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Connecting Schools and Community with Real World Science Through Technology to Promote Environmental Literacy

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CONNECTING SCHOOLS AND COMMUNITY WITH REAL WORLD SCIENCE THROUGH TECHNOLOGY TO PROMOTE ENVIRONMENTAL LITERACY

by

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TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

I have had the opportunity to work in several science careers, from collecting aquatic biology data in streams, teaching science to grades 7-12, to water quality testing in a wastewater laboratory. The careers I have chosen have given me the opportunity to apply the knowledge I have gained from learning science concepts in school to the "real world". Unfortunately, in education, I do not feel that students can make the connection between the learning of science and applying that knowledge to their professional and personal lives, and many do not concern themselves with their environment or their place within it. Science can be an abstract, complicated subject to teach. Students have a difficult time relating to the concepts, and many may not see the value in what they are learning. These issues need to be addressed not only for the sake of preparing environmentally literate citizens, but also for students to see the bigger picture, i.e., that science is relevant and present every day in the world they live in. It is also important for teachers and students to see the part they play in the degradation or preservation of the environment. In other words, students today need to become environmentally literate citizens. What better way to do this could there be than to connect students and teachers' access to environmental education (EE) that is local and readily available?

PURPOSE

The purpose of my project, the first steps of which are described in this starred paper, was to review the literature and analyze informal feedback from teachers to develop guiding principles and apply them in the creation of Interactive Communications Technology (ICT) to connect St. Cloud, Minnesota area schools to the St. Cloud Wastewater Treatment Facility. In this paper, I describe the first steps of the project. I review the literature on environmental education (EE) and pedagogy, summarize the informal conversations I had with teachers, develop a few guiding principles, and show examples of a few ICTs that I have created with the study's goals in mind. Through this project, it is my hope that the citizens of St. Cloud will gain the opportunity for outreach in the community, and this will help facilitate engagement between students and education professionals.

METHODOLOGY

<u>Technical Terms</u>

Connected Science: The bridging of science concepts, students' knowledge, and community based knowledge to provide meaningful and intellectually challenging science learning (Bouillion & Gomez, 2001, p. 878).

Environmental Education (EE): Teaches children and adults how to learn about and investigate their environment, and to make intelligent, informed decisions about how they can take care of it (North American Association for Environmental Education, 2014).

Environmental Literacy: The capacity to understand and participate in evidence-based decision making about the effects of human actions in environmental systems (Covitt, Gunckel, & Anderson, 2009).

Information and Communication Technology (ICT): The study and ethical practice of facilitating learning and improving performance by creating, using and managing appropriate technological processes and resources (Richey, 2008).

Place-Based Education: Using the local community and environment as a starting point to teach concepts in language arts, mathematics, social studies, science, and other subjects across the curriculum (Sobel, 2004, p. 7).

As stated above, my overarching goal was to build relationships with and link the city of St. Cloud with students in the community schools through science and technology. The process I used to achieve that goal, as described in this paper, consisted of the first three components of my project: the literature review, beginnings of a relationship between the St. Cloud Wastewater Treatment Facility and grades 7-12 science teachers, and a sample construction of an ICT.

Literature Review

Within the overall literature on environmental literacy and education, I researched the objectives of environmental literacy and best practices for teaching grades 7-12 environmental education while analyzing 7-12 Minnesota academic standards. This laid the foundation by which the ICT prepared students for future environmental decision-making. The review also examined the pedagogy that supports school-community partnerships and the discussion of real world science in the classroom. This linked science water systems and community resources as tools for the teaching of concepts. Finally, the literature review looked at environmental education ICT platforms for relevancy and usefulness. This review of relevant literature served as a guide as I attempted to develop the St. Cloud ICT guiding principles.

Building relationships with teachers. The second step was the process by which the St. Cloud Wastewater Treatment Facility attempted to build relationships with grade 7-12 science teachers. As part of my position, I contacted and had informal conversations with teachers interested in including wastewater as a topic of study in their curriculum and used their thoughts in the creation of guiding principles.

Sample ICT. The third component was a sample construction of an ICT using the guiding principles developed from the literature review and the outcomes of teacher communication.

I conclude my paper with a discussion of the next steps in school community partnerships and ICT development.

