

THE USE OF TECHNOLOGY TO ENHANCE ENVIRONMENTAL LITERACY

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CHAPTER ONE

INTRODUCTION

The Beginning of a Passion

Nature has always been a central focus of my life, constantly at the heart of my time and thoughts. In *A Sand County Almanac* Aldo Leopold wrote, “There are some who can live without wild things, and some who cannot.” (p. xvii) I am one who cannot. When I stop to think about why the outdoors has been so important in my life, I always recall my childhood and the adventures that are embedded in my memory. I grew up on a 15 acre hobby farm in central Iowa that bordered the Raccoon River Valley and most of my time was spent exploring the river and the woods and grasslands that separated the river from my house. It is this relaxing and innocent time, spent in my youth that laid the foundation for my professional passion in life.

My neighbor Myron and I would usually follow paths from our houses through the woods and down to a meadow where we would meet to plan out the afternoon’s escapade. Early on, our favorite pastimes were seeing who could climb the highest in a newly discovered oak tree, or trying to get a glimpse of the animal whose tracks we came across in the mud of the river bank. We didn’t realize it at the time, but we were learning through inquiry. The invertebrates (caddisflies, dragonfly nymphs, backswimmers) that we found in the stream intrigued us and motivated us to learn their names. We wondered what they were for, so we also learned about the animals that depended on them for food. It was our first lesson in ecology, and we didn’t even know what ecology meant.

As we got older our after school treks became longer and longer and our observations became more detailed. We were able to identify bird calls and name the

animals that made the tracks we were following. We started to use the observations we had made to our advantage when we went hunting and fishing. For example, we knew the types of trees squirrels liked to make nests in, and which trees they would go to for food. When we went squirrel hunting, all we had to do was find a comfortable spot that was between the oak trees that squirrels used for food and the maples that they used for shelter and wait for them. More times than not, though, we would be so interested in watching the squirrels and rabbits that we would forget about shooting. I especially loved to watch the squirrels chase each other. They were so playful and free, as they flew up and down the tree trunks and branches. We also started to study the type of invertebrates fish preferred as food and the temperature when the fish were most active. We planned to use this information to help us be more successful when we went fishing, but instead usually spent more time continuing to identify insects and sample water than catching fish.

When I was old enough to carry my gear and spend the night away from our yard alone, I started extending my treks from hours to days. I would pitch a tent on a corner of our rural land, and stay out enjoying nature as long as I pleased. I preferred to watch stars rather than television, and chose to listen to the sounds of birds and crickets instead of the radio. Even at a young age, I felt at peace in the solitude of my rambles. These trips not only allowed me to learn about nature, but in the process I taught myself how to plan for a trip and cook for myself. I also learned how to sew so that I could repair my gear and even make some of my own, as it was very important to me to fit well into my surroundings and try to mimic the efficiency of nature. All of these skills prepared me to later find jobs that allowed me to share my passions for nature with others.

I started to take classes in school that helped me make connections between the plants, animals, and landscapes that I enjoyed at home every day. Biology, plant science, and environmental studies were my favorite high school classes, and I looked forward to sharing new observations with the teacher and my classmates. It amazed me that the things I enjoyed in my free time turned out to be serious classes in school. This motivated me to learn as nothing had before.

My love for the outdoors matured when I graduated from high school and went to college at Iowa State University in Ames, Iowa and had to choose a major. I chose Animal Ecology as my area of study because the description in the Iowa State information packet looked exactly like living my lifetime favorite hobbies. It became real to me that I could actually study and make a career doing the things I loved most. I initially hoped to graduate and then try to find a job that would allow me to be outside most of the time observing plants and animals, such as being a park ranger. During college, my extracurricular activities helped to round out my training in environmental issues and outdoor activities. I was able to get a job at the Iowa State Outdoor Recreation Center, and was paid to take fellow novice students on camping, hiking, canoeing, caving and rock climbing trips. I participated in Project Eco, which provided experiential learning to elementary school children, where I helped conduct the environmental education lessons. I also completed an internship at an environmental awareness group that focused on door to door education of the public on water quality issues. Each of these things helped build my experience in environmental science, and continually honed my dreams and perspective.

At the end of my college journey, I found that sharing my passion for the outdoors was so enjoyable that I decided to become a teacher. I wanted to spend most of my life sharing my enthusiasm for the environment with students and hopefully play a role in encouraging more and more people to enjoy the outdoors more and television less.

My experiences and education led me to be very concerned for the state of the environment, and I believe that helping students experience nature is the best way to protect our resources. Students need to feel the impact of the environment personally in order to care about it, and they need to care about it to want to learn about nature and how to preserve it. This became my mission upon graduation from college, as a teacher of biology and environmental science.

In the last eight years of teaching some of my passion has been replaced with cynicism and some of my enthusiasm has been replaced by the practicality that comes with the demands of a traditional education system. Much of my time is spent trying to find ways to pique student interest and hold their attention. I am also sure many teachers who decided to teach for the same reasons I did have also found that too much of our time is spent on menial tasks. These menial tasks take time and energy away from motivating and educating students. This has then become the basis for my current challenge, and the focus of this project. The following scenario is an example of how dedicated teachers still try their best to motivate students as much as possible, and is the starting point of my project.

The Perfect Lesson

It is 8:30 in the morning and you have been up most of the night preparing a lesson on the biomes of Minnesota. You have included maps, history, questions, and

short activities that you are sure will pique the students' interest and hold their attention for the entire hour. Your notes that you worked on for hours are on transparencies to be used on the overhead. You have included popular state parks and pieces of history from the school's area so that students will be able to see how the landscape has changed over time.

Now it's show time. You start out the lesson by asking questions that will help students recall some of their prior knowledge and hopefully grab their attention for the start of the lesson. The students are now ready to start copying your notes from the overhead and learn about Minnesota's biomes. You are on a roll. You are on your second page of notes and students are participating in discussions and seem to be taking all of the notes.

Now you are on the third page and the number of students participating in the discussion seems to be dropping off. You look around the room and heads are starting to drop here and there. You start the fourth page of notes and now no one is answering your questions without being called on first. The eyes of the students have that glazed over look that tells you that you have lost them. It has only been 20 minutes.

The Dilemma

What happened? It started off so well and the students were involved. The notes were pertinent to their lives and their current location. How did you lose them? Anyone who has taught for even a short period of time has had this happen to them. I know it has happened to me more times than I would like to admit. This scenario raises some very interesting and important questions: What do we have to do to hold students interest? What can we do to make students active participants in the education process?

According to The Sourcebook for Teaching Science website (2001), the A.C. Nielsen Company reports that the average American watches more than 28 hours of television per week. With students watching this much television, playing countless video games, and surfing the internet, they are losing the ability to stay focused for an extended period of time. If our job as teachers is to educate students and teach them how to become lifelong learners, we must change how we are approaching our task. We need to find the activities that increase student attention spans and make them interested in the material that we are presenting, as well as meet the educational needs of all the different learners in our classes. As the student population changes, educators must keep up with the methods that allow all students a chance to reach understanding.

The decrease in student attention spans is a problem that all educators face. Another problem facing environmental educators is the gap between what citizens think they know about the environment and what they actually know about environmental issues. It is important for environmental educators to not only keep the attention of their students but to also help change some common student misconceptions about the environment. This is particularly difficult in a subject where facts and data change each

minute, and effective education demands accuracy with extremely current information. Students today are exposed to many types of media that have been developed to catch their attention and they are used to having access to the most current information available. It would be senseless for environmental educators to expect students to be interested by monotone overheads and information that is outdated. Educators quickly lose credibility if the information that they present to students is obsolete.

The Need for Environmental Education

Minnesotans are concerned about the environment and are more informed about environmental issues than citizens in many other states in the country. According to *The Minnesota Report Card on Environmental Literacy* (Murphy 2004) Minnesota adults' scores on general environmental knowledge questions were either equal to or greater than scores of the average adult in the United States. Even though Minnesota adults scored higher than adults in other states, the *Report Card* (Murphy 2002) concedes that 46% of adults in Minnesota have below average knowledge about the environment. This means our state is ahead of the country, but we still have work to accomplish.

Most Minnesotans also agree that we should educate our students about the environment. Ninety percent of the adults surveyed for the *Environmental Report Card* responded that our schools should provide environmental education. There are numerous environmental issues that informed citizens need to be aware of in Minnesota. The destruction of wetlands, pollution caused by burning fossil fuels in automobiles and power plants, climate change, and invasion of exotic species are just a few of the many local and global threats to Minnesota's natural resources. In a state known for its outdoor recreation and enjoyment, such as its ten thousand lakes reputation, Boundary Waters

Canoe Area, and heavy interest in fishing and hunting, the segue into the importance of environmental issues should be instinctive.

It is clear that the citizens of Minnesota want the schools to provide environmental education, and there are many issues that people need to be educated about to help solve them. The question then becomes what do we teach our students and how do we teach them so that they understand and respond to these environmental issues. The Minnesota Office of Environmental Assistance has created the *Environmental Literacy Scope and Sequence* (Landers, Naylon, and Drewes 2002) which provides concepts and their applications to natural and social systems as well as benchmarks for each grade level. This project was a collaborative effort of Pam Landers, Mike Naylon, and Annette Drewes along with contributions from many other experts from all environmental education fields. *The Environmental Literacy Scope and Sequence* provides the framework for what should be taught. This project will address how some of these concepts should be taught, to maximize the response of the students.

Project Mission

The hurdle that this project will explore is students' decreased and altered attention spans, and how environmental educators can use the technologic tools currently available to hold the learners' attention for longer periods of time than traditional teaching methods. The project will also demonstrate that this use of current technology is essential to provide current, accurate information in environmental education. It will show that it is critical that educators use the technology available to them to create interactive multimedia presentations that the students find interesting, using the most up-to-date information available.

This project will study the effect technology has on the environmental literacy of a group of juniors and seniors in an environmental studies course. Students will complete a unit on water that contains traditional methods of teaching and then they will complete a unit on air that includes the use of technology. Students will then take a test to assess their environmental literacy in the areas of air and water. Before conducting the classroom study a literature review will study the problem that attention span has on learning and how technology in the curriculum can help overcome this problem. The literature review will also define environmental literacy and describe its importance.

CHAPTER TWO

LITERATURE REVIEW

The goal of this research was to study the effect of technology on the environmental literacy of high school students. According to *Webster's Universal Encyclopedic Dictionary* (2002), technology means "a manner of accomplishing a task especially using technical process, methods, or knowledge". (p. 1896) The use of the term technology for this study relies on this definition. The teacher and student in this study used technology when they accomplished tasks they would normally accomplish using less technical processes. Examples of this include presenting notes using PowerPoint presentations instead of the whiteboard or overhead projector, using the internet to research topics instead of using books, and using computer programs to create brochures instead of using writing utensil. The most common uses of technology in this study were the use of word processing programs, PowerPoint, the internet, DVD players, and a video projector.

Before looking at the effect technology has on environmental literacy, it was important to first define environmental literacy and describe its importance. Only after this is defined is it possible to understand the obstacles to environmental literacy that currently exist, and how technology will help overcome these obstacles. Sources from international organizations, environmentalists, researchers, and educators were used to develop a working definition of environmental literacy. The definition formed from these sources was considered as assessments and activities were created for the study group.

Environmental Literacy

Today there are a number of environmental issues that affect our planet. These issues affect every person on some level. Many issues consistently appear in the media and are regularly debated in the public forum all around the world. Global climate change, water pollution, air pollution, population changes, habitat loss and specie extinction are only a few examples of the current issues. It is important that citizens are informed about these issues so that they can actively understand the environmental context and impact of their own actions (and thus be able to alter these actions if and when appropriate). I feel that it is also important for students to understand that citizens can influence public policy effectively through informed input.

Environmental education started out of the conservation movement which was concerned with saving America's diminishing natural resources in the 1920s and 1930s. One of the first people to discuss the concept of environmental literacy was Aldo Leopold. Leopold (1949) was one of the first people in the United States to look at conservation from a scientific standpoint, and is well known for his many lectures and writings on conservation. Leopold addressed the issue of public knowledge of the environment in his essay, *The Land Ethic*. He used the term "conservation education" to describe what many educators would view as environmental education today. Leopold not only raised the increasing need for environmental education, but he urged for a change in the content. Leopold discussed the state of conservation education by writing:

Conservation is a state of harmony between men and land. Despite nearly a century of propaganda, conservation still proceeds at a snail's pace; progress still consists largely of letterhead pieties and convention oratory. On the back forty we still slip two steps backward for each forward stride.

