as walking in a park, contribute to people's knowledge and overall interest in science. More recently, informal science experiences are seen to have cognitive learning outcomes that broaden knowledge beyond just facts and include process skills and awareness of community (Storksdiek, Robbins, & Kreisman, 2007). Learning on and from such experiences is becoming more accepted as an extension and improvement of classroom teaching by exposing students to science in hands-on settings and introducing them to real world science (DeWitt, & Storksdieck, 2008).

Learning in informal environments is diverse and has a broad range of intended outcomes. These outcomes range from inspiring emotional reactions, reframing ideas, introducing new concepts, to communicating the social and personal value of science, promoting deep experiences of natural phenomena and showcasing cutting edge scientific development (National Research Council 2009, 2-10). However, unless there is a connection back to the classroom and focused learning outcomes, the experiences are not valued. DeWitt & Storksdieck (2008) explain that certain experiences have more potential to help teachers maximize student learning than others and those programs that are developed and aligned with current curriculum goals in mind can be integrated back into the classroom seamlessly.

Several principles are noted as part of life long scientific learning. These principles include the idea that knowledge, practice and science learning commence early in life. Effective science education reflects the ways in which scientists actually work, acknowledging that scientific knowledge is continually changing and growing. Informal settings tend to evoke emotional responses and support direct experiences with phenomena, developing positive attitudes towards science (Falk, 2009; Louv, 2007)

There are six strands of learning that informal science educators believe should be incorporated in informal programs and facilities in order to ensure the highest quality of learning experiences offered to the community.

These strands include:

Strand 1: Experience excitement, interest and motivation to learn about phenomena in the natural and physical world

Strand 2: Come to generate, understand, remember and use concepts, explanations, arguments, models and facts related to science

Strand 3: Manipulate, test, explore, predict, question, observe and make sense of the natural and physical world

Strand 4: Reflect on science as a way of knowing; on processes, concepts and institutions of science and on their own process of learning about phenomena

Strand 5: Participate in scientific activities and learning practices with others, using scientific language and tools

Strand 6: Think about themselves as science learners and develop an identity as someone who knows about, uses and sometimes contributes to science (National Research Council, 2009 p2-29)

Although these strands can be interdependent the most salient and authentic learning comes from these strands being woven together and the learner exposed to each strand of learning so that they may identify with science on a personally relevant level. Nature and exposure to informal learning experiences focusing on outdoor learning are influential on a child's development by promoting emotional and spiritual growth and intellectual capacity (Kellert, 2009). Kellert notes that during middle childhood, defined as between the ages of 5-12 years of age, an impression lasting only a few seconds may be imprinted for life. The exposure to the natural world and learning a connection to the surrounding environment is key to this development at an early age. By the ages of 13-

17 there is more development of ethical reasoning about the natural world along with conceptual understanding, however, without the introduction to such natural experiences and connection to the world around them at an early age, this development is not complete (Kellert, 2009).

Children at elementary school level are absolutists by definition, according to Kuhn (2007) believing that information and knowledge is something that exists separate from them, coming from outside sources. However, the value of inquiry and argumentation needs to be introduced at a young age to show students that skills such as these are necessary to be productive and successful in life. Holzer (1997) claims that positive childhood experiences lead to adults who are environmentally conscious, which would then mean that informal facilities are achieving their goal (Holzer, 1997; Falk, 1997; Falk, 2009). In the past, it was thought that elementary students that participated in informal experiences didn't retain information and would not be influenced by their experience. However, Falk (1997, 2004, 2007, 2009) claims that elementary students also retain as much as older age groups, being able to describe feelings, experiences they had while on a field trip. In order to continue this trend, more educational weight and opportunities need to be placed on informal facilities, their programs and their ability to assist with contextualizing learning and connecting kids with science.

According to Main (2004), researchers in the environmental education field believe that conservation education should promote the understanding of basic ecological concepts; it should be fun and enjoyable and motivate participants to engage in a life-long process of learning about the natural world. It should also create a strong value system, which places importance on nature and natural things. However, formal educators need to understand the value of informal educational experiences before this gap can be bridged and curriculum can be developed to ensure that students get the hands-on science opportunities that informal experiences can provide. To affect the goal of conservation, education needs to reinforce values and beliefs that have a positive effect on nature and change values and beliefs that have a negative effect on nature, but this has been proven difficult to do in past studies.

Dierking (2004) and Falk (2009), claim that such facilities as zoos, aquariums, outdoor environmental education centers, museums and other informal science learning centers are striving to become centers for conservation by conducting scientific research, fostering dialogue about civic responsibilities to one another and the planet, and offering engaging experiences to visitors with the hope of influencing the way people understand, care about, and participate in activities that help protect wildlife. There is no complete understanding of the influence of these programs, because of the lack of research in this field. There is a real need for more focused research, particularly research about the impact of such experiences upon visitors' deeply held beliefs and values about science and the translation of that type of caring into actions that protect the environment.

Summary

Science education research dealing with elementary school students and socioscientific issues have mainly focused on fifth grade level students. This leaves quite a rich area of research yet to be examined which engages younger students in their scientific learning through the use of socioscientific issues. Few studies have utilized a long-term treatment to investigate the use of socioscientific issues based curriculum on elementary school students and their critical thinking. The present study shifts the conversation from a traditional one-treatment unit to a treatment that lasts a semester of elementary school, close to 17 weeks. Further studies like this one will be needed to develop a broader understanding of young student cognition as it develops through the course of an environmental education class, particularly within the context of socioscientific issues and informal learning experiences. Learning experiences in informal settings provoke emotional responses, raise ethical and moral questions about conservation and have the potential to motivate learners. In this sense, informal experiences hold an important role in the learners' development and infrastructure of science learning. These experiences, in a broader sense, have strengths that are an asset to the strengths of classroom learning.

CHAPTER 3: METHODOLOGY

Research Overview

This study used a quasi-experimental design with students from three intact elementary school classes randomly selected into a treatment group (SSI curriculum and informal science experiences). The treatment classes (2) were taught using a variety of SSI as the basis for learning content. Small group discussions and debates, hands-on activities during outdoor environmental units taking place at the on-site preserve and an in-depth informal outdoor experience at a county preserve were also employed. The comparison class (1) was not taught using SSI, small group discussions or debates or hands-on activities, however, they did participate in the in-depth informal outdoor experience at the county preserve. The regular curriculum of physics and erosion were taught using traditional methods of instruction such as worksheets, classroom presentations by the instructor and reading from the textbooks. The students were exposed to the methods of teaching that are teacher-focused and text-focused. The instructor for all three classes at the county preserve is an on-site science education instructor who is employed by the county, not the school. The instructor maintains a classroom on the county preserve property. Every fourth grade class throughout the northern county is bussed to the preserve in the northern area of Pinellas County once a year to take an outdoor hike with the environmental education instructor through a countywide program. In 2010, the county program changed from a one-hour outdoor environmental experience to a 6-7 hour in-depth outdoor exploration experience, allowing students more time to explore and be immersed in the local habitats.

Both qualitative and quantitative methods were used in order to gain a deeper understanding of the constructs under review. Mixed methodology has been defined as studies that combine qualitative and quantitative approaches into the research methodology of a single study or multi-phased study, whereby the quantitative methods allow for testing of existing hypotheses while the qualitative methods create the opportunity for more in-depth comprehensive information and also can determine areas for future research (Teddlie & Tashakkori, 2003). In this study, the quantitative analyses derived from survey research served to describe trends in the class as a whole, the purpose of determining whether the SSI treatment enhances the outcome measures in the study; the qualitative analyses derived from interview data provided evidence for perceptions regarding changes among individual students and details on how the process takes place in young students.

Purpose

The primary purpose of this study was to implement and analyze a semester-long (17 weeks including pre and post-testing) environmental curriculum based on the use of SSI as the primary teaching method characterized by informal discussion, structured debate and inclusion of open-ended controversial real world issues detailed in Appendix A. There have been many studies that have examined the use of SSI over a short period of time (Dolan, Nichols & Zeidler, 2009; Walker & Zeidler, 2007), however, there are very few instances of the implementation of a semester long treatment, particularly focusing on elementary school students exposed to SSI. Differences between groups that may be seen over the course of a few months may not be apparent within the shorter time frame of a single unit.

The remainder of this chapter presents design and methodology related to the research questions that guide this investigation and outlines the research design and Table 1 serves to describe the instruments used for the treatment. Issues related to research design include the selection of appropriate content and attitudinal questions, instruments, selection of appropriate socioscientific issues, data collection, the target population and samples, and data analysis.

Table 1. Instruments used during the study

Construct	Quantitative	Qualitative
Environmental Attitude and Knowledge	CHEAKS	Classroom debate/SSI
Argumentation & Critical Thinking	Written argumentation rubric	Oral Argumentation Interview

This research aimed to provide much needed feedback into the understanding of what views elementary school students have about the environment and conservation, how they feel and might act toward the environment, and how these feelings and understandings are organized when thinking critically about environmental and conservation issues. Content knowledge and attitude toward the environment and conservation issues were evaluated. Variables related to critical thinking and argumentation skills were explored through qualitative analysis of classroom discussions and interviews. This was an exploratory study of three intact groups of fourth grade students during a 17 week learning experience encompassing local and global environmental issues and conceptual science understanding.

Research Questions

RQ1. What is the impact of SSI-based unit developed for use during outdoor environmental science experiences by fourth grade students on their ability to use critical thinking when faced with controversial and emotive environmental issues?

RQ2. What differences in critical thinking exist between the treatment and comparison groups of fourth grade students after being exposed to SSI and informal science experiences?

RQ3. What differences in students' conservation knowledge and attitude exist between the treatment and comparison groups of fourth grade students after exposure to SSI and informal experiences?

Sample

The sample population for this study was drawn from three intact fourth grade classes of students enrolled at the same elementary school in northern Pinellas County. Participants were a mix of boys and girls ages 9-11 years old. One teacher from this elementary school volunteered to use their classroom to implement the SSI curriculum and participate in the written argumentation and survey instrument. The elementary school teacher is a veteran with over twelve years experience in science education and 30 years in the Education field and is familiar with conducting and promoting small group discussions where students share ideas and work on group problems or projects, debates where students take a positive or negative stance toward the topic being discussed and critical thinking, which guides students to delve deeper into their beliefs. Although this is not her normal method of teaching due to time constraints and state exams, she is familiar with these educational methods. She has earned her doctorate in education and also was a recipient of Pinellas Awards for Excellence in Teaching in 2006 for her promotion of entrepreneurship within her elementary school classroom. The researcher and teacher had the opportunity to meet to answer any questions that may have arisen from using an SSI-based curriculum in the spring semester and summer break, prior to the classroom implementation and outdoor environmental experience. The researcher discussed the theoretical background of SSI-based curriculum, including the use of personal relevance of science content, evidence based reasoning and ethical and moral issues. The teacher is already familiar with these approaches to education and is comfortable and welcomed the opportunity to bring moral and ethical issues into her classroom. To monitor contamination across treatment and comparison due to the fact that all groups attend the same school, the researcher periodically observed the classroom on non-treatment days to make sure the SSI curriculum was not used as well as debriefings periodically throughout the semester with the teacher to go over what is being taught in the comparison classes.

The teacher and principal were initially contacted about their participation in this study in October 2009. The students were selected on their basis of participation in this teacher's class. All students (who provided permissions) completed two quantitative measurements, CHEAKS and the written argumentation assignment at the beginning and the end of the semester. Students were randomly selected from the class to participate in the interviews.

Operationalized Variables

Contextualized Argumentation

Contextualized argumentation is the process of using evidence and reasoning to support claims within the context of environmental education, focused on conservation. The general process of argumentation involves several people defending different viewpoints on a particular topic.

Critical Thinking

Critical thinking encompasses effective communication and problem solving skills and enhances the willingness to reflect and analyze information and conflicting views on topics.

Socioscientific Issues curriculum

A curriculum designed to explicitly make the connections between science and real-world issues. Within this framework, critical thinking and argumentative discourse is included to promote moral and ethical reasoning.

Instruments/Measures

Environmental content knowledge and environmental attitudes were examined through the use of the Children's Environmental Attitude and Knowledge Scale (CHEAKS) (Leeming & Dwyer, 1995). Contextualized argumentation and critical thinking were evaluated through an interview protocol and written argumentation.