LITERATURE REVIEW

Environmental Literacy and Education

Every day people make decisions that affect the environment in which they live. The choices made are intimately connected with not only with the natural systems, but also the socio-economic and political dimensions of society (Fauville, Lantz-Andersson, & Säljö, 2014). Environmental dilemmas are complex, because in many cases there is no perfect solution. These dilemmas also have a tendency to challenge the roles we play in our environment as well as make us reflect on our place on this fragile planet. Environmental issues have been discussed on a regular basis in the news and on the Internet because they have become a frontline issue. Expectations that citizens understand the environment and its complexities along with the contributions humans make in preserving or degrading the system is a big task. How does one reach these understandings? Professionalizing the field has been difficult. Sociopolitical in nature, a great deal of skepticism about the intensions and biases of environmental education in schools is present (Marcinkowski, 2010). EE is too often seen as overly emotional, hyped, superficial, and inaccurate (Marcinkowski, 2010). The EE community has had difficulty defining what it is that society needs to know and be able to do for some time (Landers & Naylon, 2002). Since environmental education is not a discipline, it is difficult to incorporate it into the education system, and is up to each individual teacher's interest—mostly on "natural study, ecology, or environmental issues" (Landers & Naylon, 2002). The EE community has taken steps to clarify what environmental literacy should look like, and what the scope and sequence of this literacy ought to be, to help educators contribute to student achievement (Marcinkowski, 2010). The field continues to fight to be seen as an important part of education, and the North American Association for Environmental Education (NAAEE) works diligently to address the criticisms and provide balanced, scientifically accurate guidelines for EE programs (Marcinkowski, 2010).

Based upon these considerations, I believe that to serve the surrounding school districts best, it is important for any civic or governmental agency to look at pedagogy as the driving force that will help create a technology to foster the ideals of what an environmentally literate citizen should be able to do. It is necessary then, to research what environmental literacy is by defining the components of quality environmental learning, why the components are significant, and the outcomes of teaching EE to students in grades 7-12. It is also essential to compile best practices for teaching grades 7-12 environmental literacy by looking at strategies with which to teach EE. Addressing the different reasons to teach EE to middle school and high school students, and their unique learning styles serves as the pathway for them to achieve literacy. Finally, to provide legitimacy, it is important to anchor the technology aspects in the Minnesota science standards and analyze whether or not they are a continuous framework for environmental literacy. These will serve as my guide for the rest of my literature review.

Environmental Literacy Background and Objectives

Understanding and appreciating the natural world and our place in it is an important goal for environmental education. There are assumptions that EE is a modern initiative because of the recent increase in concerns about the environment, but international political groups started defining and developing objectives of EE in the 1970s. The Belgrade Charter (UNESCO, 1976) and Tbilisi Declaration (UNESCO, 1978) stand as a strong foundation of core concepts and skills needed for literacy (Simmons, 2000). The NAAEE are one of the more current, national organizations that are helping to shape education toward developing more environmentally literate citizens. They have defined that an environmentally literate person knows:

> That their daily choices affect the environment, how those choices can help or harm the environment, and what they need to do individually or as part of a community to keep the environment healthy and sustain its resources, so that people enjoy a good quality of life for themselves and their children. (2014)

Environmental literacy is deeply rooted in the environmental education movement. The existence of EE in schools and the progression of environmental learning from kindergarten to college is key in preparing citizens to make thoughtful decisions and participate in problem solving for sustainability through what they have learned (Marcinkowski, 2010). The overarching objectives to gaining environmental literacy were developed by UNESCO in 1975 and have been used in significant standards and frameworks ever since. The four essential objectives (pp. 6-7) to achieve environmental literacy include:

- Awareness: to help social groups and individuals acquire an awareness of and sensitivity to the global environment and its allied problems.
- Attitude: to help social groups and individuals acquire a set of values and feelings of concern for the environment, as well as the motivation to actively participate in environmental improvement and protection.
- Skills: to help social groups and individuals acquire the skills for identifying and solving environmental problems.
- Participation: to provide social groups and individuals with an opportunity to be actively involved at all levels in working towards resolution of environmental problems. (UNESCO, 1978)

The objectives are arranged like a flexible ladder, from the simple to the more complex, each building on the step below. However, as with many models, the steps overlap in real life. The most important point to realize is that environmental literacy is not achievable without all the steps (Elder, 2007).

If people are aware of their environment and its accompanying problems, it is logical that they become more sensitive to it (Simsek, 2011). Thus, awareness and sensitivity are fundamental to environmental literacy. Many times, people do not pay attention to environmental dilemmas because they are not aware of them and cannot make the connection to how they affect them. Teaching students to be aware makes the environment a conscious part of a person's disposition and can be thought to influence their willingness to recognize and be responsive to the world around them (NAAEE, 2014). Environmental awareness by itself has a limited lasting effect but is beneficial for issues shown in the media and contributes toward government and public policy (Coyle, 2005).

There are dispositions that EE can teach students to develop a sense of value and concern for the environment. These qualities are not difficult because the connections are simple, but it is more than just giving scientific knowledge because if educators can foster a learner's sense of place in their environment, then it integrates with their attitudes and concerns (Simsek, 2011). One of the most significant ways a teacher can foster a nature of environmental intention is to make it a situation that they can relate to and care about, because if it affects their lives and the lives of their loved ones, they will take personal responsibility (Trilling & Fadel, 2009). A willingness to make an individual commitment and connect with an environmental issue is a step beyond just being aware.