The usual answer to this dilemma is ‘more conservation education.’ No one will debate this, but is it certain that only the *volume* of education needs stepping up? Is something lacking in the content as well? (p. 243)

Leopold did not use the exact phrase “environmental literacy”, but his implication of this concept, its importance, and its shortcomings, is evident. Leopold went on to describe how the current conservation education consisted only of teaching actions that were easy to implement and that required no sacrifice, such as the government only setting aside land for protection that was undesirable to people for other uses. Leopold’s many writings have also helped to shape and improve the content that is included in today’s environmental education. His influence helped move current environmental education to view natural and social systems as interdependent.

Today there are many components by which to define environmental education and literacy. Three prominent definitions are listed below along with the Minnesota State Legislature’s definition of environmental education.

A document from the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Tbilisi Intergovernmental Conference in 1978 described environmental education as:

Environmental education is a life-long, multidisciplinary approach to teaching, mass communication, community participation or some other activity aimed at the development of a world population that is aware of, and concerned about, the environment, and its associated problems that has the knowledge, skills, attitudes,

motivations, and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones. (p. 12)

Hines, Hungerford, and Tomera described environmental education in their *Analysis and Synthesis of Research and Responsible Environmental Behavior* in 1986/87:

Environmental literacy includes these variables (a) knowledge of ecological concepts, (b) environmental awareness, (c) knowledge and skill in the use of environmental action strategies, and (d) evaluation of environmental issues and responsible citizenship behavior. (p. 1-8)

Lo, Affolter, and Reeves define environmental in the following way in their *Building Environmental Literacy through Participation in GIS and Multimedia Assisted Field Research* in 2002:

Environmental literacy is defined as the ability to comprehend and critically evaluate (1) basic scientific principles that govern natural systems, (2) linkages among living organisms and the physical environment, and (3) consequences of human activities on natural systems. Ultimately, the goal of environmental literacy is to promote the attitudes that support a lifelong commitment to protecting and enhancing the environment on local and global levels. (p. 10)

The state of Minnesota includes the following goals for environmental literacy in Statute §115A.073 (1998): Pupils and citizens should be able to apply informed decision-making processes to maintain a sustainable lifestyle. In order to do so, citizens should: 1)

understand ecological systems; 2) understand the cause and effect relationship between human attitudes and behavior and the environment; 3) be able to evaluate alternative responses to environmental issues before deciding on alternative course of action; and 4) understand the effects of multiple uses of the environment.

Each one of these definitions of environmental literacy includes knowledge, attitude, and action. In my mind, the goal of environmental education is to not only pass on information but to develop attitudes of appreciation for our natural resources as well as a commitment to taking actions to help protect and preserve natural resources. True environmental literacy is a result of effective environmental education, encompassing the personal application of knowledge by the educated individuals.

The Importance of Environmental Literacy

I believe that environmental literacy is important because the natural resources of the world are facing more pressure than ever before. As the human population grows, countries develop the demand for consumer goods and the need for energy increases. The earth has a finite amount of natural resources to support all of the organisms that live on it. These resources include the air, water, and nutrients that all organisms depend on for survival. These resources make up the natural capital of the planet. Many of these resources recycle through the ecosystem and can be utilized by numerous generations. When these resources are polluted or destroyed the natural capital of the planet is reduced, resulting in permanent planet alteration. In many cases, alternatives must then be found if minimal change to the planet's status quo is desired.

Understanding the relationship between social and natural systems is crucial. Every citizen needs to understand the impact his or her decisions and actions have on the

environment in order to be able to change attitudes and behaviors to move towards a sustainable lifestyle. The main need for environmental literacy is to provide an understanding of the connection between human consumption and the environment, from a global to a personal level.

The connection between human consumption and the environment is a very complex relationship that could never fully be explained or understood. This relationship can, however, be explained well enough to demonstrate the need for change in human consumption by looking at carrying capacity and ecological footprints. These two concepts help outline the need to develop sustainable lifestyles.

Carrying capacity is the number of organisms that can be supported by the natural capital of an area. If the number of organisms in an area is under the carrying capacity and not using the natural capital faster than it can be regenerated, the population is referred to as sustainable. A sustainable population can survive in an area for a long period of time without diminishing the natural capital of that area.

When the population in an area is larger than the carrying capacity then it starts to diminish the natural capital of the area and eventually the population will crash. In the case of humans it is hard to determine carrying capacity because different populations of people use resources differently. Humans can also import and export resources from one area to another. This means that we must look at the global carrying capacity of the earth and then look at how humans in different areas use resources. Humans in developed countries use many more natural resources than people in developing or undeveloped countries.

One way to measure the impact of humans on the environment and how they use natural resources is the concept of an “ecological footprint”. Dr. William Rees coined the term “ecological footprint” and he and Mathis Wackernagel (1996) explain its definition in the following excerpt from their book *Our Ecological Footprint*:

The Ecological Footprint concept is simple, yet potentially comprehensive: it accounts for the flows of energy and matter to and from any defined economy and converts these into the corresponding land/water area required from nature to support these flows. This technique is both analytical and educational. (p. 3)

The concept of an Ecological Footprint can be calculated for an economy and then broken down into a per person calculation. The measurement is calculated in hectares and measure how many hectares of land/water each person needs to sustain their lifestyle. There is a problem when an economy requires more land/water than it has available. The economy must then use natural resources from another economy to maintain its status quo.

The basic processes measured by the ecological footprint are the consumption of energy in the form of food and the output of waste as carbon dioxide. This is a very simplified explanation of the ecological footprint, yet it covers the effects every human has on the environment. This simplified calculation becomes difficult when humans not only add carbon dioxide to the environment through respiration but also by combustion of fossil fuels. At the same time the earth’s natural ability to convert carbon dioxide into biomass and oxygen is hindered by deforestation and desertification. Wackernagel and Rees (1996) describe these problems in the same text. They list the following problems:

The list of threats to the life-support system in which we are embedded is overwhelming: deserts are encroaching on ecologically productive areas at the rate of 6 million hectares per year; deforestation claims over seventeen million hectares per year; soil oxidation and erosion exceeds soil formation by twenty six billion tones per year; fisheries are collapsing; the draw-down and pollution of ground water accelerates in many places of the world; as many as seventeen thousand species disappear every year; despite corrective action, stratospheric ozone continues to erode; industrial society has increased atmospheric carbon dioxide by twenty eight percent. (p. 31)

This list is a small sample of the reasons that citizens today must be environmentally literate. It is clear that the environment faces many challenges and it is important that society needs to make changes toward a sustainable future. Not only do citizens need to be environmentally literate to deal with all of these issues, citizens want environmental literacy taught in public schools. According to *The Minnesota Report Card on Environmental Literacy* (2002) ninety percent of Minnesotans want schools to provide environmental education. Environmental education is the first step toward a sustainable future. To ensure that future generations are environmentally literate, environmental educators must take advantage of the most effective methods of educating and motivating students. This project will show that one of these methods is the use of technology to help maintain students' attention in environmental courses.

The Educational Problem

Sixty years ago less than ten percent of households owned a television, according to the Television Bureau of Advertising (2001). According to the same source over ninety eight percent of households have at least one television today. By the time students reach the age of eighteen they will have watched over 25,000 hours of television (American Academy of Pediatrics) which is more time than they have spent doing any other single activity other than sleep. This change in television viewing habits over the last sixty years has been correlated with other changes as well. Children are more violent, obese, and hyperactive than they were sixty years ago according to the following articles:

Dr. Steven Gortmaker wrote in the *Boston Globe* (2004), “Our Children are spending more time than ever in front of the television. Their viewing opportunities are no longer contained to afternoons and Saturday mornings; many networks are devoted to entertaining them all day. While parents may be cognizant of the negative effects that excessive sedentary behavior can have on children, we may not be as aware of the persistent messages children receive from advertisers about unhealthy foods. The food industry spends billions of dollars each year to woo our children to their high calorie products that possess little or no nutritional value. On average a child watching TV sees a commercial from the food industry every five minutes.”

Beresin, writes in the *DevelopMentor* online newsletter (Fall 2004):

Over the past 30 years there has been extensive research on the relationship between televised violence and violent behavior among youth. Longitudinal, cross-sectional, and experimental studies have all confirmed this correlation.

Televised violence and the presence of television in American households have

increased steadily over the years. In 1950, only 10% of American homes had a television. Today 99% of homes have televisions. In fact, more families have televisions than telephones. Over half of all children have a television set in their bedrooms. This gives a greater opportunity for children to view programs without parental supervision. Studies reveal that children watch approximately 28 hours of television a week, more time than they spend in school. The typical American child will view more than 200,000 acts of violence, including more than 16,000 murders before age 18. Television programs display 812 violent acts per hour; children's programming, particularly cartoons, displays up to 20 violent acts hourly.

And finally Christakis, Zimmerman, DiGiuseppe, and McCarty wrote in *Pediatrics* (April 2004):

We found that early exposure to television was associated with subsequent attention problems. This finding was present even while controlling for a number of potential confounding factors, including prenatal substance use and gestational age, measures of maternal psychopathology, and socioeconomic status. The magnitude of the risk associated with television viewing, expressed in our analysis in terms of hours per day of television viewed, is clinically significant when one considers the full range of hours of television viewed in our sample (0–16). A 1-SD increase in the number of hours of television watched at age 1 is associated with a 28% increase in the probability of having attention problems at age 7. This result is robust and stable over time—a similar effect size is obtained for the

number of hours of television watched at age 3. To our knowledge, ours is the first study to test the hypothesis of very early television viewing on subsequent inattention using a nationally representative longitudinal sample. (p. 113)

It is clear that children today have more access to television than any other time, and that they are watching many more hours of television every year. The increase in obesity and violence in students are troublesome facts, which likely change the focus and interests of students compared to previous times. The problem that has the most direct impact on student learning, however, is the loss of attention span and the decreased ability to concentrate. This problem impairs all aspects of learning, including the ability to successfully achieve environmental literacy of students through environmental education courses.

Meeting the Challenge

Gambro and Switzky (1996) studied the level of environmental understanding in tenth and twelfth grade. They also studied how the environmental knowledge of students grew from tenth to twelfth grade. Their findings were very discouraging as shown by the following information from their article in the Spring 1996 *Journal of Environmental*

Education:

These combined results indicate that a majority of high school students have low levels of environmental knowledge, and that they cannot apply the knowledge that they do have. Their levels of environmental knowledge seem insufficient and will

not enable them to successfully confront environmental issues and make intelligent decisions concerning future environmental hazards. These findings are especially alarming because many of these students will not receive any more formal education once they have completed high school. (p. 28)

This article demonstrates the challenge that environmental educators are faced with. Environmental education clearly needs to be improved and teachers need to find ways to improve their instruction. Instructors must understand what motivates students and what holds their attention during instruction.

For a student to become environmentally literate they must understand how energy and matter flow through an ecosystem and they must also understand how social systems are organized and how they function. The student must then be able to apply this knowledge to the many environmental issues that are facing the world today. To accomplish this daunting task it is important that all students are attentive in class and that they are interested, willing, and able to study these topics outside of school.

Unfortunately, the trend in today's student populations is not toward the desired attentiveness. It is my experience that teachers today are faced with the challenge of not only presenting the appropriate content but they must also motivate students and use teaching methods that hold student attention for the duration of the lesson. This last challenge is becoming more difficult every year, but fortunately there *are* methods for catching the interest of students. One way to do this is through the use of technology.

Students are spending a great deal of time in front of the television and on their computers. Newer technologic devices, such as the iPod and other portable electronic

devices are hugely popular with students as well, which reinforces the concept of youth's fascination with ever-advancing technology. Teachers should take advantage of this allure of technology to motivate students. Many schools have numerous resources available for teachers to use that will help hold the interest of students. Access to the internet, PowerPoint software, and word processing programs are common in today's schools and provide many opportunities for teachers and students.

There are many forms of technology that are used by educators and the amount of technology available to schools increases every year. For the extent of this project, technology includes the use of the internet, PowerPoint, videos, word processing software, and electronic means of communicating and assessing student work. It is also important to acknowledge the fact that technology is not the only answer to teaching environmental literacy. Inquiry, outdoor experience, authentic experiments, and many other methods of instruction are also very important. Technology is a tool that should be used with these other means of teaching.