The written instruments provided information about changes in the treatment and comparison groups as a whole, while the qualitative interviews provided information regarding individual's changes in thinking over the course of the semester.

Children's Environmental Attitude and Knowledge Scale

The CHEAKS, as used in this study, consists of 66 questions divided into sub categories of environmental attitude and general environmental and conservation knowledge. Each of the responses has a five point Likert scale, which ranges from strongly disagree to strongly agree. Scoring for the survey is based on agreement with contemporary views of conservation behaviors and attitude, with higher scores reflecting more contemporary views and lower scores reflecting more naïve views and lack of awareness and action.

The CHEAKS was written in response to criticisms that there was a lack of solid instruments in existence specifically designed to assess environmental attitude and knowledge in young children. Leeming, Dwyer, Porter and Coberu (1993) reviewed 33 studies that incorporated an environmental knowledge and attitude scale for assessment of children. However, the studies found did little to document reliability or validity of the instruments used. Due to early documentation that children acquire knowledge and develop attitudes about environmental issues as early as kindergarten, and that these early attitudes shape thinking later in life, the construction and validation of CHEAKS was undertaken. The researchers based the development of CHEAKS on the structure and content of an adult scale developed by Maloney, Ward and Braucht (1975) that measures ecological attitudes and knowledge.

The pilot test for the initial draft was conducted with 1,219 students in grades 1-7 from ten elementary schools in the Memphis, Tennessee metropolitan area. The survey was re-administered to the same classes and a total of 1,040 children took the survey on both administrations; the first administration took place in the Fall semester and the second administration took place 6 months later at the end of the school year. Items used in the CHEAKS instrument were derived from the original 45 items on the Maloney et al. (1975) scale and were reviewed by a panel of four experts in environmental education and children's test construction to determine if the questions were applicable to young children (Leeming & Dwyer, 1995).

The CHEAKS instrument went through revisions after several forms of pilot testing including:

- Informal administration to children of friends and colleagues
- Administration to Sunday School classes at a large church
- Administration to intact classes at several grade levels in public schools
- Administration to more than 600 children in 22 classes in Grades K-5 in five schools in the metropolitan Memphis area (Leeming & Dwyer, 1995 p13).

The final version of the instrument consists of two sub-scales, Attitude and Knowledge, and the CHEAKS Total Scale. The Attitude subscale includes 36 items measuring attitudes toward environmental issues. Among these 36 items, 12 items reflect verbal commitment, 12 measure actual commitment to making change and 12 assess affect. The Knowledge subscale is comprised of 30 items and the total scale score is derived from the combination of the scores obtained on the attitude and knowledge scale.

Six sub-domains were sampled for the Attitude and Knowledge subscale:

- Animals

- Energy
- Pollution
- Recycling
- Water conservation
- General issues

The 36 questions in the attitude scale are presented in a 5-point Likert response format where the most pro-environmental response to each item is credited 5 points, whereas the least pro-environmental response receives 1 point. Correct responses to the 30 knowledge questions are each credited 6 points based on how the initial survey was created. Scores for CHEAKS Total Scale range from 36-360, higher scores indicating a combined positive attitudes and increased knowledge.

Convergent and Discriminant Validity

The constructs of attitude and knowledge were examined by computing the intercorrelations between subscales and comparing the pre- and posttest data. There was found to be a low intercorrelation between knowledge and attitude between younger and older children within the experimental and comparison groups. This indicates that the attitude and knowledge subscales measure independent constructs and that is how this instrument was used during the current study.

Developmental Age-Progression Validation

Researchers assumed that the knowledge subscale assessment could show significant increases due to age because older children would likely have elaborated about the content knowledge structure. However, the age progression was not expected for the attitude subscale because attitudes change due to specific exposure and experiences not because of age (Leeming & Dwyer, 1995). ANOVA tests were used to determine whether the younger and older children performed differently on the subscales and Total Scale. For the Total Scale score, older children were found to have scored higher on the first and second administration of the instrument. On the Attitude scale, the mean scores of the younger children were significantly higher than the older children on both the first and second administration. The relationships between first and second administration remained constant with the older children. On the Knowledge scale, the older children showed significantly more knowledge about the environment and this difference was maintained on the second administration of the instrument, confirming age-progression validation.

Reliability

The reliability of this instrument was examined in two ways using stability and internal consistency. Stability was assessed by using Pearson product –moment correlations, which was calculated for the pre- and posttest administrations of the CHEAKS subscales and total scale score. All of the test-retest correlations exceeded .56; the majority were in the .60 to .70 range. The CHEAKS was found to be more stable for the older children than the younger and more stable for the Attitude scale rather than the Knowledge scale.

The internal consistency of this instrument was assessed by computing the alpha coefficients for the subscales and the total scale score. The alpha coefficients for the Total Scale were consistently high and the older children were slightly more consistent in their Total Scale responses than the younger children. The alpha coefficients for the Attitude subscale were also high ranging from .89 to .91; older children being more consistent with responses than younger children. The alpha coefficients for the Knowledge subscale were less reliable, showing scores consistently lower, with the younger children.

Informal Education

All classes, treatment and comparison, participated in a field trip to a county run preserve in northern Pinellas County. All fourth grade students in the northern portion of the county are bussed to this preserve one time during the year to participate in an outdoor education experience. Previous to 2010, fourth grade students were only allocated 60 minutes of time with the environmental educator at the on site preserve, a minimal amount of time to hike and learn about erosion and water conservation. Due to an increase in funding for the program, the comparison and treatment classes that participated in this study were the first group to experience the updated program that allowed each class six hours of hands-on outdoor environmental education with the environmental education instructor. All students participated in a 90-minute hike into 3 different natural habitats, in addition to water quality sampling and testing, examination of water and wind erosion and how the habitats and environments within the preserve have changed due to human intervention. This program was chosen for its direct connection to the SSI curriculum that focuses on wind and water erosion and the protection of wildlife due to human intervention.

Contextualized Argumentation

Argumentation was analyzed using a written response and oral interview. The written argumentation texts were assessed with a rubric developed by Callahan (2009) based on previous work of Zohar and Nemet (2002) and Walker and Zeidler (2007). Transcripts from interviews were analyzed for changes in the structure of critical thinking and argumentation skills from the pre- and post-test.

Written Argumentation

This instrument measured argumentation based on the number of justifications, the structure of the argumentation and the use of subject matter knowledge. Scoring for the arguments ranged in scores from 0-2 for justifications with 0 = no justification, 1= one justification and 2 = two or more justifications. The structure of the argument was scored in a similar way with 0 = no argument, 1 = simple argument and 2 = complex argumentation (Zohar & Nemet, 2002). Subject matter knowledge was examined using a four point rubric created by Walker and Zeidler (2007) with 0 = no evidence, 1 = incorrect evidence, 2 = non-specific evidence claims and 3 = correct evidence.

The rubric assessed students' written argumentation skills on a persuasive essay based on a controversial environmental topic. High scores indicate a proper use of justifications, argumentation and a grasp of subject matter. Lower scores indicate a poor use of argumentation, justifications and subject matter.

The teacher was responsible for assigning the written argumentation activity and then giving the researcher the essays from each of the three classes. The second post-test essay was a different topic and scored at a different time.

Oral Argumentation

Participants' critical thinking and argumentation skills were assessed by guided interviews and small group discussions. Interviews provide a more comprehensive picture of student understanding of concepts and conceptual relationships and how they apply to what was learned during the environmental education units. The oral interviews were conducted with the researcher and individual students to elicit responses to a structured interview protocol. The researcher was responsible for administering the argumentation interview. Following transcription of audio recordings, two graduate students scored each transcript, with the average score of the two raters indicating the final score for the student. Students were asked to read a few short paragraphs detailing the environmental issue and open-ended questions based on the written argumentation assignment and were presented in ways to encourage a commitment to a position and justification to support one's position. Interviews were held outside the classroom. A protocol for administration of the survey, essay and interviews is detailed in Appendix G.

Data Collection

Curriculum development

The development of the SSI curriculum took place prior to the implementation of the units in the spring semester and were pulled from existing sources with input from the elementary school teacher. The teacher and researcher chose two units that spread across several class periods and were particularly cohesive in regards to content being taught in the students' science classes during the spring semester and directly connected to their immersive experience at the county preserve from earlier in the school year. Each of these units was aligned with the state standards for elementary school science education; therefore students learned the content through the multiple activities described in the unit (See Table 2, p. 67). The discussions that took place within the classroom lead to a group consensus on the issue, one that was socially determined and developed by the students, and gave them ownership of the knowledge being presented and the material being learned and products being produced through each unit. The teacher's role was to serve as a facilitator to the students, rather than the dispenser of information within these units. Each unit began with an introductory scenario that set the scene and makes explicit connections between the content to be covered and the conservation issue being discussed. Each SSI unit used small group discussion and classroom debate to share ideas and information and reach a conclusion. The ability to interact with others has been one of the most important elements of SSI due to the fact that the knowledge is socially constructed (Zeidler, Sadler, Applebaum, Callahan, 2009).

These two SSI curriculum units were also chosen because of the personal relevance to the students attending this particular elementary school. The protected preserve that is used for hiking, wildlife and plant observations and soil sample gathering was once a vast farmland decades ago. Due to the use and over-use of the land, different habitats have formed that make the topic of human impact on the land can change the canvas of our environment for the positive and negative. Therefore, a unit, activity and discussion involving land erosion was implemented into the life science portion of the environmental education classroom.

Because there are protected preserves peppered between bustling subdivisions within this community, unfortunately, many animals are seriously injured or killed by vehicles. Animals such as deer, coyote, gopher tortoises, opossum, armadillo and raccoons can be found dead on the side of the road particularly close to the marked preserves. Due to this regular occurrence within the community where the students live, a unit, activity and discussion focusing on speed limits and whether or not they should be reduced because of the animal deaths was used as a controversial topic. This was implemented for the portion of the environmental education class that focuses on physical science due to the forces in motion aspect of the unit but this unit also touches on life science content as well.

Table 2. Correlation of SSI and Sunshine State Standards for Physical Science & Life Science 4th Grade Curriculum

Sunshine State Standard	Beach and farmland Erosion	Speed Limit Reduction	Plastic Pollution	Seal Hunt
Nature of Matter 1. All matter has observable, measurable properties. 2. Basic principles of atomic theory	X	X		
Energy 1. Energy may be changed in form with varying efficiency 2. Interactions of matter and energy			X	
Force and Motion 1. Types of motion may be described, measured, and predicted 2. Types of force that act on an object and the effect of that force can be described, measured, and predicted.		X		
Processes that Shape the Earth 1. Processes in the lithosphere, atmosphere, hydrosphere, and biosphere interact to shape the earth. 2. The need for protection of the natural systems on Earth.	X		X	
Earth and Space 1. The interaction and organization in the Solar System and the Universe and how this affects life on Earth. 2. The vastness of the universe and the Earth's place in it.				
Processes of Life 1. Patterns of structure and function in living things 2. The process and importance of genetic diversity			X	X
How Living Things Interact With Their Environment 1. The competitive, interdependent, cyclic nature of living things in the environment 2. The consequences of using limited natural resources	X	X	X	X
The Nature of Science 1. Scientific processes and habits of mind to solve problems 2. Most natural events occur in comprehensible, consistent patterns 3. Science, technology, and society are interwoven and interdependent	X	X	X	X

Physical Science and Earth Science Curriculum

A short description of the two units that were used during the environmental education classes for the SSI treatment is below. An expanded description of each unit is located in Appendix A.

Unit One: Speed Limit Reduction for the Safety of Local Wildlife (Dolan & Zeidler, 2009). This unit was adapted from an in-class module detailed in Dolan and Zeidler 2009 that looks in depth at motion, velocity and mass through a hands-on outdoor activity. The students participated in the activity by measuring their own mass, velocity and momentum, which lead to a discussion about speed limits and wildlife being influenced by the increased speed on local roadways. Students were provided with articles detailing the pros and cons of lowering speed limits to protect animals in the community. This lead to an in-class debate, allowing students to see this issue from several viewpoints and provide persuasive arguments as to whether or not the local speed limits should be reduced.