Skills for environmental literacy include gaining knowledge about human and natural systems and processes as well as developing higher order thinking skills to recognize and resolve environmental problems. Schools use the Science disciplines to teach students about natural systems, and use some critical thinking and problem solving skills in the K-12 progression, but environmental education connection is interdisciplinary and includes social, cultural, and political involvement. It then can become a link for K-12 educators to cultivate responsible citizens (Simmons, 2000). As John Disinger (1993) suggests (as cited in Simmons, 2000), it also "has the potential as an exemplary vehicle for what many believe all of education should consider its primary function: furthering the development of higher-order skills—critical thinking, creative thinking, integrative thinking, and problem solving" (p. 519).

The top rung of the ladder in environmental literacy is active participation. Developing awareness and ecological knowledge is not enough to cause long lasting behavioral changes. Additionally, a well-built EE curriculum, one that develops the awareness, attitudes, and skills over time, is essential if students are to evolve into citizens that can understand and participate in discussions on the effects of human actions on the environment (Wilson, Tsurusaki, Zesaguli, & Anderson, 2007). This objective is obviously the most difficult to achieve because it requires a large amount of learning and long term changes in behaviors, enough to persuade learners to participate in action strategies such as consumer action, political action, and/or community service (Elder, 2007). Researchers Tomera et al., 1987, Hungerford and Volk, 1990 found that in order to foster long term changes in behavior, students must develop a personal connection to the environment and environmental issues, and there must be instruction that focuses on that ownership and empowerment to create long lasting changes. It is important to note, however, that environmental literacy does not guarantee that the learner will act, and it is not the role of education to decide what behaviors students should exhibit, but that they have the capacity for such behaviors through the teaching of the above objectives (Elder, 2007; Trilling & Fadel, 2009).

The Independent Commission on Environmental Education (ICEE) has called on science education to play the critical role of building environmental literacy (Salmon, 2000). Since science is a building block for EE, and EE is the foundation for environmental literacy, it is worth discussing best practices to teach EE with the purpose of fulfilling the environmental literacy objectives, as well as the possible outcomes. Specifically, because of my experience as a teacher and interactions with emerging and young adolescents, I have chosen grades 7-12 as the focus of my inquiry.

<u>Best Practices in Environmental Literacy</u>

Building environmental literacy in adolescents is a critical step in accomplishing the goal of creating a citizenry equipped to undertake environmental concerns. Research has shown that middle school and high school students play a key role in the acquisition of environmental knowledge. Younger students have the greatest capacity for learning and can intrinsically follow the purpose of environmental education. Thus, it is essential to start teaching EE at an early age and continue in the progression through high school and even into college (Stevenson, Peterson, Bondell, Mertig, & Moore, 2013). Middle school students are just starting to develop the cognitive skills associated with the objectives of environmental literacy. They are also at the peak stage of motivation to engage with their surroundings, both in nature and as a part of society (Stevenson et al., 2013). However, by the time that students are in middle school, interest in science and mathematics declines, and they have a difficult time seeing the value in what they learn, and why (James, 2011). It seems then that middle school students are at the tipping point where EE efforts should be strong and embedded in the curriculum, or else they start becoming less effective (Stevenson et al., 2013). In high school, students slow down even further in terms of environmental empowerment, and those not interested in science will not take courses that promote environmental literacy (Stevenson et al., 2013). High school is unique in the sense that it is the last chance educators have to prepare students to be responsible adults (Simmons, 2000).

EE has developed a research-based framework for literacy and the development of educational practices, but what is lacking is an organized way of measuring progress. McBeth and Volk (2010) summarize a major national study designed to create a baseline in middle school environmental literacy in the United States. They found that younger students have the most positive feelings towards the environment and a willingness to take action toward environmental problems, whereas older students appear to be more knowledgeable and skilled in their ecological understanding, but their attitudes towards the environment are moderate. What is deficient in both younger and older students is the understanding and use of decision-making and critical thinking skills, both major components of environmental literacy. This study demonstrates that K-12 environmental education is in its infancy. It also reveals that no one grade level is more important that the other in terms of learning the objectives of environmental literacy. Rather, criteria should be introduced in sequence, building off each level, to promote ecological competency as well as higher order thinking skills. In order to do this well, an examination of pedagogical approaches is essential.