The research that has been reviewed has been conducted for many different disciplines and it is being used under the assumption that if it improves student achievement in any area of education it should also apply to environmental literacy. Environmentally literate citizens must be able to read and understand information from many different sources to stay informed of current issues, thus it is logical that any research which shows improved reading skills would help increase environmental literacy. Citizens must also be able to understand statistics, so improvement in mathematical skills is also related to improvement in environmental literacy. Many of the concepts students will learn in environmental science course deal with ecology,

biology, chemistry, and physics, hence any improvement in science skills should enhance environmental studies.

As a classroom teacher I have observed that one of the main hurdles facing educators today is the lack of motivation in students. Student motivation is described by Bomia, Beluzo, Demeester, Elander, Johnson, and Sheldon (1997) as “a student’s willingness, need, desire and compulsion to participate in, and be successful in, the learning process” (p.1). Skinner and Belmont (1991) describe the importance of student motivation when they describe motivated students as those who:

select tasks at the border of their competencies, initiate action when given the opportunity, and exert intense effort and concentration in the implementation of learning tasks; they show generally positive emotions during ongoing action, including enthusiasm, optimism, curiosity, and interest. (p. 3)

Less motivated or disengaged students, on the other hand, "are passive, do not try hard, and give up easily in the face of challenges". (p. 3)

I think that one of the advantages of using technology in high school courses is the motivational effect it has on students. Reber (2005) conducted a case study on the effect technology has on the motivation of students. Reber used a course in language development at a Swiss university for his research. This course was traditionally taught by having the students read literature, discuss the information in class, and then prepare student presentations. To test the motivational effect of technology the students were given the assignment of creating a website instead of the traditional methodology described above.

After completing the course and creating a website, the students completed Reber's survey that asked them to compare the course they completed with the website construction and the traditional course. Student responses to the survey showed that they did not feel the technology helped them acquire more information but their responses suggested that the website construction motivated them more than the traditional course. Part of this was their interest in the internet and part of it was the fact that the website construction allowed them to focus on subjects in which they had an interest.

The following is a list of ways to ensure that courses are engaging student interest that was created by Brewster and Fager of the Northwest Regional Education Laboratory in their 2000 online article titled "Increasing Student Engagement and Motivation: From Time-on-Task to Homework". This list will be supplemented with descriptions of how technology can be used to accomplish the objective with examples of activities that can be used in environmental education courses.

The first objective that Brewster and Fager (2000) list to create a motivating course is to:

Ensure course materials relate to students' lives and highlight ways learning can be applied in real-life situations" (Lumsden, 1994; Skinner & Belmont, 1991).

Schoolwork should be meaningful to students outside the school building, as well as within. Students are more engaged in activities when they can build on prior knowledge and draw clear connections between what they are learning and the world they live in. They also need to feel that "school work is significant, valuable, and worthy of their efforts" (Policy Studies Associates, 1995). (p. 7)

Technology can help meet this objective with use of the internet for research. If students in an environmental course are studying threatened and endangered species, use of the internet allows them wider access to choose an organism that they are interested in, and provides them with constantly updated information. Traditional methods of teaching use textbooks or sources of information that are not as up-to-date as current internet sources. Using the internet, students can select organisms that they are concerned about and also find organizations that they can contact or support to help protect or rescue the organism(s). This allows students to see the problem of extinction as a real life problem, and an issue that should concern them both in and out of school time.

The second aim that Brewster and Fager point out as being important in a course is creating an environment in which students:

“have some degree of control over learning” (Brooks et al., 1998). This can be done in any number of ways, from giving students choices between different assignments, to minimizing adult supervision over group projects, to letting students monitor and evaluate their own progress (Anderman & Midgley, 1998; Dev, 1997; Policy Studies Associates, 1995). Anderman & Midgely (1998) note that this doesn't mean teachers must relinquish control of the classroom: "Even small opportunities for choice, such as whether to work with a partner or independently" (p. 3) give students a greater sense of autonomy. (p. 8)

Environmental educators can use technology to give students control over their learning by giving them options about how they will present information to the class. The assessment for a unit on solid waste and the importance of reusing and recycling

could be some type of informational material which persuades their peers that they should recycle and reuse materials. Teachers can provide a list of ways in which students can create their persuasive message. Students could use video cameras and movie software to create a commercial that will be played on school television, or they could use publishing software to create an informational brochure to be distributed in the community, or they could create a presentation to be given at a city council meeting with the use of PowerPoint software. The possibilities for student application become endless when technology is available and used.

The third objective recommended by Brewster and Fager (2000) is for teachers to:

Assign challenging but achievable tasks for all students, including at-risk, remedial, and learning disabled students. Tasks that seem impossible easily discourage learners, as do those tasks that are rote and repetitive (Dev, 1997; Policy Studies Associates, 1995). Remedial programs that limit students to repetitive basic skills activities actually "prompt students' lack of engagement in their schoolwork and frequently result in limited achievement" (Policy Studies Associates, 1995). Students need to feel successful and that they've earned success. (p. 8)

Environmental educators have many tools accessible to them that allow at-risk, remedial, and disabled students to demonstrate what they know or to help them gain understanding. Two of the most common uses of technology that can be used by students with learning disabilities are books on tape and voice-guided writing software. Students who struggle with reading can listen to books to help gain understanding and reinforce

what they have read, and students challenged by writing can speak into a microphone to complete a writing assignment. Teachers can also recommend websites that are suited to a student's ability when they are researching issues.

The fourth goal of a motivating course according to Brewster and Fager (2000) is to:

Arouse students' curiosity about the topic being studied. Strong, Silver, and Robinson (1995) suggest using the "mystery" approach, in which students are presented with fragmentary or contradictory information about a subject and are then asked to examine available evidence to develop their own hypotheses. This kind of activity also builds on students' needs for competence and autonomy, giving students an opportunity to direct inquiry and "discover for themselves." (p. 8)

Environmental educators can use the internet to present two sides to environmental issues. For example, the final project for an environmental course might be to hold a mock city council meeting in which the students debate an environmental issue that is of local concern. Students can be assigned roles to play at the meeting and a list of websites can be provided to students that present contradictory information. The council member roles could be played by teachers who will vote on the solution to the issue based on the facts presented by the different sides at the meeting. This will force students to separate facts from opinions and it will also force them to look more in-depth

into the information presented in class. This and other similar scenarios exactly mimic the ideal desired outcome of achieving environmental literacy.

The final objective listed by Brewster and Fagen (2000) to create a motivational course is to:

Design projects that allow students to share new knowledge with others. Strong, Silver & Robinson (1995) observe that when students do assignments that only the teacher will read, they are entering into a nonreciprocal relationship. More often than not, the teacher already knows and has no real need for the information the student is providing him or her. Projects are more engaging when students share what they are learning in reciprocal relationships, as in collaborative projects where each student's knowledge is needed by others in the group to complete an assignment. (p. 8)

This objective can be completed in a number of ways with the use of technology. Students can create PowerPoint presentations that are shared with their class or they can create a webpage that will be displayed on the school website. Students can also complete the recycling assignment described above.

These are all methods environmental educators can use to motivate their students. The information listed above shows how important student motivation is for academic achievement. The following discussion reviews studies which also show how technology can be used to improve student achievement.

Bialo and Sivin-Kachala (1996) summarized a report that they wrote on the use of technology in schools. The researchers started with one thousand studies that had appeared as articles in professional journals or as doctoral dissertations between 1990 and 1995 and chose one hundred and seventy six projects. The other projects were not used because of weaknesses in their methodologies. The following statement discusses the researchers' findings (Bialo and Sivin-Kachala, 1995):

educational technology has demonstrated a significant positive effect on achievement. Positive effects have been found for all major subject areas, in preschool through higher education, and for both regular education and special needs students. Evidence suggests that interactive video is especially effective when the skills and concepts to be learned have a visual component and when the software incorporates a research-based instructional design. Use of online telecommunications for collaboration across classrooms in different geographic locations has also been shown to improve academic skills. (p. 2)

Guerrero, Mitrani, Schoener, and Swan (1990) studied New York City's Computer Pilot program to see if it had an effect on the achievement level of remedial and low achieving math and reading students. The review found that students who used computers recorded personal gains of 90% in math and 80% in reading compared to their own previous results. The use of technology becomes a useful tool when environmental courses have a heterogeneous population and teachers are responsible for challenging both gifted and remedial students.

I believe that it is clear from the research reviewed that environmental literacy is important to protect and manage the natural resources that humans depend on, and that there are many hurdles facing educators at all levels, including environmental educators. The research also indicates that the use of technology can help overcome some of these hurdles by motivating students and helping them improve their academic achievement which includes environmental literacy. The next chapter outlines a comparison of two units taught to two separate sections of an environmental studies course, made up of a mixed population of junior and senior high school students in a first ring suburb of St. Paul. One unit relied on traditional methods of teaching, and the other used methods of teaching which incorporated the use of technology.

CHAPTER 3

METHOD

Study Design

This study was conducted to examine the question: What effect does technology have on environmental literacy? A group of 38 students participated in two environmental science units with different teaching methods and then tested to determine if one of the teaching methods increased student achievement. According to Anderson, Herr, and Nihlen (1994) this would be considered a case study. The case study focused on a particular group of students in an idealized situation aimed at investigating the influence technology has on student achievement.

The particular group of students in this case study was made up of 38 juniors and seniors in an environmental science course. The students in this study group were made up of students in all percentiles of their class, varied English proficiency, diverse cultural backgrounds, and varied attitudes toward school. The diverse backgrounds of students in this course make it representative of other heterogeneous classes. Even though there were a limited number of total students in this course the diverse backgrounds of the students make the data collected important to other courses with heterogeneous populations.

The results from this study were collected in the form of unit tests and student surveys. The unit tests were used to show the influence technology had on student achievement and the student survey information was used to determine if the use of technology had an effect on students' perception of the course content. The quantitative data collected were the students' scores on the two unit tests. This data was analyzed

using the Chi-square test. The qualitative data collected were the comments students recorded in their journals. This data was used to discuss how the use of technology changed the attitudes of students.

The Environmental Studies Course

The environmental studies course that was used as a study group met 70 minutes per day, five days per week, for 24 weeks. The two units conducted during this study were each approximately five weeks long. This course was offered to juniors and seniors who had completed one year of physical science and one year of biology. The content of the course started with an overview of ecology which included material and energy flow in ecosystems, food chains and webs, types of ecosystems, and descriptions of natural and social systems. The course then went on to analyze current environmental issues. Students used Holt's *Environmental Science* (2000) as a textbook in this course.

The two issues that were studied during this case study were air pollution and water pollution. These two topics were chosen because of the similar cause and effect of the problems, types of natural and social systems involved, and the resources available for student use. Two topics with many similarities were chosen to help lower the number of variables students were exposed to during the two units. The goal was to study the influence of technology on environmental literacy. The amount of vocabulary, processes, and skills taught in each unit were very similar to ensure that any change in student achievement or attitude was a result of the technology.

The Traditional Unit: Water Pollution

The students first completed the traditionally taught unit on water pollution. An overview of the water pollution unit is described below. The unit plan included the objectives that students should know at the end of the unit, the activities they conducted, and the products they created to demonstrate understanding. The complete lesson plans and rubrics are included in Appendix A.

Part I: Getting to Know Water

Students were assigned to groups of three or four and each group was given a property of water to research and then gave a presentation to the class. Properties that groups studied included: density, dissolved oxygen content, adhesion, cohesion, polarity, surface tension, rate of vaporization, transparency, universal solvent, and phase changes. There was also some lab work completed during this part of the unit. Some of the labs were open-ended and some were more cookbook type labs.

The first part of this unit focused on the properties of water and at the end of this lesson students should have been able to: 1) explain the physical properties of water, including density, dissolved oxygen content, adhesion, cohesion, polarity, surface tension, rate of vaporization, transparency, universal solvent, and phase changes, 2) discuss how these physical properties of water are important to life on earth.

Students learned about the properties of water by designing a laboratory investigation to study the properties of water. One group of students decided to study the effect temperature had on the dissolved oxygen content of water. Another group studied how the density of water changed with temperature. Other examples of experiments

included measuring how quickly colored water moves up the vascular tissue in celery and comparing factors that affect the rate of evaporation.

The students were expected to choose the variable that they wanted to examine, and then they designed an experiment that controlled that variable. They conducted the experiment and recorded all relevant data in data tables that they constructed. The students then analyzed their data by creating graphs and performing statistical analysis. They finished their study by writing a conclusion based on the data they collected.