Unit Two: The Dust Bowl Scenario (Dolan, Nichols & Zeidler, 2009). This unit offered students the opportunity to see how the local preserve was formed through the erosion of farmland through natural and human influences. Two hands-on activities exemplify water erosion and wind erosion and how the land is changed in both scenarios. Students were given articles providing them with information about beach erosion that is occurring on the local beaches in the community and a possible solution to the erosion in the form of crushed glass as a 'filler.' Students took a pro or con stance on the use of crushed glass to solve the beach erosion issue during an in-class debate.

Teacher training

The teacher chosen for this study was willing to meet 3 times prior to the start of the Spring semester of school to solidify her understanding of using SSI curriculum within the classroom. The meetings lasted 1.5-2 hours and included discussion of the theoretical framework behind SSI, successful incorporation of debate and discussion into the science classroom and a discussion of each of the units to be used during the semester took place; such as what it should look like and to emphasize that as the teacher she needed to take a hands-off approach during the debates and open discussion, letting the students guide the discussion. The discussion included the theoretical framework behind a SSI curriculum, including the use of ethical issues, personal relevance of content used, and a dependence upon evidence-based reasoning for claims. The goal of these meetings was to inform and empower the teacher to draw upon the subject matter content, her life experiences and pedagogical content knowledge when implementing the SSI curriculum. In addition, the teacher understood the importance of exposing students to SSI learning, creating an atmosphere that challenges beliefs, promotes tolerance, mutual respect and sensitivity.

During the implementation of the curriculum during the Spring semester, the researcher observed each treatment class to ensure that the SSI curriculum was being implemented appropriately. The teacher agreed to participate in short debriefing interviews after each class to go over any concerns or questions she may have during the use of the SSI units and to suggest any changes or techniques that can be used to further her skills in this area. The researcher was also on hand twice a week to observe the comparison classes to ensure that the teacher was not implementing the SSI activities into the non-SSI curriculum.

Quantitative Procedures

Environmental content knowledge and attitude was assessed through the administration of the CHEAKS. The researcher discussed the structure of the CHEAKS with the teacher who happened to be familiar with the instrument. The teacher administered the survey in class and was able to read the instructions and even the questions aloud for the students to follow along. Following the administration of the survey, the teacher provided the completed surveys to the researcher for coding and random number assignment.

Argumentation and critical thinking were assessed through the writing of a short in-class persuasive essay regarding a conservation issue. The students were given basic information about a conservation issue that could potentially influence the health of the environment from multiple perspectives. The teacher was responsible for administering the essay assignment and provided completed essays to the researcher for coding and random code assignment.

Qualitative Procedures

Argumentation and critical thinking were assessed through the use of interviews. The researcher conducted the interviews in an outdoor, relaxed setting and assessed the results by using the argumentation protocol. The researcher audio-recorded the interviews and transcribed the data. Data was categorized using the rubric from the written argumentation assignment to verify students' justification, argumentation skill and subject matter knowledge.

Time Frame for data collection

Initially the teacher was identified and agreed to be a part of the research study in the Fall 2009 semester. The pretest data collection took place in the beginning of the Fall 2010 semester. The administration of the curricula took place throughout the Spring 2011 semester with the post-test data collection occurring following the completion of the units.

Table 3: *Timeline for Conducting Study*

	Oct 2009	Aug. 2010	Sept. 2010	Feb. 2011	March 2011	April 2011	May 2011
Teachers identified/ trained	X						
Pre-test data collection		X	X				
Science curriculum				X	X	X	
Post-test Data Collection						X	X

Table 4: *Timeline for Treatment*

Speed Limit	Part I: 2 class periods, 90 minutes each, week 1 and week 2	Part II:1 class period, 90 minutes, week 3	Part III: 1 class period, 90 minutes, week 4	Part IV: 1 class period, 90 minutes, week 5	Part V: 1 class period, 90 minutes, week 6
Dust Bowl	Part I: 2 class periods, 90 minutes each, week 6 and week 7	Part II: 2-3 class periods for hikes, 90 minutes each, week 8, week 9 and week 10	Part III: 1-2 class periods, 90 minutes, week 11 and week 12		

Data Analysis

For each assessment of quantitative analysis including the Children's Environmental Attitude and Knowledge Survey (CHEAKS) and the written argumentation rubrics a series of t-tests were used. This helped to identify within group differences and between group differences from the pretest and posttest data collected. Attitude and knowledge was analyzed using the CHEAKS and justifications, structure of argument and subject matter knowledge was analyzed from the written argumentation essays. SPSS statistical software was used to complete all researcher-derived statistical analysis.

Qualitative data was analyzed by coding for themes and provided specific examples as to why a student's response may differ or vary between the pre- and post-test. Semi-structured interviews were used to provide data in conjunction with data gathered through the survey instrument and written argumentation activities (Lincoln & Guba, 1985). Each of the interviews lasted approximately seven to ten minutes and took place outside in a wooded area located in close proximity to the science classrooms. The researcher audio recorded the interviews, and transcribed the recordings.

Three analogue forms of reliability and validity as outlined in Lincoln & Guba (1985) are credibility, triangulation and transferability. Credibility can be reached through different methods of data gathering so that reliable results can be determined such as by conducting interviews and collecting written data. In this study, the researcher spent long periods of time in the classroom during data collection, twice weekly so that during the implementation of the SSI units the students didn't find the researcher obtrusive. This allowed the researcher to gather evidence that the SSI modules are only being used in the treatment classrooms and not in the control classrooms. Triangulation is used so that the data gathered is truly meaningful to the study and it also uses multiple sources, methods and investigators. During this study several researchers helped to score and transcribe the data and multiple methods such as written activities, surveys and interviews were used. For this study, each of the constructs was examined through two different sources. Environmental attitude and knowledge were examined through the use of the CHEAKS (pen and paper) as well as interviews; argumentation was examined through the use of essays (written) and interviews (oral). The constructs in this study were examined both quantitatively and qualitatively through the use of the CHEAKS, written argumentation, oral argumentation interviews and the implementation of an SSI curriculum involving classroom debate.

The analysis of the data involved multiple investigators so that the data was evaluated properly and without bias. The researcher employed three graduate students that are in the science education program and have been exposed to socioscientific issues and the importance of argumentation and critical thinking within their doctoral coursework. The researcher conducted the data gathering and interviewing and utilized the graduate students for the scoring. Prior to scoring, the researcher met with the doctoral students to discuss how to score the essays and interviews. Three student essays were chosen to score together so a consensus could be reached and to allow discussion of each of the criteria. Following the cooperative scoring, each doctoral student then scored three essays independently. Initially a discussion arose over the correct scoring of justification for the argument/reason after an interrater reliability score of 62.3% was recorded, after which, three more essays were scored independently and an interrater reliability rating of 90.4% was achieved. The interviews were scored by the same doctoral students and utilized the same aspects of argumentation analyzed to score the written essays.

Transferability, loosely defined, is how well the results can be used in new situations. Although research cannot be directly compared to other situations, the procedures used to collect the data can be transferred to new situations. The methodology is described in detail so that studies may be duplicated to examine alternative outcomes dealing with SSI, critical thinking, argumentation and informal education at the elementary school level.

Summary

This study used a mixed methods approach consisting of quantitative and qualitative instruments. The quantitative portion of this study used the CHEAKS and the written argumentation assignment to determine the effectiveness of a semester long Physical Science and Earth Science curriculum using socioscientific issues to guide the content. The qualitative data provided through the interviews conducted by the researcher to determine how much students have grown in their argumentation and critical thinking ability based on the SSI guided curriculum within the 4th grade environmental education classroom.

CHAPTER FOUR: RESULTS

Introduction

Both data analysis and discussion of particular tables are presented in chapter four, with major themes of the study reserved for chapter five. As this study focuses on three outcomes, each of the research questions are addressed and then answered in their original order. Environmental knowledge and attitude were investigated by using the CHEAKS instrument to gather quantitative data. Argumentation and critical thinking were studied through the use of a persuasive essay on a science topic to gather quantitative data and an interview protocol to gather qualitative data. Both statistical data and interview data were utilized in order to provide more clearly the answer to each of the research questions. Interview data are represented with both a numeric value and the interview administration, with the numeric value representing the student's random identifier.

Research Questions

Research Question 1

What is the impact of SSI based unit developed for use during outdoor environmental science experiences by fourth grade students on their ability to use critical thinking when faced with controversial and emotive environmental issues?

Oral argumentation

The argumentation interviews examined student responses to two different scenarios: plastic pollution and seal hunting. Three criteria were examined during the interview, the same criteria used to score the written argumentation exercises: structure, justification and subject matter knowledge. The first two constructs were scored from zero to two, with two being the highest score, and subject matter knowledge was scored from zero to three, with three being the highest score; interpretations from these interviews are detailed in the tables below. Three students from the treatment group and three students from the control group were randomly selected by their classroom number being drawn from a bowl by the teacher and interviewed to further explore their ability to construct an argument for or against an environmental topic and whether the students were able to examine the issue from multiple perspectives. All of the students interviewed were able to offer a reason for their belief, however, the students from the treatment group were able to more clearly see the issues from multiple perspectives and offer reasons for both sides of the issue.

In tables 5 & 6 below are excerpts from the student interviews from the comparison group and treatment group along with a brief explanation of the researcher's interpretation of student responses. The interviewer is identified by "I" while the student is identified by "S." The responses highlight that the students participating in the treatment group were more likely to articulate their reason and offer alternative viewpoints on issues after exposure to SSI, while the students from the comparison group remained unable to offer alternative viewpoints on the issues.

Table 5

Pre-post comparisons of treatment student responses to argumentation prompts

Pretest Key Indicator Treatment	Posttest Key Indicator Treatment	Researchers' Interpretation
Scenario: Plastic Pollution	Scenario: Seal Hunting	
I: Do you think plastics should be banned, all plastics? S: well I think not all plastics should be banned because we should use some plastic but you should not use a lot. Like instead of using plastic bags um, you should use, um fabric bags or stuff like that. I: Your friend disagrees with you. They think all plastics are good or all plastics are bad and should be banned. What argument would they use that all plastics should be around? S: they would probably think that because they just use plastics so much they think well there's no way that they can take all the plastics away and they are not going to stop using them.	S: I think it should be partially banned, not all the way banned but sort of banned. I: No what if your friend disagrees with you what would they say as their position if they disagreed with you? S: they would probably say that clothing, boots, fuel for lamps and furnished harnessed for huskies and we need that and then they would say that they probably don't think its gonna go they don't think its gonna go extinct because there are so many right now. I: how would you answer them back to make them see your point of view? S: I would say, well yeah, but if you can have five a year that's gonna provide you that but you can't have like a hundred a year because then you are going to throw most of it away.	In the pre interview this student offers an alternative to plastics in their stance that plastics are both good and bad by suggesting the use of fabric bags as seen at grocery stores. When the student is asked to articulate an argument for plastics the justification that there is already too much stuff made out of plastics was given but no supporting reasoning. It is evident in comparing the pre-interview transcript and the post-interview transcript that this student offered a more detailed justification with reasons in the post interview for their initial stance. They were also able to articulate the issue from both sides of the argument and used subject matter knowledge gained through the article they were provided on the topic of seal hunting. They were able to see that there may not be just one solution to the problem, but alternatives and compromises to the issue.
S: umm well the plastic pollution is basically killing a lot of wildlife and yeah like a lot of and getting into peoples um stuffs food chain and for and for people its creating illnesses. I: Do you think that all plastics should be banned? S: um (pause) no but people just need to like use it better and like not pollute it and throw it but recycle it. Yeah I don't think it should be banned just use it better I: So what if your friend says that they believe that all plastics should be banned, what do you think their argument would be to say that they should all be banned? S: That a lot of marine life is getting killed and people are getting illnesses so I can see their point of view but….	I: Your friend disagrees with you and thinks that it shouldn't be banned that they should do whatever they want, what do you think their reasons would be for picking that side? S: That Canada might not have enough stuff to give to people because they are killing these many seals I: How would you convince your friend or how would you answer them to prove your point to them? S: That they killed in 2009 338,200 seals total that's like a thousand schools put together and they killed everyone.	During the pre interview, although this student seems to understand that there is a way for plastics to exist but be used differently, they don't offer a solid justification when asked to articulate the argument to convince their friend they are right about the plastics issue. In the post interview exchange, this student is making the claim that too many seals are being killed using a much-needed resource for the country, but compared it to killing students in a school (wiping out schools of kids).
S: um well, they pollute the environment and they like also like in Germany, South Africa and Australia they banned it, because of they clog sewers and harm wildlife and also sometimes sea turtles eat them and things like that and a lot of times the animals will eat them and a lot of them die and really its just a really bad pollution because they are made of toxics anyway so. I: Do you think plastics should be banned? S: I just think they should be reduced in use because we've, when we go out on the nature trail you can actually see all the plastics sitting around and I'm in the environmental club and I noticed that um like two out of every five pieces of trash is plastic so its really a harm to the environment. I: What do you think your friend would tell you to convince you that they were right? S: That most, we reuse it and all like that it's made of plastic and this is made of plastic and so is this (pointing to things around the playground) so yeah um that we all use it.	S: well I think the problem is that too many seals are being killed in Canada and too many hunters and fishermen are just murdering the seals for their coats and for food, I: Do you think that the seal hunt should be banned up there? S: well, I don't really think it should be banned since the Inuit they have to live off the seals and they have been living off them for a long time so I think there should just be more limits to how many seals you can kill. I: What do you think your friend would say to convince you they were right? S: that we if its overpopulated then the balance of nature would be um offset I: and how would you answer your friend to get your ideas back across to them? S: well they already killed so many and even though some need them for food we shouldn't kill as many because then even right now they are saying its over populated	During the pre interview this student makes good use of subject matter knowledge by pointing out animals being harmed as well as illness and what she sees from her own experiences. She is also able to see that plastics are good and bad, but offering the solution to limit the use of them. In the post interview, this student is able to see that although seal hunting is "murder" there should be a limit on what is killed due to the need in some cultures for seal meat. She is able to see the issue from multiple perspectives.