Environmental Literacy Pedagogy

Finding the best approaches to develop environmental literacy in students has its challenges. Each grade level brings different attitudes, cognitive skills, and behaviors to the classroom that affect how they perceive the environment they live in. There are approaches to teaching EE that encourage the awareness, attitude, skills, and participation that true environmental literacy exhibits. It is important to research and utilize pedagogy that will fulfill the goals of providing an ICT that promotes environmental literacy and linkage of school to community.

Scholars have examined and synthesized overlapping choices of pedagogical approaches for developing environmental literacy effectively. They involve the use of inquiry methods and so-called 'connected science' that comprises place-based education and science in daily life. All of them are highly relevant to building a community-based technology for teaching students about the environment and wastewater.

Investigation and inquiry. Investigational approaches to science and environmental education are designed to encourage students to find solutions to real world problems. Such approaches create learning environments where students are "asking and refining questions; designing and conducting investigations; gathering and analyzing information and data; making interpretations, creating explanations, and drawing conclusions; and reporting findings" (Krajcik, Blumenfeld, Marx, & Soloway, 2000; Linn, Clark, & Slotta, 2003; Songer, Lee, & McDonald, 2002, as cited Marx et al., 2004). Inquiry-based approaches to environmental education give the opportunity for students to develop their critical thinking and problem-solving skills, while motivating them to explore and find ways to work effectively. Trilling and Fadel (2009) consider investigational approaches that include "authentic learning adventures [as]-they deepen understanding, hone skills, provide emotional satisfaction, and reveal new ways to work, learn, and thrive in our world" (p. 94). In environmental education, this type of learning fosters all four environmental literacy objectives, and gives the learner a sense of involvement and ownership in problem solving.

Connected science. The understanding and application of the skills, natural systems, and processes of science fosters environmental literacy. Science, in the context of environmental literacy, requires relevancy and should involve a part of the community in which students actually live. Unfortunately, students often see science as abstract and disconnected from the real world, and, from their perspective, it is often difficult to see how it is relevant in their own lives (Bouillion & Gomez, 2001).

A different approach to teaching in the form of connected science links science in the classroom and science in the community. Connected science is a means of "bridging science concepts, student's knowledge, and community based knowledge as a way to provide meaningful and intellectually challenging science learning" (Bouillion & Gomez, 2001, p. 878). Connected science is a concept that not only focuses on the "big ideas" of science, but also builds off students ideas and backgrounds in their community to use science as a tool for personal connections and significant environmental understanding. If educators can teach the idea that science connects to place, then students would be better prepared as environmentally literate citizens to reason effectively about human actions and natural systems. There are several approaches to teaching in this format, thus making science relevant: place-based education, teaching science from real life, and a systems approach (Feinstein, 2011).

Place-based Education

Schools are often isolated from the communities in which they reside. Especially in science teaching, formal education is seen as a separate entity, a place where learning formally takes place, disconnected from the relationships surrounding them (Gruenewald & Smith, 2008). One approach to uniting the local community and environment to schools is place-based education. David Sobel (2004) defines place-based education as the process of:

> Using the local community and environment as a starting point to teach concepts in language arts, mathematics, social studies, science, and other subjects across the curriculum. Emphasizing hands-on, real world learning experiences, this approach to education increases academic achievement, helps students develop stronger ties to their community, enhances students'

> appreciation for the natural world, and creates a heightened commitment to serving as active, contributing citizens. (p. 7)

As stated earlier, understanding and appreciating the natural world and everyone's place in it is an important goal for environmental education. Although place-based education should be multidisciplinary in nature, it is important to point out that teaching students about their local natural environment builds their sense of connection to the place in which they live, and promotes the objectives of environmental literacy of awareness, attitude, skills, and participation (Fisman, 2005; Sobel, 2004). If schools can create place-based environmental learning as student centered with real-world problem solving using authentic learning experiences, students will take ownership and learn critical thinking skills that will come naturally and last into adulthood to instill environmental stewardship (Trilling & Fadel, 2009). Science as a discipline plays an important role in teaching EE, since it is the pathway by which schools usually teach this field. Science place-based education includes all learners as they connect new science-related ideas to community-based experiences (Zimmerman & Land, 2014). Place-based education teaches students to "do" science rather than merely learn about it, and make real decisions about real scientific data in their community (Sobel, 2004). The benefits of using place-based EE are more than just success with instilling the objectives of environmental literacy and real science. Sobel (2004) found that students that participate in place-based science "performed better in science, and developed the ability to make connections and transfer their knowledge from familiar to unfamiliar contexts" (p. 28).

The best approach for creating place-based EE and/or science into schools is to initiate a partnership with the local community. Community members serve as resources and partners to facilitate real world learning and provide the context through which the education takes place (Gruenewald, 2005). In the formal sense, there are core strategies for creating place-based environmental education that include hiring an environmental educator to build connections and guide the program (Sobel, 2004). Unfortunately, many schools do not have this option or the resources to pursue a recognized place-based program. However, educators and community members who are enthusiastic about real-world learning can connect through science curriculum planning, community outreach programs, school career days, etc. to collaborate and create learning that incorporates student's ideas and leads to understanding of local environments and fosters a connection to place.