During the first day of the water pollution unit the students were introduced to the properties of water. The teacher provided a list of properties with a brief description of the properties in the form of an overhead transparency. The students copied the notes and then were divided into groups of three or four. The teacher handed out playing cards as the students came into class to ensure that the groups were formed randomly. The groups then discussed the property they wanted to study and then used their textbooks and the World Wide Web to research their property.

During the second and third day of this unit the students planned their experiment and determined a method to control the variable they wanted to test. Each member of the group was responsible for writing an individual lab report. The students then set up their experiments and conducted the lab and collected data. Each group was responsible for analyzing the data and discussing possible conclusions. Each member wrote their own conclusion with references made to the data they had collected.

The fourth and fifth days of the unit were used to complete the lab report and create a short description of how the property that was studied related to life on earth. The groups then informally presented this during a class discussion. Examples included

the ability of aquatic plants to carry out photosynthesis because of water's transparency and the moderation of earth's climate due to the high specific heat of water.

Part II: Round-and-Round It Goes

The second part of the unit focused on the water cycle. Students took notes over the different processes and parts of the cycle from an overhead projector transparency. They then constructed a model showing the water cycle that gave examples of each process. After studying the water cycle and creating the model students should be able to: 1) define condensation, precipitation, transpiration, evaporation, and runoff, 2) diagram the water cycle, and 3) describe how plants and animals fit into the water cycle.

Students demonstrated their knowledge of the water cycle by creating a 3-D model. The students created a model of the water cycle that showed all of the processes and included descriptions of each one. The model also had plants and animals included in it to show the roles they play in the cycle and how they are dependent on the water cycle.

The teacher presented overhead transparency notes on the water cycle and its processes for the sixth day of the water pollution unit. On the seventh day of the unit the students started working on their models. They finished their models on the eighth day and then displayed them for their peers to score. Each student had to fill out a rubric for their model and the models of three other students.

Part III: How We Interact with Nature

The third part of the unit studied the relationship between natural and social systems related to water pollution. This started as a broad discussion of what these types of systems are and the students created a large list of any social or natural system. Examples of their ideas included the legal system, the Environmental Protection Agency, Sierra Club, river systems, water cycle, ground water, and lakes. The assessment for this part of the unit consisted of an essay that discussed three social systems and a description of how they affected our water resources. Examples included how agriculture produced chemical runoff into streams and runoff from lawn chemicals polluting storm drain water that ran into rivers or lakes.

At the end of this lesson students were expected to be able to: 1) describe four to five social and natural systems, 2) list natural and social systems that are associated with water, and 3) discuss how natural and social systems influence or interact with each other regarding water. Students demonstrated their knowledge of natural and social system interdependence by brainstorming a list of as many natural and social systems that a group of three or four students can generate in ten minutes. The students then used the list of systems created with their group and chose three pairs of systems (one natural and one social) that interact or influence each other. The essay was meant to be a five paragraph essay. The first paragraph should have discussed the general ideas of natural and social systems. The three body paragraphs explained how the pairs of systems are related. The closing paragraph discussed whether the interactions discussed in the essay are positive or negative and if there are any possible solutions for the negative impacts.

The teacher introduced the concepts of natural and social systems as they led a discussion and recorded notes on the white board on the ninth day. Students were then divided into groups and given fifteen minutes to develop a list of systems. Each group then reported back to the class and the systems were recorded on the white board. During the tenth day the teacher introduced the format of an essay on the white board and students chose three pairs of systems and shared their systems with the teacher and also shared their thoughts on how the systems interact. If the student had chosen appropriate pairs of systems and interaction then they began writing. The essays were shared with the class on the 11th day.

Part IV: I Love Water

The fourth part of the water pollution unit allowed students to study how they use water. They completed two online water use calculations and then compared the accuracy and effectiveness of the two calculators. This was the only part of the unit that incorporated technology. They also discussed how they could reduce their water use on a daily or weekly basis. At the end of this lesson students were expected to be able to: 1) describe what activities use water and estimate which ones use the most water, 2) discuss strengths and weaknesses of assessing daily or weekly water use, and 3) construct a pie graph to illustrate how much water each activity consumes relative to the other activities.

Students demonstrated their understanding of the concepts from this lesson by creating a water use table and a pie graph showing how they used water. The students were divided into pairs and each pair of students constructed a list of activities that consume water and then ranked the list from most water used to least water used. They then completed the water quizzes online and recorded the amount of water they use

according to two calculators. Students then analyzed their water use activities and created a list of how they could reduce their water use. After completing the water use table the students constructed a pie graph that illustrated which activities use the most water.

Many of the students were surprised by the amount of water they used each day but most of them found many ways to reduce their water use each day. Ideas of lowering water usage included taking shorter showers, turning the water off while brushing teeth, doing dishes by hand if the dishwasher isn't full, and using landscaping plants that do not require watering in the summer.

This lesson started on the twelfth day of the water pollution unit and the introduction to this lesson started with a teacher led discussion on personal water use. Topics that were included in the discussion were estimations of the number of gallons of water a person might use per day and what they could do to limit water use. Students were then be divided into small groups and each group created a list of activities that use water and they then ranked the list in order of greatest uses. On the following day students completed the two online water use quizzes to determine estimated water use per day. Students then compared their water use activities that they listed the day before to the questions they were asked on the quizzes.

The last day of this lesson consisted of students in groups of three or four working together to create tables with strengths and weaknesses of each calculator. Students answered three questions as they critiqued the online calculators: 1) what made them accurate in estimating water use, 2) What made them inaccurate in estimating water use, and 3) what questions would you add to the calculator to make in better? The last

activity of the lesson was the creation of individual pie graphs showing what percentage of their total water use each activity makes up.

Part V: Minnesota's Water Polluted... No Way

This lesson took the information that students had learned in previous lessons and applied it to local issues. This lesson started by placing the students in small groups and each group chose an issue that deals with Minnesota. Examples of issues that are related to Minnesota included pH changes in lakes due to acid rain, the use of phosphate in fertilizers, agricultural runoff, and mercury contamination. Each group presented its findings to the class in the form of a brochure or poster. The final assessment of this unit was a town meeting to discuss or debate the possibility of banning lead fishing lures and weights from county lakes, streams, and rivers.

The objectives for this lesson were to enable students to: 1) discuss the causes and effects of a water pollution issue affecting Minnesota, and 2) design and analyze solutions to that problem. Students verified understanding by writing a brief report that described the issue they researched. The report included the cause of the problem and the effects the problem has on the environment and society. The report also included the groups that are involved with the problem. The report ended with possible solutions to the problem.

After writing the report students designed and constructed a brochure that was meant to educate the public on the issue and its solutions. The brochure was created with markers, colored pencils, or crayons. The goal of the brochure was to point out causes of the problem that the students chose to study and then discuss how humans and the environment were affected by this problem. The last part of the brochure directed

community members on how they could change their behaviors in order to reduce the problem.

Final

The final assessment was a cumulative assessment that tested student knowledge of the vocabulary, cause and effect relationship of human activities, and how each citizen could modify their behavior to help reduce environmental problems. For the final assessment each student was assigned a role to play at a town meeting and they were responsible for researching information to present at the meeting that supported their position. The issue discussed at the meeting was the possible banning of lead lures and weights from use in the county lakes, streams, and rivers. Examples of roles researched by the students included: mayor, city council, fisherperson, bait shop owner, teacher, environmental group representative, homeowner, small business owner of company that manufactures lead jigs, bird watcher, and canoe enthusiast.

During the first day of the final assessment project the teacher divided the class into groups of two to three students and assigned them a role to play. The teacher then informed the students of what was expected in their report. They then created a list of what they knew about the problem and what they thought they should find out. The next day the students spent the class period researching their issue online and in library. The third day was spent discussing what students had found while researching and what they had trouble finding. The rest of the day was spent finishing their research.

Students spent the second to last day of the unit writing out a script or outline of what they wanted to discuss during the town meeting. The students were also directed to think about opposing views and how they would respond to those viewpoints. The last

day of the unit was spent simulating the town meeting. The teacher and two students played the role of the city council and determined that lead should be banned from the county's lakes, streams, and rivers.

The Technology Enhanced Unit

After completing the water pollution unit students completed a unit on air pollution. All of the notes for this project were given as PowerPoint presentations. Videos from an internet streaming video service were used with the PowerPoint presentations. The student projects were also technology based. The air pollution unit is described below and follows the same format as the water pollution unit. The complete lesson plans and rubrics are included in Appendix B.

Part I: Getting to Know the Atmosphere

Students were assigned to groups of three or four and each group was assigned a layer of the atmosphere to research and create a PowerPoint presentation that was presented to the class. The presentations included the gases that make up the layer, the temperature of the layer, and any characteristic of that layer that is important to life on earth.

After completing this lesson students were expected to be able to: 1) describe how the atmosphere is structured in layers, and 2) discuss how the physical properties of the atmosphere make life possible on earth. Students demonstrated their understanding of the objectives by creating PowerPoint presentations that informed the other students about the findings from their research. Students were also expected to explain to the class how their layer is important to life on earth. Examples of this description included:

How weather in the troposphere causes the recycling of water and how the ozone layer of the stratosphere reflects ultraviolet rays.

This unit started as the teacher briefly introduced the layers of the atmosphere that were going to be studied. The teacher then broke the class into groups of three to four students. Each student group then had time to research their atmospheric layer online or in textbooks. The student groups used the second day of the unit to continue researching their atmospheric layer online or in reference books in the library.

Student groups then started creating the presentations on the third day after a brief introduction to PowerPoint. Each member of the group was responsible for one slide of the presentation. This allowed students who were proficient with the PowerPoint software to provide assistance to those students that were not as proficient with the software. The fourth day was used to finish the presentations and practice presenting their findings. The fifth and sixth days of this unit were spent presenting the slideshows and assessing each student's research.

Part II: What We Cannot See Can Hurt Us

The second part of this unit included the study of outdoor air pollution. Students viewed a PowerPoint presentation during the seventh and eighth day of this unit. The lecture on air pollution incorporated video clips and photographs from the internet into the PowerPoint presentation. This presentation also included links to websites with current statistics on the amount of air pollution in the local area. Students were given an outline of the notes and they will be responsible to fill in the outline as the presentation

was given. This allowed students to focus on the material but still required them to pay attention and fill in the outline as the information was presented.

The three goals of this lecture were to teach students to: 1) name the major sources of air pollution, 2) distinguish between primary and secondary pollutants, and 3) explain how we could reduce air pollution. After listening to the lecture and participating in the discussion, students were given time to review their notes. The students also participated in a review activity the day after the lecture.

The review activity was an online scavenger hunt that the students filled out as they found information on the internet. The scavenger hunt directed the students to the Health and Energy webpage created by Tom Socha at http://healthandenergy.com/air_pollution_causes.htm . The students were given the specific website to start with so that they would not waste time or find themselves on inappropriate websites. The students were asked to find the following information for their online scavenger hunt: 1) List the six main types of air pollution, 2) List the location of the top polluting plants for each of the pollutants listed above (what are the plants' names and what state are they in), 3) In a few sentences discuss whether or not you feel the U.S. air is cleaner now than it was 10 years ago. Use the facts listed on the site to explain your answer, and 4) What are the worst electric plants in the country when it comes to producing pollutants? What are the best electric plants?

The students recorded their answers in a Microsoft Word document and turned in an electronic copy in the teacher's shared folder. This method also models reduction of paper in the school and demonstrates one way that technology has helped reduce waste. During this discussion some students questioned how much electricity this took and if the

electricity generated created more air pollution than making the paper. This led to a very good discussion and the students agreed that this should be researched more during the solid waste unit.

On the tenth day of the unit students examined a case study on the internet to look at a specific example of a problem caused by air pollution. Students were directed to the World Resource Institutes website to study an air pollution problem in Chattanooga, TN. The students read the case study and then answered the following questions: 1) Make a bulleted list of the many problems that affected Chattanooga, TN, 2) Answer the three questions listed in detailed paragraph form (these questions are listed on the website), and 3) Make a bulleted list of some of the solutions that were implemented. These questions prepared students for the assessment of this lesson listed below.

After completing the scavenger hunt and the case study the students were introduced to the assessment for this lesson. The students created a public announcement to educate the public about a pollutant that they were assigned. After researching the pollutant the students developed a public announcement that described the cause of the pollutant and effect the pollutant had on the environment and on human health. The public service announcement also included ways to reduce the pollutant. The presentation was presented in the form of a brochure made with Microsoft Publisher, a television commercial, or a PowerPoint to be presented at a town meeting.