Table 6

Pre-post comparisons of comparison student responses to argumentation prompts

Pretest Key Indicator Comparison	Posttest Key Indicator Comparison	Researchers' Interpretation
Scenario: Plastic Pollution I: So do you think plastics should be banned? S: well we humans use them for a lot of stuff so umm I think it could be banned I: Why do you think it could be banned? S: Because we use it for a lot of stuff but since plastic can be melted down and reused to create something else then it could be banned to create something else. I: Your friend disagrees with you they think that plastics should not be banned so what do you think their position would be? S: well, they would probably argue for the plastic not being banned. Well there's a lot of reasons that it could be banned and couldn't be banned. I kind of agree with them and disagree with them so I'm not really sure.	Scenario: Seal Hunting I: Do you think it should be banned? S: umm well if it means I don't think it should be banned because like we should think if seals umm should be extinct or Canada. I forgot I: Your friend disagrees with you, they believe that it should be banned what do you think their position or their argument would be to you? S: umm I think that the argument should be about to think about how seals could like live or die and if it would be better or worse and if Canada like wouldn't be nothing better or worse. I: so what would your friend say to you to convince you that seal hunting should be banned? S: umm (long pause) probably umm it should be banned then she should probably say that if umm (long pause) well if it should be banned then Canada would be nothing so she would have to give a reason then if it would be banned then umm this is so hard I can't make it out.	In the pre interview, the student repeated their stance but did not offer any kind of supporting evidence or justification for their reason behind why plastics could or couldn't be banned. When the student was asked to look at the issue from a different perspective, they also did not offer any type of justification. During the course of the posttest interview, this student repeated their own argument as that of their friends and offered as a justification that Canada as a country would be nothing if there weren't any seals left so it should be banned. Although there was a rough justification offered, the student failed to see the issue from multiple perspectives.
: What's your point of view? S: I think we should keep it because it more has a good use than a bad use. I: Now, your friend disagrees with you and they think plastics should be banned what would they say to convince you they were right? S: Their position would be they don't want plastic s they think they should be banned they don't want them they don't think they need them; they just think its bad to have them.	I: So your friend disagrees with you, what would their position be? S: Their would be that this should be banned we do not need those seals dying what did they ever do to us? There really any reason that we should be hunting seals what about seals hunting us? We wouldn't like that its no way to treat something I: so how would you then answer your friend? S: Well, harp seal hunting is not very good because it's just very sad. People might feel uncomfortable; it doesn't make them happy. Sometimes the seals may not be healthy and they can make you sick. So you always want to be as careful as you can and don't take risks. They're bad ones.	During the pre interview this student offered statements that could be viewed as a different perspective from their own, however, they repeated what the interviewer said in regards to banning plastics. During the course of the post interview this student seemed to make an emotional connection with the topic by putting themselves in the place of the seals, the student still did not offer a solid justification or any subject matter knowledge about seal hunting and why it should be banned.
I: Your friend disagrees with you, what would their position be? S: Well, umm can you rephrase the question? I: Your friend disagrees with what you just said, what would their position or argument be? S: That plastics should be banned and that plastics should be banned and that we shouldn't use plastics at all. I: What would their reasons be? S: Well, maybe because of the pollution	I: Do you think that seal hunting should be banned? S: Umm well yes umm yes and no because they rely so much on it but seals if that reduces the population and I only think it should be allowed if the population grows too much. I: Your friend disagrees with you, they think that seal hunting should be banned, what would their position be? S: She would think that seal hunting should be banned because it reduces the population	During the pre-interview exchange, this student at first had a difficult time understanding the question, but offered a justification for their friend's argument for wanting all plastics banned. The justifications were because plastic causes pollution. In the posttest interview exchange this student offered a general justification for why seal hunting should be banned but did not offer supporting information for their stance and when asked to view the issue from their friends perspective they could not.

Students from the comparison group did not improve from pretest interview to posttest interview with the exception of one student that scored a zero for each of the constructs (structure, justification, subject matter knowledge) 0-0-0. This student improved to a 1-1-0 on the posttest interview that focused on seal hunting. The students from the treatment group scored higher than the comparison group on the initial pretest interview focusing on plastic pollution, but this could be due to the fact that two out of three of the students randomly selected for interviews were involved in the recycling program at the elementary school. The students from the treatment group improved their scores from pretest to posttest by at least one point per construct. However, the seal-hunting scenario may have elicited too many emotional responses because it involves killing an animal that most deem as cute and cuddly.

Research Question 2

What differences in critical thinking and argumentation exist between the treatment and comparison groups of fourth grade students after being exposed to SSI and informal science experiences?

This study addressed whether the use of a socioscientific issues based curriculum could have positive effects on argumentation skills of fourth grade students. There were three criteria examined for the written argumentation exercise: the use of justifications, offering support for the issue being examined or to offer reasons against the issue. Argumentation structure examined how well the student could articulate their views and the use of subject matter knowledge that pertained directly to the topic being examined.

Students initially were given the written exercise pretest while on-site at the county preserve in the Fall semester of 2010. The posttest was administered seven months later at the end of the spring semester. Both justifications and structure were scored from zero to two, with two being the highest score (Zohar & Nemet, 2002). Subject matter knowledge was scored from zero to three, with three being the highest score following the protocol developed by Walker and Zeidler, (2007). The treatment group contained 34 students while the comparison group contained 18 students. The initial descriptive statistics are presented below.

From initial examination there were positive gains in both justification and structure for both treatment and comparison over the course of the semester long treatment. Subject Matter Knowledge remained the same for the treatment group, but was well above the comparison group scores on both the pre and posttest written exercise. A series of t-tests were run to determine if there was any statistical significance within groups or between groups.

Table 7*: Pre and Posttest Justification Scores*

Justification	Mean			Standard Deviation		
	Pretest	Posttest	Differences	Pretest	Posttest	Differences
Treatment	1.11	1.46	.342	.530	.505	.639
Comparison	.95	1.37	.421	.524	.496	.606

Table 8: *Summary of t-tests Justification*

	Within Group Comparison (pre vs. post)		
	t	df	sig
Treatment	3.74	34	.003*
Comparison	3.024	18	.007*
	Between Group Comparison (treat vs. comp)		
	t	df	sig
Pretest Score	1.110	52	.272
Posttest Score	.620	52	.538
Differences Score	-4.37	52	.664

Alpha .01 (.05/5) *p<.01

A paired-samples t-test was conducted to compare the pre and post test scores of the treatment group and comparison group in regards to the justifications used in their argument. There was a statistically significant difference within groups from pretest (M=1.11, SD=.530) to posttest (M=1.46, SD=.505) conditions; t(34)=3.74, p<.01 for the treatment group. There was also a significant difference within groups from pretest (M=.95, SD=.524) to posttest (M=1.37, SD=.496) conditions; t(18)=3.024, p<.01 for the comparison group. When comparing the differences scores between treatment group (M=.342, SD=.639) and comparison group (M=.421, SD=.606) conditions; t(52)=-4.37, p<.664 there was no significant differences found.

One might infer that there was less room for improvement in the semester long treatment for the treatment group because their pretest scores were already high. The results for the t-tests for subject matter knowledge are listed below in Tables 9 & 10.

Table 9: *Pre and Posttest Subject Matter Knowledge Scores*

SMK	Mean			Standard Deviation		
	Pretest	Posttest	Differences	Pretest	Posttest	Differences
Treatment	1.77	1.77	.000	.770	.646	.766
Comparison	.58	1.47	.894	.961	.697	1.32

Table 10*: Summary of t-tests Subject Matter Knowledge*

	Within Group Comparison (pre vs. post)		
	t	df	sig
Treatment	.000	34	1.00
Comparison	2.935	18	.009*
	Between Group Comparison (treat vs. comp)		
	t	df	sig
Pretest Score	4.974	52	.000*
Posttest Score	1.574	52	.122
Differences Score	-3.146	52	.003*

Alpha .01 (.05/5) *p<.01

A paired-samples t-test was conducted to compare the pre and post test scores of the treatment group and comparison group in regards to the subject matter knowledge that was used within the argument. There was not a significant difference within groups from pretest (M=1.77, SD=.770) to posttest (M=1.77, SD=.646) conditions; t(34)=.000, p<1.00 for the treatment group. There was a statistically significant difference within groups from pretest (M=.58, SD=.961) to posttest (M=1.47, SD=.697) conditions; t(18)=2.935, p<.01 for the comparison group. When comparing the differences scores between treatment group (M=.000, SD=.766) and comparison group (M=.894, SD=1.32) conditions, t(52)=-3.146, p<.01 there was a statistically significant difference between the treatment and comparison group with the comparison group making the greater strides.

The scores for the treatment group were static from the pretest to the posttest written activity. This could be due to the fact that there was some confusion about seals and whales, with students using incorrect terminology to explain their reasons for banning seal hunting. Some students referred to seals as whales and other students answered purely by emotional response rather than using subject matter knowledge to heighten the quality of their argument. The t-tests results for structure are listed below in tables 11 & 12.

Table 11*: Pre and Posttest Structure Scores*

Structure	Mean			Standard Deviation		
	Pretest	Posttest	Differences	Pretest	Posttest	Differences
Treatment	1.20	1.34	.142	.531	.482	.601
Comparison	1.37	1.53	.157	.597	.513	.688

Table 12*: Summary of t-tests Structure*

	Within Group Comparison (pre vs. post)		
	t	df	sig
Treatment	1.00	18	.331
Comparison	1.00	18	.331
	Between Group Comparison (treat vs. comp)		
	t	df	sig
Pretest Score	-1.065	52	.292
Posttest Score	-1.307	52	.197
Differences score	-.083	52	.934

Alpha .01 (.05/5) *p<.01

A paired-samples t-test was conducted to compare the pre and post test scores of the treatment group and comparison group in regards to the structure of their argument. There was not a significant difference within groups for pretest (M=1.20, SD=.531) and posttest (M=1.34, SD=.482) conditions; t(18)=1.00, p<.331 for the treatment group. There also was not a significant difference within group pretest (M=1.37, SD=.597) and posttest (M=1.53, SD=.513) conditions; t(18)=1.00, p,.331 for the comparison group. When comparing the differences scores between the treatment group (M=.142, SD=.601) and the comparison group (M=.157, SD=.688) conditions; t(52)=.934, p<-.083 there is also no significant difference.