Science in Daily Life

A truly effective science connects its real uses to daily life (Feinstein, 2011). Daily life science linkage can happen when the science is meaningful and relevant. Science standards guide schools to teach the designated core concepts and skills of multiple science disciplines; however, it is up to educators to teach the application of the science concepts and skills for relevancy. The use of environmental dilemmas is an excellent approach to help students in this regard. Environmental dilemmas can be personal, and using them encourages students to question, evaluate evidence, make informed decisions, and become a participating member of the environment (Covitt et al., 2009; Feinstein, 2011).

<u>A Systems Approach</u>

Another perspective on teaching science education meaningfully and as used in daily lives is through a systems approach that uses resources from the local community (Covitt et al., 2009). The topic of water quality is a fine example of an issue that connects science to community, and human interaction to environmental systems. The need to protect water as a sustainable resource is an environmental concern critical for communities worldwide. Therefore, understanding how water moves through a system and interacts with human impacts is important for making human and environmental decisions (Covitt et al., 2009). The connection between the water cycle and human interactions ties easily into daily life and can be learned effectively by taking advantage of community resources such as water treatment facilities, wastewater treatment facilities and storm water schematics, as well as the watersheds that flow in the community. A simple question to ask might be, "Where do you get your water from?" or "Where does water go after you use it?" These questions link personal experiences and combine them with the relatable science of water systems, creating an authentic social context in which to learn.

Unfortunately, the current K-12 science curriculum and standards do not support the ability of educators to use the ideas of connected science to teach about water in environmental systems. Covitt et al. (2009) assessed what elementary, middle, and high school students know and can reason about the structure of environmental systems through which water flows, and how students trace matter through natural and human altered water systems. They found that even though students studied water systems in multiple science disciplines (Physical Science, Geology, Biology, and Chemistry), very seldom could they trace water and other materials through the environment, or understand water entering or exiting water systems. Personal connection, drawing from students' ideas, and building off prior knowledge can address water systems as a whole and gradually help students build connections for deeper, more meaningful understanding.

All three environmental literacy pedagogies target student's inquisitiveness and connection to place. An example that incorporates all three is the study of the Chicago River Project (Bouillion & Gomez, 2001). Teachers started the project using an investigational approach with students observing the Chicago Riverbank near their school. They noticed trash and debris and formulated the question, "How can we clean up the riverbank?" The process took a connected science approach when teachers taught the students about pollution in water systems, river modeling, soil erosion and ecosystem interactions. They also collected and analyzed water quality data. The project evolved into place-based environmental education when students formed project partnerships in the community such as with riverbank landowners, artists, parents, local scientists, and government entities to share their knowledge and motivating actions. The uses of all three pedagogies led to the cleanup of the riverbank, authentic student learning, and student satisfaction. However, the question remains: Can such holistic approaches be sustained in an era of standards and accountability?

Minnesota Academic Science Standards

Pitfalls

The effect of testing in schools and the emphasis on accountability and standards have limited subject areas in what and how they teach, and programs that may have significant value and learning opportunities have often been left on the shelf (Ernst, 2007; Gruenewald, 2005). This is especially true with EE. Even though there is growing evidence of the positive outcomes of teaching EE for environmental literacy and higher order thinking, teachers still do not incorporate it into curriculum because true EE is usually interdisciplinary and includes community projects (Ernst, 2007). Minnesota is no exception to the rule. The Minnesota Department of Education (MDE) implemented academic standards for Science in 2009, so all students have access to high quality science content and instruction. MDE (2013) defines science as:

> The active study of the natural and man-made world, including processes, structures, designs, and systems. Science students use their senses and tools to observe record and analyze data about the world and to make conclusions based on evidence. Scientifically literate young people can understand basic science concepts, use skills for doing scientific investigations, solve technical problems, and design technologies for today's world.

When developing the academic standards, the advisory board took into consideration Minnesota State Statute 115A.073 goals (MDE, 2013) for environmental education, which are as follows:

(a) 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 courses of action; and
(4) Understand the effects of multiple uses of the environment.
(b) Pupils and citizens shall have access to information and experiences needed
To make informed decisions about actions to take on environmental issues.

Minnesota has organizations that are actively working towards incorporating EE into schools, government, and society as well as tools to measure baseline environmental literacy in MN citizens. The MDE considered this and used specific documents to assist in the development of the current 2009 science standards. These documents include *Greenprint for Minnesota,* the state plan for environmental education developed by the Environmental Education Advisory Board (Minnesota Pollution Control Agency, 1996) and the *Environmental Literacy Scope and Sequence*, a tool for educators to help mainstream environmental education by providing a system approach (Minnesota Pollution Control Agency, 2013).