Part III: Nowhere to Run, Indoor Air Pollution

The third part of the air pollution unit studied indoor air pollution. The students used the internet to research an indoor air pollutant. The students then created a small poster with Microsoft Publisher that explained the source of the indoor air pollutant, its

effect on human health, and how it can be reduced. The posters were displayed throughout the school to help educate the school population about the dangers of indoor air pollution. After finishing this unit the students were expected to: 1) describe four to five indoor air pollutants, 2) explain the source of the pollutants, and 3) discuss how to reduce the pollutants.

Students started this lesson on the 13th day of the air pollution unit and began research of their assigned indoor air pollutant in the computer lab. Students were given three days to complete their research and design their posters. Students who were very proficient with Microsoft publisher worked with less proficient students to help them master use of the software.

Part IV: The Air We Share

The fourth part of the unit looked at air pollution as a global issue. The class watched a PowerPoint presentation on global warming and acid rain. This presentation included video clips of melting ice caps and large fish kills due to changes in pH of lakes. These video clips were from United Streaming, an online collection of videos that teachers can download from the internet if the school has a subscription. The class then discussed why air pollution is considered a global problem. The students then completed an online activity sheet provided by Prentice Hall that had links to help them answer questions and links that provided data for students to analyze. The questions on the online worksheet directed students to use maps to analyze conditions that affected acid rain, study the formation of acid rain, measure pH, discuss the affects on various parts of the environment, and list actions that individuals can take to reduce acid rain formation.

At the conclusion of this lesson students were expected to be able to: 1) describe how one country's pollution can be another countries problem, 2) discuss why it is important for all countries to commit to reducing green house emissions, and 3) discuss social systems that create problems to certain countries reducing emissions. To demonstrate the ability to meet these expectations students composed an email that they could send to their state representative. The students used the internet to study the Environmental Protection Agency's policies on air pollution and then wrote a letter to their state representative informing them whether the EPA air pollution standards should be strengthened, eased, or kept the same. The students had to use data from activities in the unit to justify their statements.

Final

The final project for each student was to design and construct a webpage that could be used to educate the public to the general problems of air pollution. This website was supposed to contain the following: 1) a brief PowerPoint presentation describing the major sources of air pollution, 2) a table that lists the pollutant, its source, and its effect on human health and the environment, 3) an email link to send comments to, 4) a hyperlinks to other websites with similar information, 5) at least one graphic created by the student.

The Survey

At the end of the air pollution unit the students had two days to review all of the projects that they had completed during the water pollution and air pollution units. The students then created a game that would help students review. Students were divided into groups of three and assigned either the water pollution unit or the air pollution unit to

review. Students had the option of creating a board game such as *Monopoly* or *Shoots-and-Ladders* or a computer based game such as *Jeopardy* or *Who Wants to be a Millionaire*. The students created the games and then traded with other groups to play their game for review. After reviewing the two units for four days the students completed a survey to measure their environmental literacy pertaining to air and water pollution and their attitudes toward technology.

The survey contained the following questions. The complete survey with the multiple choice options is found in the Appendix C.

Survey Questions:

1. When neighborhood residents noticed a large number of dead frogs in the local pond, they traced the problem to a nearby car repair shop. It turned out that a tank of antifreeze had developed a leak. This is an example of
2. What is the cause of most of the pollution in the ocean?
3. Most large cities get water for households and industries from
4. What is the most practical solution to the problem of making sure that everyone has enough fresh water to use?
5. Some communities have banned detergents containing high levels of phosphates because:
6. A major reason the era of building large dams in the United States has come to a close is that
7. Thermal pollution affects aquatic environments because it
8. A possible result of pumping large amounts of water from an aquifer is that
9. Sludge is difficult to dispose of because

10. Most of the water used in the United States is for
11. Carbon monoxide, sulfur dioxide, particulate matter
12. When automobile emissions react with oxygen gas and ultraviolet rays of the sun, a pollutant is formed that is called
13. Ethanol
14. Two-thirds of the sulfur dioxide that pollutes our air is produced by
15. Which of the following is often used to remove poisonous gases by emissions released by industries?
16. Which type of building would most likely have poor indoor air quality?
17. Schools in the United States have spent over \$40 billion to remove
18. Which of the following pH measurements of rainwater would indicate acid precipitation?
19. Which of the following contributes the most to acid precipitation?
20. Most of the pollution that causes acid precipitation to fall in southeastern Canada is released from
21. Which unit of study do you feel like you have the best understanding of the information?
22. Which unit of study did you like the most?
23. Do you prefer taking notes from an overhead projector or PowerPoint presentation?
24. Do you think that the use of technology improves student learning?
25. Do you think that the use of technology motivates you to learn more than when technology is not used?

Limitations

One of the most serious limitations of the survey was the proximity of the survey to the air pollution unit. Students had completed the water pollution unit weeks before the survey and they completed the air pollution unit only days before the survey. Students were given daily review questions of the water pollution unit to keep it fresh in their memories and they also created review games but this must still be considered a limitation.

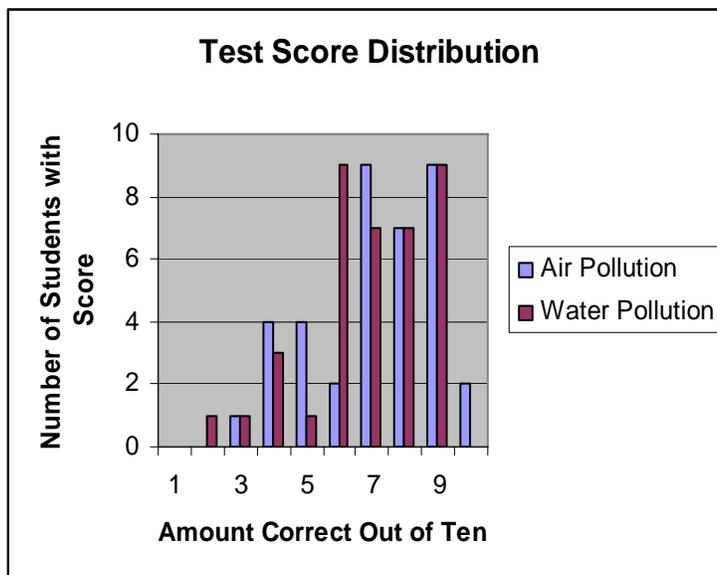
Chapter four will discuss the outcomes of this study based on the data collected from the survey. The survey collected both quantitative and qualitative data that measured student environmental literacy, as well as, their attitudes toward the material and the technology used in the air pollution unit. The quantitative data will be statistically analyzed and the qualitative data will be discussed to summarize student attitudes toward the use of technology in the air pollution unit and the lack of technology in the water pollution unit.

CHAPTER FOUR

RESULTS

After completing a traditionally taught water pollution unit and a technology enhanced air pollution unit the students took a survey to test their knowledge of the two subjects and to record their attitudes about the lessons and technology. The sample size was not large but it was a diverse sample of the student population. The survey consisted of ten multiple choice water pollution questions, ten multiple choice air pollution questions, and five multiple choice questions dealing with student attitudes toward the two units and technology. The data collected from the multiple choice part of the survey is shown in Figure 1.

Figure 1. *Test Score Distribution of Environmental Literacy Survey*



The data collected in this study was analyzed by finding the mean, standard deviation along with the values for the Student's t-Test, Z-test, and the Chi Squared test. These calculations will help us determine if there is enough of a difference between the

scores from the two units to claim that technology enhanced environmental literacy. All three of these tests require the formation of a null hypothesis, H_0 , and an alternative hypothesis, H_1 . The information produced from these three tests gives the probability for rejecting the null hypothesis and accepting the alternative hypothesis.

The other quantitative data that was collected to study how technology affected student attitudes will also be discussed. This data is based on students' attitudes and opinions and cannot be statistically analyzed. This quantitative data can only be used to understand how students felt about the units, not how much they actually understand from each unit. This data is still important to collect and can be as useful as the data measured student understanding when it applies to student attitudes.

The null hypothesis for the Student's t-Test and the Z-test is that the use of technology did not produce a significant difference between the means of the air pollution and water pollution survey questions. The alternative hypothesis is that the use of technology did create a significant difference in the means of the air pollution and water pollution survey questions. If the use of technology improved student environmental literacy the results of the t-Test and Z-test should allow the null hypothesis to be rejected. If we cannot reject the null hypothesis it means that the difference in the average test scores might be due to something other than the variable that was tested in this study.

Table 1. *Student scores on the Environmental Literacy Survey*

Score out of 10	1	2	3	4	5	6	7	8	9	10	Students	Total Point	Average Score
-----------------	---	---	---	---	---	---	---	---	---	----	----------	-------------	---------------

													s	
Number of Students with Score	Water Pollution (Normal)	0	1	1	3	1	9	7	7	9	0	38	262	6.89
	Air Pollution (Technology)	0	0	1	4	4	2	9	7	9	2	38	271	7.13

The class mean for the ten water pollution questions was 6.98 questions answered correctly and 7.13 for the ten air pollution questions (Table 1). This shows an increase of two percent from the water pollution questions to the air pollution questions. To evaluate whether or not the difference in means was significant the Student' t-Test was performed on the data using a Student's t-Test calculator designed by the University of St. Benedict and St. John's University's Physics department. The Student's t-Test results, which are listed in detail in Appendix D, were: $t=0.557$, $p=0.579$ standard deviation=1.85, and the degrees of freedom=74. This information was used to determine the probability of these two means being significantly different. Based on these figures there is not enough difference between the means to be significant.

The following is a description provided by William M. Trochim (2002) on a website hosted by Cornell University of how the Student's t-Test is calculated and what it tells us:

The t-value will be positive if the first mean is larger than the second and negative if it is smaller. Once you compute the t-value you have to look it up in a table of significance to test whether the ratio is large enough to say that the difference between the groups is not likely to have been a chance finding. To test the significance, you need to set a risk level (called the alpha level). In most social research, the "rule of thumb" is to set the alpha level at .05. This means that five

times out of a hundred you would find a statistically significant difference between the means even if there was none (i.e., by "chance"). You also need to determine the degrees of freedom (df) for the test. In the t-test, the degrees of freedom is the sum of the persons in both groups minus 2. Given the alpha level, the df, and the t-value, you can look the t-value up in a standard table of significance (available as an appendix in the back of most statistics texts) to determine whether the t-value is large enough to be significant. If it is, you can conclude that the difference between the means for the two groups is different (even given the variability).

Based on the Student's t-Test there was not enough of a difference in the means of the test scores to reject the null hypothesis. The Student's t-Test is a useful calculation when using small samples. In this case the value for t would have had to be greater than 2.04 to say with ninety five percent confidence that the means were considerable enough to be due to the variable that was introduced.

The Z-Test score was also determined to compare the means of the two groups. The Z-score was used to determine the probability that the mean test score of the air pollution survey will fall within one standard deviation of the mean of the water pollution survey. If the probability of this occurring is high then there is little statistical difference between the two means. According to Dr. Madhukar Pai on the Statistical Inference: Estimating and Testing Hypothesis website the Z-score:

What is the logic behind *P values*'? To understand this, one has to again fall back on the knowledge of normal distribution. We know that 95% of all the values in

the data will fall within 2 standard deviations of the mean. The probability of a value falling beyond 2 standard deviations on either side of the mean is 5% (0.05).

To compute *P value*, the observed difference between 2 means is divided by the standard error. The result (expressed as number of standard errors) is called the Zee (Z) value.

The result for the Z-Test for the means of the air pollution and water pollution surveys was $z=.758$ (See Appendix E). This value is not great enough to reject the null hypothesis that the use of technology did not produce a significant difference between the means of the air pollution and water pollution survey questions.

The data that seems to be more significant than the mean is the number of students who answered seven or more of the ten questions correctly. Seventy one percent of the students answered seven or more of the ten air pollution questions correctly and only sixty percent of the students answered seven or more of the ten water pollution questions correctly. This is an increase of eighteen percent. There were nine students that answered six of the ten water pollution questions correctly. It is difficult to say that this result is due to the introduction of technology into the air pollution unit but the following data will show that student motivation was effected by the technology.

The Chi Squared test was used to determine if the difference in the number of students that scored above seventy percent on the air pollution survey and the water pollution survey was significantly different. The Chi Squared test for independence was used in this study. This test measures the probability of two variables being independent of each other. In this study the variables were the use of technology and student scores,

or environmental literacy. The null hypothesis for this test was that the use of technology was not related to the mean scores on the surveys. The alternative hypothesis was that the use of technology was related to the mean scores on the survey.