The changes in the scores from the pretest to the posttest could have been due to the use of a different prompt than the pretest, because the students were more familiar with issues dealing with pollution and recycling which was featured in the pretest exercise than seal hunting which was featured in the posttest exercise.

Research Question 3

What differences in students' conservation knowledge and attitude exist between the treatment and comparison groups of fourth grade students after exposure to SSI and informal experiences?

This study attempted to investigate whether fourth grade students would attain higher levels of environmental knowledge and show an improved attitude toward conservation over the course of a semester long treatment utilizing SSI. The initial descriptive statistics are listed below.

Table 13: *Pre and Posttest attitude scores*

Attitude	Mean			Standard Deviation		
	Pretest	Posttest	Differences	Pretest	Posttest	Differences
Treatment	107.31	108.37	1.057	15.285	13.189	17.086
Comparison	106.53	107.32	.789	13.753	15.250	15.547

Table 14: *Summary of t-tests Attitude*

	Within Group Comparison (pre vs. post)		
	t	df	sig
Treatment	.366	34	.717
Comparison	.221	18	.827
	Between Group Comparison (treat vs. comp)		
	t	df	sig
Pretest Score	.187	52	.852
Posttest Score	.266	52	.791
Differences Score	.057	52	.955

Alpha .01 (.05/5) *p<.01

A paired-samples t-test was conducted to compare the pre and post test scores of the treatment group and comparison group in regards to change in attitude toward conservation. There was not a significant difference within groups from pretest (M=107.31, SD=15.285) to posttest (M=108.37, SD=13.189) conditions; t(34)=.366, p<.717 for the treatment group. There also was not a significant difference within groups from pretest (M=106.53, SD=13.753) to posttest (M=107.32, SD=15.250) conditions; t(18)=.221, p<.827 for the comparison group. When examining the differences scores between treatment group (M=1.057, SD=17.086) and comparison group (M=.789, SD=15.547) conditions, t(52)=.057, p<.955 there also is no significant difference, however, the scores for both the treatment and comparison group did improve slightly showing a positive attitude toward conservation for both groups. Results for knowledge scores are listed below in tables 15 & 16.

Table 15*: Pre and Posttest Knowledge Scores*

Knowledge	Mean			Standard Deviation		
	Pretest	Posttest	Differences	Pretest	Posttest	Differences
Treatment	53.49	65.94	12.457	17.424	19.254	14.943
Comparison	48.32	60.95	12.631	14.068	16.403	17.075

Table 16*: Summary of t-tests Knowledge*

	Within Group Comparison (pre vs. post)		
	t	df	sig
Treatment	4.932	34	.000*
Comparison	3.224	18	.005*
	Between Group Comparison (treat vs. comp)		
	t	df	sig
Pretest Score	.110	52	.272
Posttest Score	.957	52	.343
Differences Score	-.039	52	.969

Alpha .01 (.05/5) *p<.01

A paired-samples t-test was conducted to compare the pre and post test scores of the treatment and comparison group in regards to change in knowledge about the environment. There was a statistically significant difference within groups from pretest (M=53.49, SD=17.424) to posttest (M=65.94, SD=19.254) conditions; $t(34)=4.932$, $p<.01$ for the treatment group. There was also a statistically significant difference within groups from pretest (M=48.32, SD=14.068) to posttest (M=60.95, SD=16.403) conditions; $t(18)=3.224$, $p<.01$ for the comparison group. However, no statistical significance was found between groups for the treatment (M=12.457, SD=14.943) and the comparison (M=12.631, SD=17.075) conditions; $t(52)=-.039$, $p<.969$.

Summary of Results

This study did produce instances of statistical significance within groups for justification and between groups for justification and structure during the written argumentation exercises. Some students showed more sophisticated reasoning from the pretest to the posttest measures when examining the student argumentation interviews. The students were energetic and optimistic throughout the study and enjoyed being outdoors during class and participating in hands on activities. The students also were happy to work in small groups and took the debates and small group discussions seriously. The students showed genuine interest in the topics used and weren't afraid to participate and offer their viewpoints when asked to discuss certain outcomes or topics. Students were highly motivated to complete the essay assignment and enjoyed the opportunity to discuss plastic pollution and seal hunting. At first, the students were concerned that there was a "right or wrong" answer, but once the teacher explained it was to be written from their point of view and what they thought or felt about the topic, the students took the time to think about the issues and give their best possible response at that time. The students were told that this would not be part of their grade, which made them more relaxed and less concerned about answering inappropriately.

Although all scores did not increase significantly between groups, it should be noted that there were gains within groups for justifications offered to support the students' arguments for or against the topic being examined. The interviews reflected a more significant change between the treatment and comparison. The students interviewed from the comparison group were able to construct a simple reason, but mostly repeated their argument as that of their friends. However, the students interviewed from the treatment groups improved from pretest to posttest by providing more than a simple argument for their view and an alternative view. They were able to use supporting evidence for their view and offer reasons that their friend may view the issue differently.

This study was not completed during the first semester as planned. The main factor for this was the length of time required to complete the informed consent process through the county due to their new submission time lines. The treatment therefore, continued until May 2011, which was close to when school was letting out for the summer.

Environmental knowledge and attitude were tested using the CHEAKS instrument. There was statistical significance found to be present for within group scores on the knowledge portion of the survey and statistical significance for between group scores on the attitude portion of the survey. The improved knowledge scores may be attributed to the content being taught across classrooms during the semester, however, the improvement in attitude toward conservation may be attributed to the way in which the content was taught through the use of SSI.

The SSI treatment provided some instances in which advances in argumentation, environmental knowledge and attitude were made; however, the advances were not as significantly evident between groups as one would hope over a long-term treatment. Although there were increases within groups, the treatment groups making the most strides in argumentation and environmental knowledge and attitude, more explicit instruction focusing on argumentation within the context of SSI may be needed to see significant gains between groups.

CHAPTER FIVE: DISCUSSION

Introduction

In the preceding chapter, the presentation and analysis of data were conducted. Chapter five consists of a discussion of the findings, implications for educational practice, recommendations for further research and conclusions. The purpose of these sections are to expand the analysis from chapter four, highlight direct links between research and practice, and provide additional directions for future research studies. Finally, a concluding statement describes the scope of the present study.

Discussion of the Findings

This study attempts to examine the use of SSI within the elementary school science classroom and its influence on the argumentation and critical thinking skills along with the environmental knowledge and conservation attitudes of fourth grade students. An SSI curriculum incorporates real world, ethically and morally debatable scenarios that are drawn from real world science issues that citizens are faced with daily. The three main characteristics of the SSI movement are their controversial nature, their open-endedness, and the inclusion of moral or ethical reasoning (Zeidler & Sadler, 2008a; Zeidler, Sadler, Simmons & Howes, 2005). Components of this movement allow students to engage in critical thinking and discussion of topics with others who may believe differently. It is a multi-faceted tool which aids in developing critically thinking students, hopefully creating meaningful dialogue and authentic learning.

An important aspect of science education is to provide students with the analytical skills needed to weigh scientific evidence and policy choices. Environmental issues are multidimensional and include ethical and political considerations, which recognize that scientific knowledge is changing and evolving, and that there is critical importance placed on environmental literacy for our society and the health of the environment. One of the goals of science education is to provide students with the knowledge and skills needed to make decisions about important environmental issues that they will likely face in the future. Chepesiuk (2007) furthers this goal by supporting the civic and practical ideas of scientific literacy to prepare children earlier on to become environmental stewards. Environmental literacy can prepare students for these responsibilities, develop and expand children's critical thinking skills, prepare them for citizenship and develop an appreciation of the natural world.

The SSI movement focuses on the incorporation of controversial scientific issues that connect students to the real world surrounding them through discussion and acknowledgement of science that is socially relevant. One of the goals of the current study was to successfully implement a semester long environmentally focused SSI curriculum with topics pertaining to local and national environmental and conservation issues. Both students and teacher expressed that the topics of discussion and hands-on activities were not only fun, but allowed the students to voice opinions and solve problems that were going on in their community. The primary goal of the current study was to investigate the relationship between socioscientific issues and three outcomes related to scientific literacy and critical thinking.

1. What is the impact of SSI based unit developed for use during outdoor environmental science experiences by fourth grade students on their ability to use critical thinking when faced with controversial and emotive environmental issues?

Allowing students the opportunity to visit an informal science facility may be helpful in exposing students to a range of science topics. However, connecting students to science in meaningful ways through these experiences with conceptual understanding of subject matter has historically been a challenge to science education (Dierking &Falk, 2004). By using socioscientific issues as the tool, these informal experiences have the potential to be pedagogically meaningful for students to develop conceptual understanding and connect the aesthetics of their experience to learning. Unfortunately, informal education programs situate sciences within the context of a single lesson or experience instead of the real world of the learner (Falk, 2008). In this instance, a socioscientific-based curriculum implemented within informal science education programs created the opportunity to connect the students with real world issues within the local community. Socioscientific issues incorporate scientific issues that carry a moral and ethical thread that can be discussed and viewed from several angles, not a "right or wrong" scenario. Within the informal science education programs using hands-on activities, group discussions and analysis of a local environmental issue students were exposed to science that was happening around them within their neighborhoods and communities, not just within the textbook. Critical thinking was tested through the use of an argumentation interview protocol. The interview process tested the students' ability to take multiple perspectives on environmental topics utilizing subject matter knowledge to create arguments for different views on the same topic. Most of the students were able to articulate their own position and viewpoint, providing a limited rationale for their position and most of the students within the comparison group were unable to provide alternative viewpoints without restating their own argument or position. Students within the treatment group improved from pretest interview to posttest interview on justification, structure and subject matter knowledge, with most of the students providing subject matter knowledge and content to enhance not only their position but also the alternative viewpoint that the students offered during the interview. Although the students provided alternative viewpoints and offered reasons for these views, explicit argumentation still needs to be taught within the elementary school classroom to enhance students' critical thinking skills. Offering students the opportunity to discuss and argue real world issues have been shown to be effective methods of teaching content knowledge by providing the context to introduce argumentation into the science classroom effectively (Zeidler, Applebaum & Sadler, 2011).

2. What differences in critical thinking exist between the treatment and comparison groups of fourth grade students after being exposed to SSI and informal science experiences?

As Walker & Zeidler (2007) highlighted, our goal as science educators is to promote environments where students think for themselves to promote opportunities for their engagement with informal reasoning. By exposing students to alternate views of science through outdoor environmental education experiences, and then applying these experiences to the concepts and context within this experience, educators may be closer to this goal. Research dealing with the impact of SSI-based curriculum focusing on elementary school students is limited and should be explored further to gain a more complete understanding as to how young children think critically and make decisions about environmental issues. This study examined the structure, justifications used and subject matter knowledge used to support written argumentation.

The pretest essay involving plastic pollution yielded a better understanding of content and use of scientific evidence because students had a familiarity with the detrimental influence of excessive plastics in the environment from personal experience and from the school being highly involved in the practice of recycling all plastic materials that are used or brought to campus. Both treatment and comparison groups showed improvement in the use of justifications and structure of argument from the pretest to the posttest. However, statistical significance was found between groups for use of subject matter knowledge with the comparison group showing the larger gain and the treatment group maintaining the same score from pretest to posttest. The treatment group had the higher scores overall from pretest to posttest, but showed a lack of subject matter knowledge when writing about the possible banning of seal hunting in Canada. Students from the treatment group seemed to answer from purely an emotional perspective showing a lack of science content to support their views during the seal-hunting prompt.