The standards were required to be implemented in the 2011-2012 school year, and 5th, 8th, and 10th grade students are currently tested for competency in science. At this time, however, there are no repercussions for students who do not pass the state science test, and the success rate on the test itself is heavily dependent on teachers using the standards as a framework for their curriculum. When examining the standards from grades 7-12, it is evident that Minnesota has interest in EE as part of the science framework. However, from the standpoint of UNESCO objectives, the MDE's definition of science, and the MN Statute for EE, the MN Academic Standards in Science falls seriously short in preparing students to integrate science into their everyday lives, and in teaching the skills needed for empowering them to be active citizens (Wilson et al., 2007).

The *Human Interaction* Substrand in the Minnesota 7-12 standards best fits with the motives for EE. Each discipline contains this Substrand, and the standards associated with it clearly require students to understand human interaction with living systems, earth systems, and physical systems. What sets these standards apart from the UNESCO objectives is that most of them only bring awareness to the environment and human impact. For example, in the 7th grade *Human Interactions with Living Systems* Substrand, the benchmark states that students should "Describe ways human activities can change populations" (MDE, 2013). The term "describe" only leads the student to give examples of the interactions, rather than go in-depth and or make personal connections to the subject, thus making it relevant to them. In the 8th grade *Human Interactions with Earth Systems* Substrand, the benchmark states that students should be able to "recognize that land and water use practices can affect natural processes" (MDE, 2013). Again, the term "recognize" only expects students to identify issues for awareness, it does not teach the deeper levels of environmental attitudes and skills needed to make decisions about the environment. In the 9-12th grade *Human Interaction with Earth Systems* Substrand, The benchmark requires students to be able to "Analyze the benefits, costs, risks, and tradeoffs associated with natural hazards" (MDE, 2013). This Benchmark appears to encourage students to examine more thoroughly the multiple dimensions of environmental dilemmas, so that they apply decision-making and higher-level thinking skills while using their knowledge of Earth systems. However, in the 9-12th grade *Human Interactions with Living Systems* Substrand, the benchmark once again merely assures that students develop awareness by using verbs such as "explain" and "describe" (MDE, 2013). Unfortunately, the MDE has shifted its focus to developing science, technology, engineering, and math (STEM) by requiring one credit of chemistry or physics in high school, a requirement that does not include the *Human Interactions* Substrand, or any EE components in the Minnesota Academic Standards in Science.

It is important to add that there are institutions, teachers, advisory boards, and associations that lobby for inclusion of environmental education in schools and communities. One example is *The No Child Left Inside Act*. It is a national movement that proposes giving states that develop environmental literacy plans additional funding. Currently, Minnesota has guiding documents for EE, but no plan that meets the criteria. Minnesota has also surveyed adults to help assess their environmental literacy. The MN Report Card on Environmental Literacy (Minnesota Pollution Control Agency, 1996) provides a glimpse of the environmental literacy of Minnesota adults so educators can develop better strategies. There is no shortage of curriculum planning programs for teachers to be involved with, or wild places for students to visit, but it is up to the institutions and teachers to make EE a priority in schools, and to instill the objectives of environmental literacy at all ages. Regrettably, the 7-12 Minnesota Academic Standards in Science do not guide curriculum in the direction of literacy and, instead, only scratch the surface of environmental awareness.

Environmental education, developed through sound scientific instruction with an emphasis on skill building, should meet the objectives set forth by UNESCO in 1975 for environmental literacy. It should start at a young age and continue to build through the middle and high school years through strategies like inquiry based and place based learning. Taking an interdisciplinary approach by uniting core subjects to environmental literacy leads to higher-level content and skills (Partnership for 21st Century Skills, 2014). This is significant in that students have the potential to grow and develop into citizens that care about sustainability and the environment, and will use higher order skills to help solve the problems surrounding the environment. Unfortunately, Minnesota is deficient in the science standards to foster this growth and development, but there is hope in the many groups associated with EE and that they will work to push the objectives forward into classrooms and, therefore, into society.

In summary, my literature review clearly shows that even though EE may be a controversial subject to teach, it is necessary for preparing students to make future environmental decisions based on scientific knowledge, sustainability, and environmental citizenry. Best practices in EE indicate that middle level students are at the cusp of losing touch with science and their appreciation of the environment if it is not embedded into the curriculum, and also that high school is the last chance to teach EE before adulthood. Unfortunately, the Minnesota Science Standards fall short of fostering environmental literacy without teacher initiation.