According to Catherine Ball (2003) on the Chi Squared Tutorial website hosted by Georgetown University:

While the issue of theoretical or practical importance of a statistically significant result cannot be quantified, the relative magnitude of a statistically significant relationship can be measured. Chi-square allows you to make decisions about whether there is a relationship between two or more variables; if the null hypothesis is rejected, we conclude that there is a statistically significant relationship between the variables. But we frequently want a measure of the strength of that relationship--an index of degree of correlation, a measure of the degree of association between the variables represented in our table (and data). Luckily, several related measures of association can be derived from a table's chi square value.

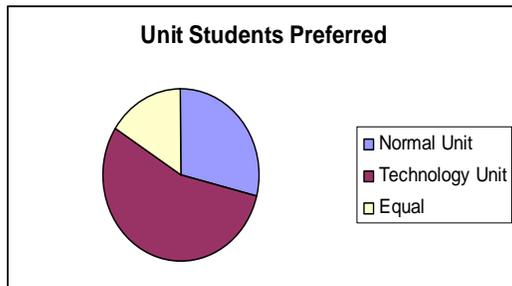
To calculate the Chi Squared value the data was entered into a template on The Chi Squared Statistic website that is hosted by Hobart and William Smith Colleges. The values that were calculated were Chi Squared Value=0.935 and $df=1$. Based on this information the null hypothesis cannot be rejected because 0.935 is less than 3.841 for $\alpha=0.05$. This means that there was not enough of a difference in the number of students that scored greater than seventy percent on the surveys to show a relationship

between the use of technology and the students' scores on the surveys. All of the calculations for the Chi Squared test are listed in Appendix F.

Student Attitudes

While the addition of technology into the unit did not create a measurable difference in the student achievement it did seem to improve student attitudes, which can be viewed in Appendix G. According to the student survey 55% of the students enjoyed the air pollution unit more than the water pollution unit. Twenty nine percent of the students enjoyed the water pollution unit more and 16% enjoyed them equally (Figure 2). The difference in content was not very noteworthy which leads to the consideration that students enjoyed the unit more because of the technology.

Figure 2. *Students Who Enjoyed the Technology Unit More than the Traditional Unit*



Seventy nine percent of the students felt that the addition of technology improved the unit and 82% of the students felt that technology motivated them. This shows that students perceive technology as a motivating factor and as an improvement to their understanding of a topic. Forty five percent of the students also felt that they gained a better understanding of the information in the air pollution unit than the traditional water pollution unit. While the data in this study does not support this belief the fact that the students enjoy the material more with technology is a very important finding.

Figure 3. *Student Perception on Technology and Learning*

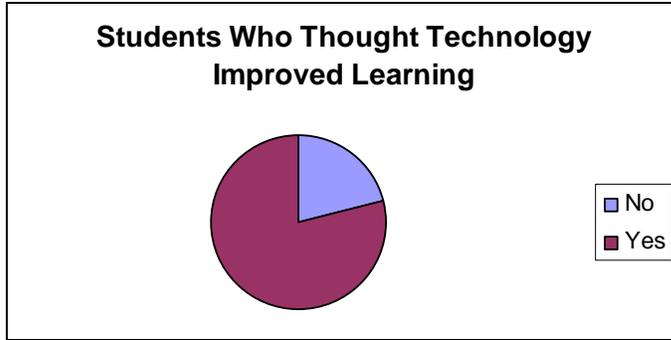


Figure 4. *Student Motivation from Technology*

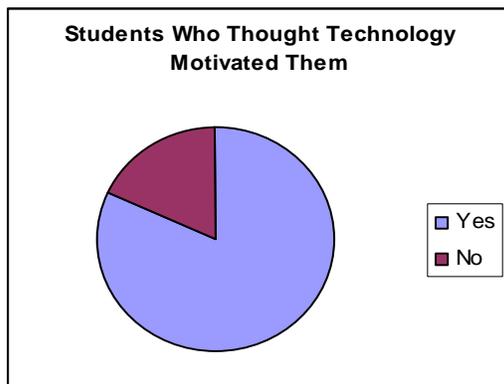
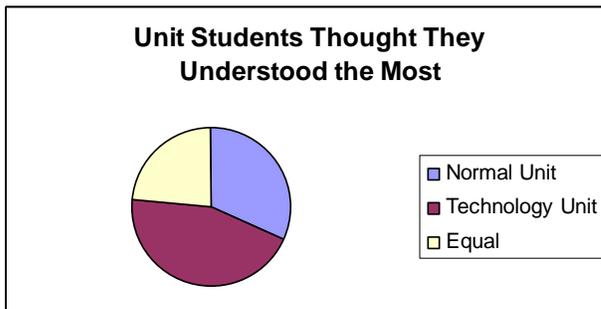


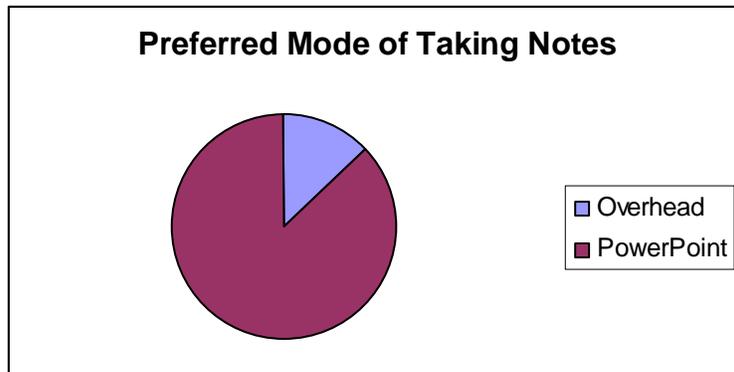
Figure 5. *Student Perception on Understanding*



Leading 30 high school students through notes can be very challenging when the students are not interested in the material or if they are not engaged. According to the survey 87% of the students preferred taking notes from PowerPoint presentations.

PowerPoint presentations may contain the same information as overhead transparencies or white board notes but students find them more interesting. Seventy nine percent of the students also thought that technology improved their learning. This could be another reason that they favored the PowerPoint presentations.

Figure 6. *Students Preferred Mode of Taking Notes*



Based on the information presented in this analysis it can be said that the use of technology in an environmental education course did not improve environmental literacy in this study. Although this was the question being tested by this study, there was some evidence of improvement of student attitude and motivation by the use of technology. The next chapter will discuss the implications of these findings and the opportunity for further study of these issues.

CHAPTER 5

REFLECTION

The use of technology in the environmental studies course was successful in many different ways. Adding technology to the environmental studies course increased the number of ways I was able to present information to students, allowed me to find current information on the topics we covered, increased the number of ways students could demonstrate their understanding, and students were motivated to be involved in the learning process. These successes were not measured with assessments but by my professional development.

In the past I had been limited to presenting information to students on overhead transparencies, the whiteboard, or during discussions. The overhead transparencies are difficult to update and store and the notes on a whiteboard have to be rewritten for each class and this takes time away from instruction. The use of PowerPoint presentations was a new way to present information to the students in a form that they preferred. The information in PowerPoint presentations can also be changed and/or updated quickly and they take less time to present than notes on a whiteboard.

I also found a large number of current videos and slideshows on the internet. This enabled me to use current information and see what other teachers were presenting to their students. The videos were also current and more specific to the topic I was covering. When I depended on the videos the school owned I was very limited in the topics I could choose. The online videos also allowed me to download small clips so that I was only using pertinent information without having to rewind or fast forward video

tapes. They also fit into the PowerPoint presentations so that they were connected to the notes they reinforced.

Using the internet for activities enabled the students to use current information for each project. When we relied on the textbooks or library reference books sometimes the information was five to ten years old. This allowed students to feel that the information was meaningful. When we relied on outdated information it felt like I was asking students to go through the motions of an activity but its significance was reduced because of the inaccurate data.

Students with special needs were able to use the technology to demonstrate their understanding more accurately than when they were dependent on writing or answering test questions. Students who had difficulty reading or writing seemed to perform better when they could apply the knowledge they had learned. They could create a video or PowerPoint instead of writing an essay or answering multiple choice questions.

Based on the survey results 82% of the students felt more motivated during the air pollution unit when technology was used. This led to fewer negative behaviors during class and it also seemed to lower the number of students that did not hand in projects. To confirm these beliefs I looked back at my graded book and discovered that there were 17 projects turned in late during the water pollution unit and only two projects turned in late during the air pollution unit. I also looked at my referral notes to find that during the water pollution unit two students were referred to the office for disruptive behavior and four students had to serve detention with me for being off task. During the air pollution unit there were no referrals made to the office and only two students had to serve

detention with me for being off task. This is evidence that students were on task more of the time and less disruptive when technology was used.

The Test Scores

Based on the data recorded from the ten water pollution questions and the ten air pollution questions, the hypothesis that technology enhances environmental literacy cannot be supported. The means of test scores from the two units were too close to describe as significantly different. If this study was carried out further it would be beneficial to use the standardized rubrics that were used to score the projects and compare the student scores on each project in the two units. The scores on the projects may provide greater insight into student understanding. Using the means from ten questions on a survey is a very limited measure of student understanding.

The definitions of environmental literacy included in the literature review all incorporated knowledge, attitude, and behaviors. The 20 questions that covered air and water pollution only measured knowledge. To probe further into each student's environmental literacy the survey could have included questions that studied a change in student attitude toward water and air pollution. Another set of questions that examined a change in student behavior toward air and water pollution would create an even more detailed measurement of student literacy.

As an environmental educator I am more concerned about students appreciating the environment that we live in and taking action to preserve our resources than I am about students being able to memorize facts. Knowledge about our environment is important but it does not have a direct effect on the environment. The behaviors of humans toward the environment are what can lead to a sustainable society.

Final Thought

As I look back on the two units that were taught and the results that were collected I am very satisfied with the outcomes. Although the test scores were not improved with the use of technology I feel that my teaching methods were improved and that I grew professionally as I researched how technology should be used in the classroom. I also feel that the students benefited from the use of technology in the way they perceived the information and in the activities that they participated in throughout both units.

I have always incorporated technology in my classes but I had never spent time researching strategies that would allow me to use technology in ways that were most valuable. This project required me to examine the way I had used technology in the past and how I should modify those techniques to enhance the effectiveness of technology's application. I also believe that there are many effective methods of instruction that do not depend on technology and those methods should be used in unison with technology.

The two most restraining hurdles to the effective use of technology in the classroom are time and money. Many schools do not have the financial resources to access the many forms of technology that are available. Computers, internet access, digital projectors, and subscriptions to video streaming websites are very expensive to purchase, cost money to support, and require technicians to maintain them. Districts must also provide training so that teachers are competent in the use of these tools. This also uses valuable staff development time which is already in short supply.

Teachers must also take the time to practice using the forms of technology and to modify their lessons to incorporate that appropriate forms of technology. The limited

time that teachers have to practice the use of technology and incorporate it into their lesson plans also has to be used to correct assignments, communicate with parents, serve on committees, and fulfill any other obligation the school requires of them.

In order for students to be exposed to the technology that they will use later in their chosen profession communities and states must provide adequate funding to school districts and school districts must provide the appropriate training for their teachers along with the appropriation of time to implement the use of technology. Our world is changing rapidly and the leaders of tomorrow need to be proficient with the use of technology to participate in an increasingly wired world.

APPENDIX A

Water Pollution Unit Plan

Part I: Getting to Know Water

Students will be assigned to groups of three or four and each group will be given a property of water to research and then give a presentation to the class. Possible properties include: density, dissolved oxygen content, adhesion, cohesion, polarity, surface tension, rate of vaporization, transparency, universal solvent, and phase changes. Students will present their findings to the class and explain how the characteristic is important to life on earth. There will also be some lab work with this part of the project. Some of the labs will be open-ended and some will be more “cookbook” type labs.

Teacher Notes: The ability level of the group should determine the property the group is assigned to study.

Objectives: Students should be able to...

- Explain the physical properties of water: density, dissolved oxygen content, adhesion, cohesion, polarity, surface tension, rate of vaporization, transparency, universal solvent, and phase changes
- Discuss how the physical properties of water are important to life on earth

Products

- A. Lab Report: Students will design a lab to study a property of water. Examples of this include measuring the dissolved oxygen content of water at different temperatures, measuring the density of water at different temperatures, measuring how quickly colored water moves up the vascular tissue in celery, or comparing factors that affect the rate of evaporation.