To move forward with educational reform, research into how young students think, their capacity for thinking critically and their moral sensitivity to environmental issues will help determine how to shape curriculum and learning modules to best suit the needs of the students. By examining the critical thinking skills of elementary school students with environmental issues, we can gain a richer perspective of the differences and similarities in how young children think about controversial issues. Socioscientific issues invite students to explore science that is multi-faceted and rich with ethical queries. With continuing emphasis being placed on standardized testing students are quickly becoming adept at regurgitating facts. Some science educators feel that this is only exposing students to a limited view of science (J. Schubel, Monroe, K. Schubel & Bonnenkant, 2009; Zeidler, Sadler, Applebaum, Callahan, 2009). Science is generally represented as separate from the world outside, divorced from social, political, ethical consideration and debate. Topics' dealing with environmental issues present opportunities to expose students to things occurring outside their window, reconnecting them with science and real-world issues. The use of SSI may have the potential to make students utilize their critical thinking skills so they can analyze and synthesize scientific information they need to uphold their arguments about the moral and ethical dilemma they are faced with. This will create a learning environment that not only exposes students to new methods of comprehending science information, but also enhance their scientific knowledge, promoting critical thinking at a young age, a skill that is a necessary component of truly becoming educated and scientifically literate (Dolan, Nichols & Zeidler, 2009).

3. What differences in students' conservation knowledge and attitude exist between the treatment and comparison groups of fourth grade students after exposure to SSI and informal experiences?

Kuhn (1993) points out that young children are naturally curious about the world around them, but that their curiosity should be guided toward scientific argumentation and scientific thinking. SSI instruction tends to focus more on facilitating the development of argument and critical thinking skills in older students through the use of moral and ethical issues, leaving a gap in the literature particularly dealing with young students. Moral issues are an embedded part of environmental and conservation topics; therefore, it is possible for informal experiences to be effective and contextually reinforcing experiences when brought back into the classroom successfully (Falk & Dierking, 1992; Falk, 2009). It is also possible that the pairing of conservation issues and SSI will help to cultivate students into informed and scientifically literate citizens (Burek & Callahan, 2005). This experience may lead to an embedded sense of environmental stewardship by offering students a glimpse at how action can lead to change and that decisions made today can have a strong influence on the future. This was examined through the use of the CHEAKS instrument, which measured environmental knowledge and attitude. There were positive gains in both treatment and comparison groups on knowledge scores, which can be explained by the content of the curriculum being taught throughout the semester in all fourth grade classes. The treatment group, which was taught with a SSI based curriculum showed statistically significant gains in their attitude toward the environment. Questions on this portion of the survey instrument asked students how likely they were to take action to conserve the environment through changing their daily habits and educating friends and family on the different ways to conserve the environment. After being taught explicitly with SSI, students showed positive gains in their views on taking action to conserve which suggests there is = evidence that teaching with socioscientific issues, exposing students to real world science topics and allowing participation in hands-on informal science activities that students have a more positive outlook on participation in activities that enhance the quality of life within our society (Zeidler & Sadler, 2009).

Implications for Practice

The use of socioscientific issues based curriculum was utilized as the primary method of instruction over the course of 2 units in 3 heterogeneous fourth grade science classes in a suburban elementary school. This treatment was useful as there have not been many instances where SSI has been used in the elementary school classroom coupled with informal education experiences.

A few studies have shown that schooling is necessary but not sufficient enough to support lifelong science literacy, emphasizing the necessity of alternative learning environments and approaches (Falk, 2009; Falk, Storksdieck & Dierking 2007). In Britain, Scotland and Wales the development of Forest School is becoming an exceedingly popular way to incorporate regular contact with woodlands or outdoor spaces for students. Forest School allows students to become more familiar with the open and green spaces, creating opportunities to learn and gain experience outside of the classroom (O'Brien, 2009).

Socioscientific issues coupled with informal educational experiences have the ability to create scientifically literate citizens by enhancing students' understanding of how science works outside of the classroom. Zeidler & Sadler (2009) place emphasis on the quality of educative experiences leading to the quality of life within our society. If the goal of scientific literacy is for students to understand complex scientific issues and make decisions based on their knowledge, then it is imperative that they are exposed to SSI within informal learning environments (Zeidler, 2007). An SSI curriculum incorporates real world, ethically and morally debatable scenarios that are drawn from real world science issues that citizens are faced with daily. The three main characteristics of the SSI movement are their controversial nature, their open-endedness, and the inclusion of moral or ethical reasoning (Zeidler & Sadler, 2008a; Zeidler, Sadler, Simmons & Howes, 2005). Components of this movement allow students to engage in critical thinking and discussion of topics with others who may believe differently. It is a multi-faceted tool necessary in developing critically thinking students, hopefully creating meaningful dialogue and authentic learning. Curriculum imbedded with socioscientific issues promotes argumentation, decision-making and critical thinking, all components of becoming an informed and engaged citizen (Zeidler & Sadler, 2011).

One teacher without substantial SSI background was able to facilitate instruction and encourage the students' participation in both science classrooms. Some student behaviors did disrupt classroom activities and discussions but those students opted not to participate in some group activities and writing exercises and were given reading assignments instead. Students expressed excitement at being allowed to voice opinions and talk in small groups about science issues that they did not know were happening in their local community. The SSI curriculum enabled the students to relate science they were learning in the classroom to issues that were occurring right in their backyard. Because of the young age of the students, the research was provided for the students in the form of articles that the researcher and teacher found that was inline with the literacy skills of the students. Although most students stayed on task while in small group discussions about the environmental issues during the research phase of this study, there were disruptions and student behavior issues. These situations were not isolated to this study, but would have been the same issues experienced when students of this age are instructed to work in a cooperative learning environment and should not be seen as a deterrent to using SSI within the elementary school classroom. Further classroom practice at the elementary school level utilizing SSI should include the explicit discussion and instruction of research skills, literacy and basic argumentation skills to provide a learning environment where the use of SSI as the main component of the science curriculum will be more likely to be successful.

Two of the constructs measured, written argumentation and oral argumentation showed achievement gains. These findings provide insight into the length of time of the SSI treatment and the need for not only a semester long or unit long treatment, but also an extended or perhaps school year long opportunity to utilize SSI. However, the skill set needed for successful argumentation was not explicitly taught and should be emphasized in future research to include the formation of a coherent argument to properly frame their view. Although the students were exposed to multiple perspectives on each issue utilized within the units, the students seemed to have a more difficult time framing their own argument when asked to participate in the written exercises but the treatment group showed great improvement in their ability to offer alternative perspectives and reasons when interviewed about the environmental issues. This finding provides evidence that although students showed gains in oral argumentation during the interviews, the structure and use of subject matter knowledge in written argumentation should be explicitly taught to the students. The SSI curriculum provides an excellent context in which to offer students the opportunity to be exposed to argumentation and critical thinking at a young age and offers the teachers the potential to teach argumentation.

Environmental knowledge and attitude did provide a measure that the SSI treatment was beneficial without any additional instruction. Gains in environmental knowledge were seen in both treatment and comparison over the course of the semester however, statistical significance was found between groups for gains in conservation attitude with the treatment group making the largest gains. Although this was a small sample these findings require further investigation, there is the potential for the development of argumentation and critical thinking skills in fourth grade students through the use of an SSI curriculum.

Recommendations for Further Research

The goal of this study was to design, implement and evaluate a socioscientific issues-based environmentally focused curriculum used to enhance learning and critical thinking of elementary school students during outdoor environmental science experiences. Both qualitative and quantitative data were collected and analyzed with the purpose of investigating this goal.

Limitations

Although there have been some significant findings, the study is not without limitations. One possible limitation is the small sample size, which may have hindered the ability to find more statistical significance between treatment and comparison groups when examining the written argumentation exercises and the developing critical thinking skills gained through the use of the SSI curriculum. A larger sample size, this may provide the opportunity for a researcher to find statistical differences between groups where this study was unable to detect them. A second limitation would be the lack of knowledge students had in the area of debate and argumentation. By providing students with explicit instruction in argumentation structure they will be better prepared to frame and discuss their viewpoints. This is imperative to the formation of scientific literacy and should be utilized at the elementary school level to offer students the opportunity to develop more advanced critical thinking skills at a young age. Also, for this particular study, the instructor that volunteered to participate was an award-winning teacher with a PhD and years of experience, which could have influenced the outcome of the study due to her teaching style.

Conclusions

Past studies have focused on SSI being utilized in a single unit of instruction at the elementary school level (Dolan, Nichols & Zeidler, 2009). This study is one of the few that attempted to utilize a long-term treatment. Three classes were utilized in the study, two receiving two units of SSI instruction over the course of the semester and one class taught in the normal manner by their teacher. The response to the SSI treatment was positive from the teacher and students due to the fact that students were able to work in small groups and express their opinions during classroom discussions and they were able to learn about real world issues that were happening in their community. They also enjoyed the opportunity to be outside and participate in hands-on activities that enhanced their understanding of the science topics being discussed in the classroom.

This study used a mixed methodology in order to determine changes within the groups, between the groups and individual student changes in argumentation, environmental knowledge and attitude. Written surveys and essays were used to gather quantitative data, while interviews provided qualitative data and highlighted changes in individual student conceptions about environmental issues. The study found statistical significance indicating that argumentation, critical thinking and SSI can be implemented and utilized at a young age level.

Argumentation was not explicitly taught during the course of this study and did not show an increase between groups on the written exercises that had been hoped for; however, positive gains were seen in the structure of the argument and the justifications used to support their argument in both treatment and comparison groups.

Environmental knowledge and attitude provided insight into how the content being taught across all fourth grade science classrooms allowed for gains in knowledge scores for both treatment and comparison groups. The context in which the science content was taught to the treatment group provided insight into how explicitly teaching with SSI may improve student's attitude and their desire to take action. This is an important outcome due to the fact that research has shown that students are becoming less involved in environmental issues (Falk, 2009). The goal of environmental literacy is provide students with the knowledge and skills needed to make decisions about important environmental issues that they will be faced with in the future, and to have the ability to take action (Louv, 2007; Aasen, Grindheim & Waters, 2009).

Qualitative analysis provided examples of students who did progress meaningfully regarding each of the constructs under investigation and provided a closer look at how younger students, with the help of SSI, can begin to see issues from alternative view points, enhancing their critical thinking and decision making skills. Future research should include topics that students are somewhat familiar with so they have a baseline of knowledge they can build on or can personally relate to the topic being discussed. Also, by using the same topic for the pre and post interviews, smaller nuances in improvement may possibly be seen.

The use of the SSI curriculum over the course of a semester within fourth grade science classrooms provided evidence that SSI can be used to provide a context for science instruction. By allowing students to think critically about important environmental concerns and discussing solutions to these problems is significant in providing much needed data dealing with elementary school students and their capacity for thinking critically about controversial issues.

This was an exploratory study aiming to examine young students' reasoning and thinking when confronted with ethical and moral issues dealing with environmental and conservation topics. The information gathered during this study provides direction for science educators in developing a SSI curriculum that could incorporate more explicit instruction on argumentation, which would help further enhance the opportunity to improve critical thinking and problem solving skills at this grade level. An area of future research may be to utilize SSI curriculum throughout the fourth and fifth grade classes, providing an opportunity for a longitudinal study involving SSI as the main science curriculum over the two-year period. The projected outcome would provide positive feedback for the use of SSI curriculum within elementary school science classrooms creating and encouraging greater critical thinking skills, argumentation skills and the understanding that science is multi-faceted and far reaching.

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Appendices

Appendix A: Description of SSI units used in study

Unit one: Speed Limit Reduction for Wildlife

Part I of this unit instills an understanding of the concepts of forces of motion, momentum, mass and velocity by allowing students to participate in a hands on activity that incorporates all of these physical science concepts. Students were asked to put on safety equipment, such as pads and helmets for this activity. Each student had the opportunity to ride on a skateboard while seated an approximate distance of 10 meters. The teacher pushed the student while an assistant was waiting at the finish line with a stopwatch to time the students ride, marking down each students time for use later in the module. At the end of the class session, students were asked about friction and how objects slow down, just as they did while riding the skateboard.

Part II of this unit began the next class period and involves a worksheet for students to calculate their velocity and momentum from the time trials they participated in during the skateboarding exercise. This activity aimed to give the students the opportunity to contextualize physical science concepts using a real-world scenario and promote critically thinking about speed limit reductions. The teacher used her mass, momentum and velocity calculations as an example of how different objects may have more or less momentum based on size. The teacher lead a discussion about speed limits and the amount of animals that are injured or killed due to encounters with motor vehicles to introduce students to the ideas of lowering speed limits to protect wildlife.