On a positive note, however, the literature reveals that there are several sound pedagogical approaches for teaching EE that involve the use of community resources and enable the development of several critical and higher order thinking skills. The review thus provided a great deal of material to inform the project, namely, the creation of guiding principles for the production of an ICT that could connect the City of St. Cloud with the St. Cloud Middle and High Schools. The next step would naturally be to identify teachers interested in collaborating scientifically and technically with the St. Cloud Wastewater Treatment Facility.

ACTIVE COMMUNITY PARTNERSHIPS

An important outcome of this project is to bring together the community environmental resource and the surrounding schools. Successfully promoting real science and environmental literacy involves teachers who are interested in the cause and willing to contribute to the learning. Following is a description of how that relationship was initiated. The City of St. Cloud sent an e-mail to 31 seventh to twelfth grade science teachers in the St. Cloud school district explaining:

> The St. Cloud Wastewater Treatment Facility would like to create a community outreach program focusing on environmental science, biology, chemistry, engineering, and technology. We would like the program to align with MN science standards and be beneficial, so we are looking for teachers to talk with in regards to curriculum and ideas as to how best serve community schools.

Of the 31 teachers contacted, eight replied with interest in connecting wastewater treatment with their curriculum. They comprised instructors in all four middle and high schools in the district who teach Physical Science, Biology, Chemistry, Geology, and Environmental Science in grades 6-12. I held informal conversations with the teachers and asked them four questions to guide the approach the city would take in building the technology and partnerships:

- *Do you teach anything about water/wastewater or environmental science issues in your class?*
- *How do you envision connecting authentic water/wastewater environmental issues with real science?*
- *What types of access to technology do you have?*
- *What technology would you like to help teach water/wastewater and/or environmental issues and authentic science?*

It became evident through my conversations that the Minnesota Academic Science Standards guided the curriculum in all schools interviewed. Except for the high school environmental science class (an elective), teachers did not appear to teach anything about water/wastewater and discussed environmental issues minimally, not because it was not important to them, but because of the lack of time and resources. Envisioning authentic science learning was a simple task for the teachers. These teachers provided several examples of science concepts that link to water/wastewater that they thought students could learn about and use to connect their science curriculum and the treatment facility: the water cycle and properties of water, conservation of matter and energy, molecule structure and function, as well as the scientific method and data interpretations. The St. Cloud area teachers suggested that using the Mississippi River, St. Cloud water plant and St. Cloud wastewater facility as the base for science learning would create personal relevancy and community learning.

Technology available to students was variable but extensive. All schools in the district have access to the Internet, but other than the Chemistry class that has its own set of MacBooks, teachers felt that reserving computer labs and laptop/iPad/Chrome Book carts could be difficult. Other technology mentioned in the interviews included document cameras, Interwrite boards, and Vernier probes.

All teachers believed that a visual representation of the facility would aid in the teaching of science concepts. The tool would be helpful because it would be available at any time, especially since most schools in the district cannot afford or have time to bring students on a field trip to the facility. Hence, the first request from the teachers to help students learn about water/wastewater and authentic science was to create an online virtual tour of the wastewater treatment facility. In addition, teachers suggested that real scientific facts such as data sets, graphs, local Mississippi water data, and interviews of employees be incorporated into the virtual tour to make a connection to science and the local community.

Information and Communication Technology in Education

A vast amount of information and communication technology (ICT) is available to schools and provides substantial and multi-faceted opportunities to learn. Today's students are eager to use technology for active learning. Students use the Internet, virtual labs, spreadsheets, and other online resources to gather, organize, and analyze information. Teachers and textbooks are no longer the sole provider of information, and their roles in the classroom have changed which includes the need to teach the skills required for the evaluation of technology use (Frisch, Jackson, & Murray, 2013). Technology, when used properly, can help make environmental education active, and aid in building environmental literacy as well as 21st century skills like digital literacy (Trilling & Fadel, 2009). EE and ICT are newer frameworks in education, but as Fauville et al. (2014, pp. 251-252) suggest, "Environmental education and ICT share the potential to support critical and action-oriented problem-based instructional practice." Both are promising,innovative tools that complement each other in learning while encouraging environmental literacy and higher order thinking skills.

ICT can take multiple forms in teaching EE and it opens up a whole new area of learning since it "overcomes budget, time, and security issues by giving students the ability to virtually visit remote places, or virtually conduct experiments that cannot be done at school" (Fauville et al., 2014, p. 279). Technologies assist in forming relevant connections between real world sciences and engage students with digital devices as part of learning (Frisch et al., 2013).