B. Presentation: Students will present their findings from their investigation to the class and explain how their property is important to life on earth. Examples of this description: Water’s transparency allows sunlight to move through water so that aquatic plants can carry out photosynthesis; Water’s change in density allows ice to float so that living organisms are not trapped as ice sinks; Cohesion allows plants to move water through the xylem without expending energy.

Rubric

Points	0	2	4	6
Variables in Lab Report	Did not list or control variables	Listed but did not control variables	Did not list variables but controlled variables	Listed and controlled variables
Conclusion in Lab report	Did not cite data or form a valid conclusion	Cited data but did not form a valid conclusion	Did not cite data but formed a valid conclusion	Cited data and formed a valid conclusion
Property’s Importance to Life	Did not relate property’s importance to life	Incorrectly related property’s importance to life	Correctly related property’s importance to life	

Schedule

Day One: Teacher should briefly introduce the properties of water that will be studied.

Teacher should break the class into groups of three to four students. Student groups should then have time to research their property online or in textbooks. Students should also discuss ideas for possible lab investigations.

Day Two: Student groups should create the lab investigation they will conduct. If time permits they should set up their lab.

Day Three: Student groups should conduct labs. Forming a conclusion will be homework for each student. Each member should have their own lab report.

Day Four: Groups should discuss what each person came up with for a conclusion and then form a group conclusion. They should then create their presentation for the class including how their property is important for life on earth.

Day Five: Group Presentations. Students should have a table with all of the properties of water that they can fill in as the presentations are given.

Example:

Property	Explanation	Importance to Life
Density		
Cohesion		

Possible Adjustments:

1. If there is a limited amount of time the properties of water could be presented by the teacher in lecture format.
2. Alternatives to the presentation could include students making video advertisements or brochures for their property

Part II: Round-and-Round It Goes

The second part of this project will be to study the water cycle. Students will take some notes over the different processes and parts of the cycle. They will then construct a model showing the water cycle that gives examples of each process.

Objectives: Students should be able to...

- Define condensation, precipitation, transpiration, evaporation, and runoff
- Diagram the water cycle
- Describe how plants and animals fit into the water cycle

Products

- A. 3-D Model: Students will create a model of the water cycle that shows all of the processes and includes descriptions of each one.

Assessment

Score	2	4	6
Model	Model is difficult to understand	Model is easy to understand	
Labels	More than half of the labels are misplaced or missing	Half to three fourths of the labels are correctly placed	Three fourths to all of the labels are placed correctly
Descriptions	More than half of the descriptions are incorrect or missing	Half to three fourths of the descriptions are correct and correctly placed	Three fourths to all of the descriptions are correct and correctly placed

Schedule

Day One: Teacher gives lecture on processes that make up the water cycle and gives examples

Day two: Students should bring materials to class and start work on models

Day three: Models should be displayed in classroom and students could be asked to use a rubric and fill it out for two to three models of other students.

Part III: How We Interact with Nature

The third part of the project will study the relationship between natural and social systems. This will start as a broad discussion of what these types of systems are. The students will then generate a list of all the natural and social systems they can think of. The final to this part will be an essay discussing three social systems and describing how they affect our water resources.

Objectives: Students should be able to...

- Describe four to five social and natural systems

- List natural and social systems that are associated with water
- Discuss how natural and social systems influence or interact with each other regarding water

Products

- A. List of Systems: In groups of 3 to 4 students should brainstorm and record as many social and natural systems as possible in 15 minutes
- B. Essay: Students should use the list of systems created with a group and choose 3 pairs of systems (one natural and one social) that interact or influence each other. This should be a five paragraph essay. The first paragraph should discuss general ideas of natural and social systems. The three body paragraphs should explain how the pairs of systems are related. The closing paragraph should discuss whether the interactions discussed in the essay are positive or negative and if there are any possible solutions for the negative impacts.

Assessment

Points	2	4	6
Format	Essay is not in paragraph form	Essay is not 5 paragraphs	Essay is 5 paragraphs
Content	Only 1-2 of the paragraphs contain the correct content	Only 3-4 of the paragraphs contain the correct content	All five paragraphs contain the correct content

Schedule

Day One: Teacher should introduce the concepts of natural and social systems. Students should then be divided into groups and given fifteen minutes to develop a list of systems.

Day Two: Teacher should introduce the format of an essay. Students should then choose three pairs of systems and show the teacher the pairs and describe how they interact. If the student has chosen appropriate pairs they can begin writing.

Day Three: Essays are due

Part IV: I Love Water

The fourth part of this project will allow students to study how they use water. They will take two online water use calculators and compare the accuracy and effectiveness of the two calculators. They will also discuss how they could reduce their water use on a daily or weekly basis.

Objectives: Students should be able to...

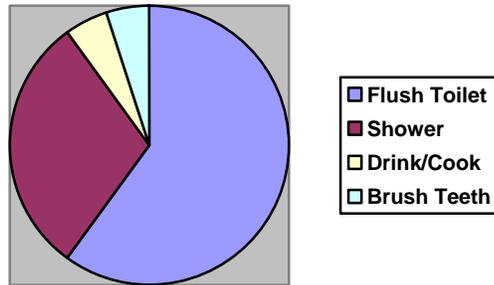
- Describe what activities use water and estimate which ones use the most water
- Discuss strengths and weaknesses of assessing daily or weekly water use
- Construct a pie graph to illustrate how much water each activity consumes relative to the other activities

Products:

- A. Table of Water Uses: Pairs of students should construct a list of activities that consume water and then rank the list from most water used to least water used. They should then take the water quizzes and record the amount of water they use according to two calculators. Students should also create a list of how they will reduce their water use.
- B. Table of Strengths and Weaknesses: The pairs of students should compare their water use list and compare the activities that are on the quizzes and the ones that

are missing. They should then create a table showing strengths and weaknesses of each one of the calculators.

C. Pie Graph: Students should construct a pie graph that shows which activities use the most water. Example:



Assessment

Points	2	4	6
Water Use Table	No Labels on table and table is hard to understand	Labels are used but table is hard to understand	Labels are used and table is easy to understand
Table of strengths and weaknesses	Only 1 correct strength or one weakness for each calculator is given	Only 2 correct strengths or 2 weaknesses are given for one of the calculators	At least 3 correct strengths and weaknesses are given for each calculator
Graph	No labels and graph is not to scale	Labels but graph is not to scale	Labels and graph is to scale

Schedule

Day One: The teacher should lead a class discussion on personal water use. Topics could include estimates of how many gallons of water students use per day and what they do to limit water use if anything. Students should then be divided into small groups to create a list of activities that use water and rank the list in order of greatest uses.

Day Two: Students should take two online water use quizzes to determine estimated water use per day. The following websites can be used:

<http://water.usgs.gov/watuse/> : Water use in the United States

<http://wwwga.usgs.gov/edu/sq3.html> : Determine how much water you use

<http://crippen2.nevada.edu/wateruse/> : water use calculator

<http://www.cnn.com/US/9811/10/water.use.down/> : water use drops?

Students should then compare their water use activities to the questions they were asked on the quizzes.

Day Three: Students in groups should work together to create tables with strengths and weaknesses of each calculator. What made them accurate or inaccurate in estimating water use. They should then create an individual pie graph showing what percentage of their total water use each activity makes up.

Part V: Minnesota's Water Polluted... No Way

Students will be placed in small groups and each group will choose an issue that deals with Minnesota. Students should choose between pH changes in lakes due to acid rain or mercury contamination. Each group will present its findings to the class in the form of a video public announcement. The final assessment of this will be a town meeting to discuss or debate the possibility of banning lead fishing lures and weights from county lakes, streams, and rivers.

Objectives: Students should be able to...

- Discuss the causes and effects of a water pollution issue facing MN
- Discuss possible solutions to the problem

Products

- A. Report: Each member of the group should write a brief report that describes the issue they are researching. The report should include the cause of the problem

and the effects the problem has on the environment and society. The report should also include the groups that are involved with the problem. The report should end with possible solutions to the problem.

- B. Public Announcement: Each group should create a five minute public announcement on video tape or DVD. The video ad should educate the public on the issue and its solutions.
- C. Town Meeting: Each student will be assigned a role to play at a town meeting and they will be responsible for researching information to present at the meeting that will support their position. The issue being discussed at the meeting is the possible banning of lead lures and weights from use in the county. Possible roles: Mayor, city council, fisherperson, bait owner, teacher, environmental group representative, home owner, small business owner of company that manufactures lead jigs, bird watcher, canoeist.

Assessment

Points	1	2	3
Report- Cause	Causes are listed but not described or described incorrectly	Causes are described correctly but not in detail	Causes are described correctly and in detail
Report- Effect	Effects are listed but not described or described incorrectly	Effects are described correctly but not in detail	Effects are described correctly and in detail
Report- Groups	Groups are listed incorrectly	Groups are listed correctly but their part is not described	Groups are listed and their role in the issue is described
Report- Solutions	Solutions are not valid	Solutions are valid but not described in detail	Solutions are valid and described in detail
Points	2	4	6
Public Announcement	Ad was creative but not informative	Ad was informative but not creative	Ad was creative and informative

Town Meeting Role	Voiced position on issue but did not have supporting evidence	Voiced position and had minimal supporting evidence	Voiced position and had substantial supporting evidence
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Schedule

Day One: Teacher should divide the class into groups of 2 to 3 students and assign them or let them choose between the two MN issues. The teacher should then inform students of what is expected in their report. They should then create a list of what they know about the problem and what they think they should find out.

Day Two: Research online or in library

Day Three: Discussion of research. Possible extra time to research.

Day Four: Write script for public announcement and start filming

Day Five: Watch public announcements

Day Six: Assign or let students choose roles for town meeting. Students should then be introduced to the topic of the town meeting. Students can have time to research the issue of lead in the environment.

Day Seven: Town Meeting. At the end of the town meeting the city council members should make a decision and describe why they made that decision. Sometimes it is fun to invite parents or other teachers to be the city council.

FINAL

At the end of the project I would let students choose the part of the project that interested them the most and let them choose their final assessment. They could choose the following: create a scientific study to demonstrate a property of water, create a 3D water cycle model with descriptions of how humans have affected each part of the cycle, creating a personal plan to reduce water along with a citywide plan, a research paper on

the creation and implementation of the Clean Water Act, or a research paper on a creative solution to a Middle East water conflict.

APPENDIX B

Air Pollution Unit Plan

Part I: Getting to Know the Atmosphere

Students will be assigned to groups of three or four and each group will be assigned a layer of the atmosphere to research and create a PowerPoint presentation to present to the class. The presentation should include the gases that make up the layer, the temperature of the layer, and any characteristic of that layer that is important to life on earth.

Objectives: Students should be able to...

- Describe how the atmosphere is structured in layers
- Discuss how the physical properties of the atmosphere make life possible on earth

Products

- A. Presentation: Students will present their findings from their research to the class and explain how their layer is important to life on earth. Examples of this description: How weather in the troposphere causes the recycling of water or the ozone layer of the stratosphere reflects ultraviolet rays.

Presentation Rubric

Score	1	2	3
Characteristics of Layer	No characteristics presented correctly	One characteristic presented correctly	Two or more characteristics presented correctly
Layer's Importance to Life on Earth	Layer's importance not explained correctly	Layer's importance is partially explained	Layer's importance is completely explained

Schedule

Day One: Teacher should briefly introduce the layers of the atmosphere that will be studied. Teacher should break the class into groups of three to four students. Student groups should then have time to research their atmospheric layer online or in textbooks.

Day Two: Student groups should conduct online or in the media center.

Day Three: Student groups should start creating presentation. Each member should be responsible for one slide of the presentation.

Day Four: Groups should finish their presentations and rehearse.

Day Five and Six: Group Presentations.

Part II: What We Cannot See Can Hurt Us

The second part of this project will be to study outdoor air pollution. Students will view a PowerPoint presentation during the class lecture on air pollution. Students will be given an outline of the notes and they will be responsible to fill in the outline as the presentation is given.

Objectives: Students should be able to...

- Name the major sources of air pollution
- Distinguish between primary and secondary pollutants
- Explain how we could reduce air pollution

Products

- A. Public Announcement: Students will be assigned a pollutant to research. After researching the pollutant they will have to make a public announcement that describes the cause of the pollutant and effect of the pollutant on the environment and on human health. The service announcement will also include ways to reduce the pollutant. The presentation can take the form of a brochure made with

Microsoft Publisher, a television commercial, or a PowerPoint to be presented at a town meeting.