Part III was conducted the next class period by providing the students with articles in support of speed limit reduction to protect wildlife and another article against lowering the speed limit. The students had half of the class period to read over both articles before being split into groups. The students were placed into groups representing different community factions: Wildlife advocates, truck drivers, business leaders and members of the residential community. Students used the data they collected during their hands-on activity to formulate their arguments for or against the reduction in speed limits.

Part IV of this module was the actual debate simulation, which occurred the next class session. Using this information, they can then determine why or why not the speed limit should be reduced to prevent more wildlife deaths. Their arguments were presented in a way that persuades a governing board. After all arguments had been presented the entire class became the governing board and voted by secret ballot as to whether or not the speed limits should be reduced to cut down on wildlife deaths in their community.

Part V of the module occurred immediately following the debate and during the next class period. This final portion of the unit offerred students the opportunity to reflect on the information presented during a class wide informal discussion about the activity and the outcome of the vote.

Unit two: The Dust Bowl Scenario

The beginning of the unit involved a hands-on activity outside the classroom in the preserve to exemplify land erosion due to weather and poor treatment of the land. Because the preserve was once a vast farmland, students saw first hand how the land has changed due to the treatment of the farmland and because of the weather patterns in Florida. Students had the opportunity to read an article provided by Agriculture in the Classroom, which details erosion from wind and rain that occurred during the Great Depression. After students had the opportunity to read the article about erosion, they engaged in two hands-on activities. A full description of the activities adapted from Agriculture in the Classroom is detailed below.

Activity A – Soil and Water

1. Cut a "V" notch at one end of each flat or box.

2. Get a piece of sod trim vegetation to two inches for easier workability. A piece of sod with weeds will even suffice for this activity. However, the denser the plant-cover, the more effective the activity.

3. Fill the second flat with soil to within one-half inch from the top of the flat. NOTE: For better results, the soil in each sample should be of similar dampness but not wet.

4. Set the flats with the "V" notches at the edge of a table or curb and tilt the unnotched end of each flat to create a sloped surface.

5. Set the jars below the "V" notches at the end of each flat. There must be room enough under the flats for the jars to stand upright.

6. Have the students pour at least one gallon of water from a height of 12" onto each flat simultaneously, if possible, with the watering cans. Pour steadily and at the same rate for each flat.

7. Time how quickly the water runs off each flat. Record the results.

8. Note which jar has the muddier water and which jar has the most water. Record the results.

9. Have students describe the appearance of the plain soil flat after the "heavy rain." Record the results.

10. Repeat the experiment, this time putting mulch over the bare soil. Notice what happens and record the results.

The water that ran off the soil surface carried soil with it. The water that ran off the sod should have been much cleaner. It also should take longer to run off and continue for a longer period of time.

This activity shows the importance of a ground cover or crop cover in protecting soils from erosion by water. If large fields are left uncovered, the topsoil (the most fertile layer) can wash away. Only the less fertile subsoil remains. Also, heavy rains can cut huge gullies in the fields making it impossible to plow. The results can be disastrous in regions where there are heavy rains.

The following activity can be done during the next class period to continue the unit on erosion.

Activity B – Soil and Wind

1. Cut away one side of the large carton, place the white paper on the bottom of the carton, and pour a pile of very dry soil or soap flakes onto the paper.
2. Turn the fan or hairdryer towards the pile and notice how the particles move.
3. Put various obstacles (pencils or rulers) in the soil. Notice what happens.

Students should be able to answer the following questions: When you checked the white paper, did you notice that it was covered with a fine layer of tiny soil particles? Even though you may not see them at first, wind can lift tiny soil particles into the air if soil is left uncovered. When pencils were put into the soil, you should have noticed that the soil blew less and tended to pile in the path of heavy winds. In areas where there are heavy winds, it is very important to protect the soil with tree fences, crop covers, crop residue, strip cropping, or by other special plowing methods.

Following these activities, take the students on a hike through a portion of the preserve so they can observe habitats that have formed due to erosion and weather patterns, specifically focusing on wetlands. Wetlands create habitat for many species of animals and plants native to Florida. Based on the knowledge gained through this activity students will then be asked to apply this knowledge during a discussion pertaining to beach erosion.

Students were given two articles on beach erosion to provide them with background information on what is happening to their local beaches. Students were asked to discuss beach erosion during a class wide conversation to make sure the concept is understood. Students were given an article that describes a possible solution to beach erosion using crushed glass proposed by a scientist in Hawaii. Students were broken into two groups, one in support of using crushed glass and one against the use of crushed glass.

During the next class period students had15 minutes to meet with their group and create a persuasive argument as to why or why not this material should be used as a solution for beach erosion. Students used their critical thinking skills to come to a conclusion about the use of crushed glass to restore our local beaches, providing students the opportunity to see that science is all around us.

Appendix B: CHEAKS (Children's Environmental Attitude and Knowledge Scale)

Frank C. Leeming, William O'Dwyer, and Bruce A. Bracken 1995

Verbal Commitment

1. I would be willing to stop buying some products to save animals' lives.

   (1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

2. I would not be willing to save energy by using less air conditioning.

   (1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

3. To save water, I would be willing to use less water when I bathe.

   (1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

4. I would not give $15 of my own money to help the environment.

   (1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

5. I would be willing to ride the bus to more places in order to reduce air pollution.

   (1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

6. I would not be willing to separate family's trash for recycling.

   (1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

7. I would give $15 of my own money to help protect wild animals.

   (1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

8. To save energy, I would be willing to use dimmer lights.

   (1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

9. To save water, I would be willing to turn off the water while I wash my hands.

   (1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

10. I would go from house to house to pass our environmental information.

    (1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

11. I would be willing to write letters asking people to help reduce pollution.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

12. I would be willing to go from house to house asking people to recycle.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

Actual Commitment

13. I have not written someone about a pollution problem.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

14. I have talked with my parents about how to help with environmental problems.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

15. I turn off the water in the sink while I brush my teeth to conserve water.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

16. To save energy, I turn off lights at home when they are not in use.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

17. I have asked my parents not to buy products made from animal fur.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

18. I have asked my parents to recycle some of the things we use.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

19. I have asked others what I can do to help reduce pollution.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

20. I have often read stories that are mostly about the environment.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

21. I do not let a water faucet run when it is not necessary.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

22. I leave the refrigerator open while I decide what to get out.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

23. I have put up a birdhouse near my house.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

24. I do not separate things at home for recycling.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

Affect

25. I am frightened to think people don't care about the environment.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

26. I get angry about the damage pollution does to the environment.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

27. It makes me happy when people recycle used bottles, cans, and paper.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

28. I get angry when I think about companies testing products on animals.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

29. It makes me happy to see people trying to save energy.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

30. I am not worried about running out of water.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

31. I do not worry about environmental problems.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

32. I am not frightened about the effects of pollution on my family.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

33. I get upset when I think of the things people throw away that could be recycled.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

34. It makes me sad to see houses being built where animals used to live.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

35. It frightens me to think how much energy is wasted.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

36. It upsets me when I see people use too much water.

(1) very true (2) mostly true (3) not sure (4) mostly false (5) very false

Knowledge

37. Most elephants are killed every year to provide people with

(1) trophies. (2) ivory. (3) oil. (4) skin.

38. Burning coal for energy is a problem because it:

(1) releases carbon dioxide and other pollutants into the air. (2) decreases needed acid rain. (3) reduces the amount of ozone in the stratosphere. (4) is too expensive. (5) pollutes the water in aquifers.

39. Ecology assumes that man is what part of nature?

(1) special (2) related to all other parts (3) not important (4) the best part (5) the first part

40. Phosphates are harmful in seawater because they:

(1) cause cancer in fish. (2) stop reproduction in fish. (3) make fish nervous. (4) make the water cloudy. (5) suffocate fish by increasing algae.

41. Compared to other paper, recycled paper:

(1) takes more water to make. (2) takes less energy to make. (3) is less expensive to

buy. (4) is harder to write on. (5) produces more pollution.

42. The most pollution of our water sources is caused by:

    (1) dams on rivers. (2) chemical runoff from farms. (3) methane gas.

    (4) leaks in the sewers. (5) human and animal wastes.

43. Ecology is the study of the relationship between:

    (1) different species of animals. (2) plants and the atmosphere. (3) organisms and their environments. (4) man and other animals. (5) man and the environment.

44. The most common poisons found in water are:

    (1) arsenic, silver nitrates. (2) hydrocarbons. (3) carbon monoxide. (4) sulfur, calcium. (5) nitrates, phosphates.

45. Where does most of the garbage go after it is dumped from the garbage trucks?

    (1) to an aquifer where it is buried (2) it is dumped into the ocean (3) it is recycled to make plastic (4) to a landfill where it is buried (5) to farmers to use for fertilizers

46. Which is most responsible for creating acid rain?

    (1) sulfur dioxide (2) carbon dioxide (3) ozone (4) nitrogen (5) ultraviolet radiation

47. Catching tuna in the ocean:

    (1) is eliminating a main food source for whales. (2) protects baby sea turtles.

    (3) also kills many dolphins. (4) is now against the law. (5) is necessary to keep the population size down.

48. Which is an example of a perpetual energy source?

    (1) nuclear (2) oil (3) wood (4) uranium (5) solar

49. Which of the following is the most dangerous to the earth's environment?

    (1) damming rivers (2) overpopulation (3) tornadoes (4) household pets

(5) nuclear power plants

50. Most of the lead in our air is caused by:

(1) cars (2) industrial plants (3) airplanes (4) burning refuse (5) cigarettes

51. Precycling means that:

(1) people buy things that can be used again. (2) more people should ride bicycles. (3) small children should wear the clothes of their older brothers or sisters. (4) items should be tested before we buy them. (5) environmental changes are always taking place.

52. Animals alive today are most likely to become extinct because:

(1) natural selection kills weaker animals. (2) where they live is getting too warm. (3) they are unable to reproduce because of pollution. (4) the habitat where they live is destroyed. (5) their food supply is destroyed by acid rain.

53. Coal and petroleum are examples of:

(1) fossil fuels. (2) renewable sources of energy. (3) energy sources that are plentiful. (4) alternative sources of energy. (5) recycled resources.

54. Environmental problems are a threat to:

(1) mostly people in small countries. (2) only people who live in cities. (3) only wild animals and endangered species. (4) mostly tropical plants and animals. (5) all living things in the world.

55. Which of the following does not do much to reduce the pollution by automobiles?

(1) properly tuned engine (2) high octane gas (3) low lead gas (4) smog control devices (5) propane engines

56. The main problem with landfills is that they:

(1) take up too much space. (2) are ugly to look at and smell bad. (3) attract rats and others pests. (4) prevent farming of nearby land. (5) do not produce enough methane.

57. Building a dam on a river can be harmful because it:

(1) makes the river muddy. (2) can no longer be used to make electricity. (3) increases level of pollution on the water. (4) causes the river to flood. (5) damages the river's natural ecosystem.

58. Where is water under the ground found?

(1) in landfills (2) in ponds (3) in low pressure areas (4) in aquifers (5) in rivers

59. Killing animals like wolves that eat others:

(1) is necessary and should be done. (2) may increase the number of other animals. (3) does not affect other animals in the area. (4) may decrease the number of other animals. (5) will help protect the environment.

60. A good example of a nonrenewable resource is:

(1) petroleum. (2) trees. (3) ocean water. (4) sunlight. (5) animals raised for food.

61. Most air pollution in our big cities comes from:

(1) cars. (2) jet planes. (3) factories. (4) big trucks. (5) landfills.

62. An item which cannot be recycled and used again is:

(1) disposable diapers. (2) newspapers. (3) aluminum cans. (4) motor oil. (5) plastic bottles.

63. What is the main problem with the use of aquifers for a water supply?

(1) they recharge too quickly (2) they are becoming used up (3) they contain too much fresh water (4) they contain too much salt water (5) it is hard to get the water

out

64. A species that no longer exists is:

    (1) protected. (2) endangered. (3) abundant. (4) extinct (5) wild game.

65. Which uses the most energy in an average house in the United States?

    (1) lights (2) TV (3) hot water heater (4) telephone (5) refrigerator

66. Which of the following groups is most interested in environmental issues?

    (1) Boy Scouts of America (2) The Sierra Club (3) Kiwanis (4) 4-H Club

    (5) American Cancer Society

Appendix C: Persuasive Essay Assignment (pretest)

Please take a few minutes to read the following story

Are we turning into plastic?

Signs of plastic pollution are all over the globe and it is slowly making its way into our food chain. Recent studies have shown that the most evidence of plastic pollution consumption can be found in dead seabirds that have washed ashore containing bottle caps, cigarette lighters and colored scraps that resemble baitfish. One animal dissected by Dutch researchers contained 1,603 pieces of plastic. More than a million seabirds, 100,000 marine mammals and countless fish die in North American waters by mistakenly eating plastic pollution.

Plastic is a petroleum-based mix of monomers that become polymers and additional chemical additives are used to make the plastic more consumer friendly. Plastic is used to bottle water, wrap food and to construct certain toys. Chemicals found in plastics have been shown to be harmful to humans and have been known to influence human health, causing serious illness.

Recycling plastic is a complicated process and research has shown that only 3-5 percent of plastics are recycled even if you separate your garbage into recyclables and non-recyclables. There is no scientific evidence to show how long it takes for plastic to biodegrade and some researchers believe that plastic never really goes away and will be in landfills for millions of years to come. Glass, however, is easily recyclable and can be melted down and re-used to create something else.

Twenty-three countries, including Germany, South Africa and Australia have banned taxed or restricted the use of plastic bags, just like the ones used at grocery stores, because they clog sewers and cause harm to wildlife. However, the American Plastics Council claims that it is not plastic that is causing the problem. They claim that plastics don't pollute, people do.

Name: ___________________________________

Please write an in-class essay to the following scenarios. Be sure to explain your position(s) clearly and tell WHY you believe the way you do.

Do you believe that plastics should be banned in your community? Please explain why you believe the way you do.

Appendix D: Persuasive Essay Assignment (posttest)

Harp Seal Hunt

The annual seal hunt has been ongoing for centuries, despite anti-sealing campaigns by animal rights groups and a possible ban on seal products by the European Union. The United States, Netherlands and Belgium have already instituted bans on Canadian seal products and if the European Union decides a similar outcome, there will be 27 members within the union closing its doors to the market.

According the Department of Fisheries and Oceans, the current population of harp seals in Canada is an estimated 5.5 million, triple what it was in the early 1970s. For 2009, the total allowable catch for harp seals is 280,000, 50,000 for grey seals and 8,200 for hooded seals, bringing it to a total of 338,200.

The federal department also indicates the annual hunt has socio-economic benefits to more than 6,000 sealers in rural communities across Atlantic Canada, Quebec and the North. Sealing can provide as much as 35 per cent of a sealer's annual income, which is approximately $25,000.

Archeological evidence indicates that the Native Americans and First Nations People in Canada have been hunting seals for at least 4,000 years. Traditionally, when an Inuit boy killed his first seal or caribou, a feast was held. The meat was an important source of fat, protein, vitamin A, vitamin B_{12} and iron, and the pelts were prized for their warmth. In recent years, the Inuit seal hunting accounts for only three percent of the total hunt. Seal has been the main staple food, and has been used for clothing, boots, fuel for lamps and furnished harnesses for huskies.

The ban on seal hunting being considered by the Canadian government will influence not only the economic strength of the local Canadian communities, it also influences the health of the Inuit peoples because they rely so heavily on seal to survive. However, animal rights groups claim that the killing of seals is inhumane and cruel and should be banned across Canada.

Name: ______________________________

Should the seal hunt be banned in Canada? Please explain why.

Appendix E: Rubric for analysis of written argumentation

Criterion	Score PRE	Score POST	Description
Justifications (Zohar and Nemet, 2002)	**2**	**2**	Two or more valid justifications
	1	**1**	One valid justification
	0	**0**	No justifications offered
Structure (Zohar and Nemet, 2002)	**2**	**2**	A complex structure with justification supported by another reason.
	1	**1**	A simple structure consisting of a conclusion supported by at least one reason
	0	**0**	No valid justification
Subject Matter Knowledge (Walker and Zeidler, 2007)	**3**	**3**	Correct consideration of specific evidence claims or SMK.
	2	**2**	Consideration of non-specific evidence claims or SMK.
	1	**1**	Incorrect consideration of evidence claims or SMK.
	0	**0**	No evidence claims or subject matter knowledge (SMK) are considered.

TEST	**J**	**S**	**SMK**	
PRE	_____	_____	_____	
	POST	_____	_____	_____

Appendix F: Argumentation Interview

Please take a few minutes to read the following story

Signs of plastic pollution are all over the globe and it is slowly making its way into our food chain. Recent studies have shown that the most evidence of plastic pollution consumption can be found in dead seabirds that have washed ashore containing bottle caps, cigarette lighters and colored scraps that resemble baitfish. One animal dissected by Dutch researchers contained 1,603 pieces of plastic. More than a million seabirds, 100,000 marine mammals and countless fish die in North American waters by mistakenly eating plastic pollution.

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Recycling plastic is a complicated process and research has shown that only 3-5 percent of plastics are recycled even if you separate your garbage into recyclables and non-recyclables. There is no scientific evidence to show how long it takes for plastic to biodegrade and some researchers believe that plastic never really goes away and will be in landfills for millions of years to come. Glass, however, is easily recyclable and can be melted down and re-used to create something else.

Twenty-three countries, including Germany, South Africa and Australia have banned taxed or restricted the use of plastic bags, just like the ones used at grocery stores, because they clog sewers and cause harm to wildlife. However, the American Plastics Council claims that it is not plastic that is causing the problem. They claim that plastics don't pollute, people do.

Interview questions

1. What is the problem under consideration?

2. Do you think plastics should be banned? Offer reasons for your position?

3. Your friend disagrees with you. Define his or her position. Offer reasons for that position (what will your friend say to convince you that s/he is right)?

4. How would you answer your friend? Explain

Appendix F: Continued

Please take a few minutes to read the following story

Harp Seal Hunt

The annual seal hunt has been ongoing for centuries, despite anti-sealing campaigns by animal rights groups and a possible ban on seal products by the European Union. The United States, Netherlands and Belgium have already instituted bans on Canadian seal products and if the European Union decides a similar outcome, there will be 27 members within the union closing its doors to the market.

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Archeological evidence indicates that the Native Americans and First Nations People in Canada have been hunting seals for at least 4,000 years. Traditionally, when an Inuit boy killed his first seal or caribou, a feast was held. The meat was an important source of fat, protein, vitamin A, vitamin B_{12} and iron, and the pelts were prized for their warmth. In recent years, the Inuit seal hunting accounts for only three percent of the total hunt. Seal has been the main staple food, and has been used for clothing, boots, fuel for lamps and furnished harnesses for huskies.

The ban on seal hunting being considered by the Canadian government will influence not only the economic strength of the local Canadian communities, it also influences the health of the Inuit peoples because they rely so heavily on seal to survive. However, animal rights groups claim that the killing of seals is inhumane and cruel and should be banned across Canada.

Interview questions

1. What is the problem under consideration?

2. Do you think the seal hunt should be banned? Offer reasons for your position!

3. Your friend disagrees with you. Define his/her position. Offer reasons for that position (what will your friend say to convince you that s/he is right?)

4. What will you answer your friend? Explain

Appendix G: Data Collection Protocol

CHEAKS Pre-Test and Post-test Administration: The pre-test survey measuring environmental attitude and knowledge was administered the first day of class in the fall semester for each of the 3 groups involved in this study. The teacher read the instructions to the students and administered the survey; the researcher was on hand to answer any questions or clarify any language students didn't understand. The post-test survey measuring environmental attitude and knowledge was administered a month before students left for the summer. The survey was administered in the same manner with the teacher reading the instructions and the researcher being on hand to answer any questions or clarify any language students didn't understand.

Persuasive Essay Pre-Test and Post-Test: The persuasive essay assignment, measuring structure, justification and subject matter knowledge was administered the first day of class in the fall semester for each of the 3 groups involved in this study. The teacher read the instructions to the students and administered the assignment. The researcher was on hand to answer any questions or clarify any language students didn't understand. The post-test persuasive essay assignment measuring structure, justification and subject matter knowledge was administered a month before students left for summer break. The essay assignment was administered in the same manner with the teacher reading the instructions and the researcher being on hand to answer any questions or clarify any language students didn't understand.

Interview Pre-Test and Post-Test: The interviews were solely conducted by the researcher, and took place in the same location for each student randomly selected to be interviewed. Interviews took place outside, at a picnic table located on school property but just outside the classroom under a large shady tree. Students were given a few minutes to read the scenario (the same scenario from the persuasive essays) and then were asked by the researcher if they need anything clarified. The researcher then asked the student:

1. What is the problem under consideration?
2. Do you think (plastics/seal hunting) should be banned?
3. Offer reasons for your position.
4. Your friend disagrees with you. Define his or her position and offer reasons for that position (what will your friend say to convince you that s/he is right?)
5. How would you answer your friend? Explain

Each interview took approximately 10 minutes and 3 students from each of the groups were interviewed. Interviews took place during the first and second week of the semester before the administration of the curriculum for the pre-test survey. Post-test interviews took place during the last month of the school year.

Appendix H: Field Notes

Unstructured Teacher Debriefing Interview

The instructor believed that the erosion activities went well and that the students were engaged in the activity because they were raising their hands and asking excellent questions dealing with the experiment. An abundance of students offered to volunteer to help with the activity and seemed to genuinely understand how this activity related to the schoolyard and how it was designed and even connected it back to the field trip to Brooker Creek Preserve earlier in the year. The instructor made a suggestion to move the locale where the activity took place for the second group because although students were paying attention, the bright sun was in their eyes and she observed that some of them looked a little uncomfortable and warm. She explained that if the students are uncomfortable they won't pay attention and she wants their full attention. The activities were moved to a grassy area behind the school building that provided shade.

The instructor explained that the speed limit activity was very engaging for the students but it was unfortunate that because of rainy weather it was moved to different days and both groups did not participate in the activity on the same days, which she had planned for. The students were excited to get outside and learn in a different environment. A few students shared stories with the group about seeing animals on the side of the road that had been hit by cars and how it happens certain times of the year. One of the students brought up the fact that the entrance road to Brooker Creek Preserve is a very long road with a very slow speed limit because it is an animal crossing and it would be a great idea to have slow areas on the road around the school and neighborhoods because of the animals trying to cross the road. The instructor started a discussion by posing a question about all of us living in this area and if we built our houses where the animals live? The students agreed that the population in the area could be forcing the animals to try to find new homes and that is why they try to cross streets and that there is a lot of traffic and maybe food is hard to find. The students were engaged during this activity and the instructor also added some thinking exercises by posing the question about living in the animal's habitat. There was only one area that this activity could be done on the school property, which was uncovered. Due to inclement weather, the activity had to be pushed off but there wasn't anything that could be done about that issue. The instructor liked both projects and plans on possibly using them in her future classes to get the students involved in different types of learning and critical thinking.

Classroom Observation During Debate Scenarios

The instructor explained to the class how to conduct themselves during the debates about the beach erosion and speed limit reduction. She impressed upon the students that they were to be respectful of ideas presented throughout the discussion and that they were only allowed to speak when the other person was completely done expressing their ideas about the topic. The instructor numbered off the students so there were two groups; a pro and a con team. Those teams gathered together and read over materials provided by the instructor about the topics being debated. The groups had to argue the issue from either the pro or con side, depending on what their group was assigned. They had to come up with ideas to sway the opinion of all the members of the class and at the end of the debate a vote was taken to see which side was more persuasive. The instructor had the students sit in straight lines facing one another and told students that they were to present one of their ideas and then let the other team present an idea and then they could open the discussion up to other group members to rebut the statements. Students were to raise their hand when they had something to say and would be called upon in the order in which they raised their hand. The beach erosion debate was the most intense because a majority of the students did not believe that glass should be used as an environmentally friendly way to stop beach erosion. After the beach erosion debate, all of the students were willing to use glass to help stop the beach erosion because the team that was in favor of using this material did a great job with the facts and explaining to the rest of the class how it was an environmentally friendly alternative. The speed reduction debate was less intense because a majority of the students already believed that the speed limit should be reduced for the safety of the animals and after the debate, the students believed the same and took the same stance on the topic.