Public Announcement Rubric

Score	2	4	6
Source of Pollutant	Source not explained correctly	Source partially explained	Source correctly explained
Effect on Environment	Effect not explained correctly	Effect partially explained	Effect correctly explained
Effect on Human Health	Effect not explained correctly	Effect partially explained	Effect correctly explained
How to Reduce Pollutant	No explanation of how to reduce	Some explanation of how to reduce	Complete explanation of how to reduce

Schedule

Day One: Teacher gives lecture on air pollution.

Day two: Students research their pollutant.

Day three: Students create their public announcement.

Day four: Students present their announcement.

Part III: Nowhere to Run, Indoor Air Pollution

The third part of the unit will look at indoor air pollution. Students will use the internet to research an indoor air pollutant. The student will create a small poster with Microsoft Publisher that will explain the source of the indoor air pollutant, its effect on human health, and how it can be reduced. The posters will be displayed throughout the school.

Objectives: Students should be able to...

- Describe four to five indoor air pollutants
- Explain the source of the pollutants
- Discuss how to reduce the pollutants

Products

- A. Poster: The poster should be created to catch the reader's eye and be informational.

Poster Rubric

Score	2	4	6
Source of Pollutant	Source not explained correctly	Source partially explained	Source correctly explained
Effect on Human Health	Effect not explained correctly	Effect partially explained	Effect correctly explained
How to Reduce Pollutant	No explanation of how to reduce	Some explanation of how to reduce	Complete explanation of how to reduce
Creativity/Organization	Very hard to follow	Creative but hard to follow or easy to follow but not creative	Creative and easy to follow

Schedule

Day One: Students will be assigned their pollutant and begin research.

Day Two: Students will finish research and begin designing poster.

Day Three: Students will start to create posters.

Day Four: Posters will be graded and displayed.

Part IV: We Share the Air

The fourth part of the unit will look at air pollution as a global issue. The class will watch a PowerPoint presentation on global warming and acid rain. The presentation will also show video clips from United Streaming. United Streaming is an online collection of videos that teachers can download from the internet if the school has a subscription.

The class will discuss why air pollution is considered a global problem.

Objectives: Students should be able to...

- Describe how one country’s pollution can be another countries problem
- Discuss why it is important for all countries to commit to reducing green house emissions
- Discuss social systems that create problems to certain countries reducing emissions

Products:

- A. Email: Students will use the internet to study the Environmental Protection Agency’s policies on air pollution and write a letter to their state representative informing them whether the EPA air pollution standards should be strengthened, eased, or kept the same.

Email Rubric

Score	1	2	3
Understanding of Policy	Does not demonstrate understanding of policy	Demonstrates some understanding of policy	Demonstrates complete understanding of policy
Support for recommendation	Does not build argument for recommendation	Builds partial argument for recommendation	Builds strong argument for recommendation
Format	More than 4 errors in format	Two or Three errors in format	One or fewer mistakes in format

Schedule

Day One, two, and three: The PowerPoint and video will take three days including class discussion.

Day four: Students will research EPA standards on air pollution and compose and send an email to their representative.

FINAL

The final project for each student will be to design and construct a webpage that can be used to educate the public to the general problems of air pollution. This website should contain the following: 1) a brief PowerPoint presentation describing the major sources of air pollution, 2) a table that lists the pollutant, its source, and its effect on human health and the environment, 3) an email link to send comments to, 4) a hyperlinks to other websites with similar information, 5) at least one graphic created by the student.

Final Rubric

Score	2	4	6	8
PowerPoint Information	Information is incorrect	Information is partly correct	Information is mostly correct	Information is correct
PowerPoint Format		PowerPoint is hard to understand		PowerPoint is neatly organized
Table Information	Information is incorrect	Information is partly correct	Information is mostly correct	Information is correct
Table Format		Table is hard to understand		Table is hard to understand
Email Link	Email link does not work	Email link works		
Hyperlink	Hyperlink did not work	Hyperlink worked but it was not to useful sites	Hyperlink worked and it was to useful sites	
Graphic	Unrelated graphic	Related graphic		

APPENDIX C

Air and Water Pollution Survey

Please circle the letter of the word or phrase that best answers the question, ties words together, or completes the phrase.

1. When neighborhood residents noticed a large number of dead frogs in the local pond, they traced the problem to a nearby car repair shop. It turned out that a tank of antifreeze had developed a leak. This is an example of
 - A. point pollution
 - B. nonpoint pollution
 - C. thermal pollution
 - D. ground water pollution
2. What is the cause of most of the pollution in the ocean?
 - A. Pollutants carried into the ocean by rivers
 - B. Sewage sludge dumped directly into the ocean
 - C. Oil spills from tankers and oil rigs
 - D. Ships dumping garbage into the ocean
3. Most large cities get water for households and industries from
 - A. deep wells
 - B. rivers or lakes
 - C. pumps connected to springs
 - D. removing salt from sea water
4. What is the most practical solution to the problem of making sure that everyone has enough fresh water to use?
 - A. Desalination
 - B. Drilling more wells into aquifers
 - C. Water conservation
 - D. Building more dams
5. Some communities have banned detergents containing high levels of phosphates because:
 - A. phosphates cause chemical reactions that raise the temperature of river and lake water, disrupting ecosystems
 - B. phosphates are not efficient cleaners
 - C. excessive phosphates in lakes may begin a process that causes fish to suffocate and die
 - D. phosphates kill algae and disrupt normal food webs in lakes
6. A major reason the era of building large dams in the United States has come to a close is that
 - A. smaller dams are more economical

- B. we have all of the water and electricity that we need
 - C. they are now too expensive to build
 - D. the environmental consequences are too great.
7. Thermal pollution affects aquatic environments because it
- A. can make water too warm for fish to tolerate
 - B. reduces oxygen in the water
 - C. has been circulated around power-plant engines
 - D. both A and B
8. A possible result of pumping large amounts of water from an aquifer is that
- A. farms produce fewer crops
 - B. the recharge zone shrinks
 - C. the aquifer cannot be recharged fast enough
 - D. groundwater stops being collected
9. Sludge is difficult to dispose of because
- A. it sinks to the bottom of waste-water treatment plants
 - B. it often contains toxic or hazardous materials
 - C. there is so much of it
 - D. it is noncombustible
10. Most of the water used in the United States is for
- A. Industry
 - B. Agriculture
 - C. Residential
 - D. Electricity generation
11. Carbon monoxide, sulfur dioxide, particulate matter
- A. secondary pollutants
 - B. primary pollutants
 - C. thermal inversions
 - D. primary sources
12. When automobile emissions react with oxygen gas and ultraviolet rays of the sun, a pollutant is formed that is called
- A. ozone
 - B. carbon dioxide
 - C. radon
 - D. sulfur dioxide
13. Ethanol
- A. can be used as a fuel for cars and trucks
 - B. is less polluting than gasoline
 - C. can be made from corn or sugar cane
 - D. All of the statements are correct

15. Two-thirds of the sulfur dioxide that pollutes our air is produced by
- A. automobile exhaust
 - B. industrial boilers
 - C. electrical power plants
 - D. catalytic converters
15. Which of the following is often used to remove poisonous gases by emissions released by industries?
- A. Catalytic converters
 - B. Scrubbers
 - C. Warm inversion layer
 - D. Crushed limestone
16. Which type of building would most likely have poor indoor air quality?
- A. A building in a cool climate with a good ventilation system.
 - B. A building in an urban area where windows are often open
 - C. A tightly sealed, air-conditioned building
 - D. A building that has not been repainted or recarpeted for several years
17. Schools in the United States have spent over \$40 billion to remove
- A. non-water-based paint
 - B. carbon dioxide
 - C. volatile organic compounds
 - D. exposed asbestos fibers
18. Which of the following pH measurements of rainwater would indicate acid precipitation?
- A. pH 6.0
 - B. pH 4.1
 - C. pH 7.3
 - D. pH 9.6
19. Which of the following contributes the most to acid precipitation?
- A. Burning of fossil fuels
 - B. Ethanol
 - C. Radon and ozone
 - D. All of the above contribute equally
20. Most of the pollution that causes acid precipitation to fall in southeastern Canada is released from
- A. Germany
 - B. central Canada
 - C. the midwestern and eastern United States
 - D. the southern United States

21. Which unit of study do you feel like you have the best understanding of the information?
- A. Water Pollution Unit
 - B. Air Pollution Unit
 - C. I understand them equally
22. Which unit of study did you like the most?
- A. Water Pollution Unit
 - B. Air Pollution Unit
 - C. I liked them both equally
23. Do you prefer taking notes from an overhead projector or PowerPoint presentation?
- A. Overhead
 - B. PowerPoint
24. Do you think that the use of technology improves student learning?
- A. Yes
 - B. No
25. Do you think that the use of technology motivates you to learn more than when technology is not used?
- A. Yes
 - B. No

APPENDIX D

Student's t-Test Data

T-test calculator

<http://www.physics.csbsju.edu/stats/t-test.html>

St. Benedicts and St. John's University

The results of an unpaired t-test performed at 09:49 on 10-JAN-2006

t= 0.557

standard deviation= 1.85

degrees of freedom = 74

The probability of this result, assuming the null hypothesis, is 0.579

Water Pollution Scores: Number of items= 38

2.00 3.00 4.00 4.00 4.00 5.00 6.00 6.00 6.00 6.00 6.00 6.00 6.00 6.00 6.00 7.00 7.00 7.00
7.00 7.00 7.00 7.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00 9.00 9.00 9.00 9.00 9.00 9.00
9.00 9.00

Mean = 6.89

95% confidence interval for Mean: 6.296 thru 7.493

Standard Deviation = 1.83

Hi = 9.00 Low = 2.00

Median = 7.00

Average Absolute Deviation from Median = 1.42

Air Pollution Scores: Number of items= 38

3.00 4.00 4.00 4.00 4.00 5.00 5.00 5.00 5.00 6.00 6.00 7.00 7.00 7.00 7.00 7.00 7.00 7.00
7.00 7.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00 9.00 9.00 9.00 9.00 9.00 9.00 9.00 9.00
10.0 10.0

Mean = 7.13

95% confidence interval for Mean: 6.533 thru 7.730

Standard Deviation = 1.88

Hi = 10.0 Low = 3.00

Median = 7.00

Average Absolute Deviation from Median = 1.50

APPENDIX E

Z-Test Calculation

z-Test: Two Sample for Means		
	Air Pollution	Water Pollution
Mean	7.131578947	6.894736842
Known Variance	1.88	1.83
Observations	38	38
Hypothesized Mean Difference	0	
z	0.757990489	
P(Z<=z) one-tail	0.224228338	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.448456677	
z Critical two-tail	1.959963985	

APPENDIX F

Chi Squared Calculations

<i>Number of Students with Score</i>	0-6 Points on Survey	7-10 Points on Survey	
Water Pollution Unit without Technology Observed	15	23	38
Expected	13	25	
Air Pollution Unit with Technology Observed	11	27	38
Expected	13	25	
	26	50	76

Expected Values

Expected Value for 0-6 Points	$(26*38)/76$	13
Expected Value for 7-10 Points	$(50*38)/76$	25

	$(\text{Observed}-\text{Expected})^2/\text{Expected}$	
0-6 Points on Water Pollution Survey	$(15-13)^2/13$	0.308
0-6 Points on Air Pollution Survey	$(11-13)^2/13$	0.308
7-10 Points on Water Pollution Survey	$(23-25)^2/25$	0.16
7-10 Points on Air Pollution Survey	$(27-25)^2/25$	0.16
Chi Squared Value	Total	0.936

Chi Squared Value	0.936
Degrees of Freedom	1
For significance at the 0.05 level, Chi Squared Value should be equal to or greater than	3.84

APPENDIX G

Quantitative Data on Student Attitudes

Question	Answer			
21. Which unit of study do you feel like you have the best understanding of the information?		Water	Air	Equal
	Number of students	12	17	9
	Percent of Students	32%	45%	23%
22. Which unit of study did you like the most?		Water	Air	Equal
	Number of students	11	21	6
	Percent of Students	29%	55%	16%
23. Do you prefer taking notes from an overhead projector or PowerPoint presentation?		Overhead	PowerPoint	
	Number of students	5	33	
	Percent of Students	13%	87%	
24. Do you think that the use of technology improves student learning?		Yes	No	
	Number of students	8	30	
	Percent of Students	21%	79%	
25. Do you think that the use of technology motivates you to learn more than when technology is not used?		Yes	No	
	Number of students	7	31	
	Percent of Students	18%	82%	

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