In order to utilize ICT resources effectively, teachers can consult EE websites and other technologies (see Appendix) which list the qualities that make ICT an effective tool to increase the chances that "a lesson will be remembered and can be used in other similar situations" (Trilling & Fadel, 2009, p. 31), of course, assuming that the focus is on learning. The International Society for Technology in Education has developed standards for "Digital Age Skills" for students (International Society for Technology in Education, 2014). Two of these standards complement the objectives of environmental literacy by encouraging the use of skills to develop well-informed citizens for the 21st century. Communication and collaboration using technology is similar to place-based education as it supports the process of students working collectively for enhanced learning. Technology also supports the development of critical thinking, problem solving, and decision-making skills. These standards were taken into account as I examined websites and technologies for my production of an ICT.

From the literature review, we see that active engagement is necessary for the success of EE. Technology can expand this to a large user community and increase national and international environmental awareness by allowing the user an opportunity to participate in multiple studies and forums, with access to real world data. Google Earth, United States Geological Survey, Environmental Protection Agency, and Hands on the Land, all have a large active community that create and display interactive data. Online simulations mimic scientific and environmental situations and visualize tools, concepts, and skills used by scientists to solve environmental problems. Ecokids, Phet Interactive Simulations, and Discovery Education are all free websites with research-based simulations that are designed to support active student learning in multiple science disciplines. Websites of local organizations also assist in enhancing the existing curriculum and can be used as a resource in environmental learning. The Minnesota Science Museum, County Soil and Water Conservation Districts, Minnesota Pollution Control Agency, Department of Natural Resources, and local city WebPages offer virtual tours, worksheets, curriculum, real-world data, contacts for speakers, and opportunities to volunteer. Engagement with local groups increases a sense of community and creates connections to local environmental concerns.

On a cautionary note, ICT tools can bring negative challenges to classrooms as well. Teachers are sometimes afraid of using technology since they are not as comfortable using it as their students are, and lack of training and support puts teachers further behind in technical understanding (Fauville et al., 2014). Computer hardware and software issues, lack of Internet access, and limited accessibility may create additional obstacles for effective teacher instruction. Carefully examining the use and application of environmental digital games are essential, since entertainment may become the focus instead of the concepts and content (Fauville et al., 2014). The use of ICT should be complementary to traditional tools because research examining the use of technology and student learning is not well documented, and if used solely, may contribute to alienation from nature and sense of community (Fauville et al., 2014).

The integration of the main ideas of the literature review and conversations with teachers gave me the foundational knowledge needed to understand why EE should be incorporated into school-community relationships, and how. Examining numerous environmental websites provided me with practical ideas of what a valuable ICT resource looks like, and how to build an effective tool for EE. What I needed were some guiding principles to use in the design of an ICT that would encourage positive skills and abilities concerning the environment to foster competencies, knowledge, and dispositions for environmental literacy in students (North American Association for Environmental Education, 2014).

INFORMATION AND COMMUNICATION TECHNOLOGY GUIDING PRINCIPLES

From the literature, it is evident that the current necessity to build citizens' knowledge of the environment is immense. We have also seen that in the promotion of environmental literacy, the Internet has led to an explosion of available resources.. However, technology is changing constantly. Therefore, in order to make sense of all this information, guiding principles are necessary that can be applied to any ICT and be based upon sound pedagogical approaches and the expertise and experiences of teachers. The following were the principles I was able to discern.

Principle One: *The ICT should lead to awareness of and sensitivity towards the environment.*

The first principle and the simplest idea is that awareness, incorporated into an ICT, aids in student sensitivity towards the environment. Building the ICT should enhance student awareness and help them make connections to their environment by creating a sense of place in their world. Not only that, the ICT must develop the ability of students to become aware of environmental issues in their community and formulate questions that connect them to the larger environmental community. Therefore, building awareness through an ICT can result in students developing conscious environmental relationships and constructing ideas and opinions about environmental issues.

Principle Two: *The ICT should support concern and other appropriate attitudes that help students develop a sense of value for the environment.*

The dispositions attained from the ICT should influence a student's willingness to choose actions that demonstrate positive personal responsibility towards impacts on the environment. Situations that students can relate to and care about can be a significant addition to the ICT, and used as a stepping-stone towards participation in community environmental issues.

Principle Three: *The ICT must employ evidence-based pedagogy to help students understand the interdependent relationships between environmental systems and human interactions through knowledge of science and development of higher-order thinking skills.*

The understanding and application of science concepts, natural systems, and relationships between human impacts and environmental systems is critical in encouraging environmental literacy. The ICT should use pedagogical approaches such as place-based education, investigational approaches and/or connected science to bridge science, student background, and community knowledge as a way to provide learning that promotes higher-order thinking skills.

Principle Four: *The ICT must provide opportunity for students to be actively involved in participating in environmental problems.*

The ultimate goal for environmental literacy is active participation. Achievement of the most complex of objectives is through a well-built environmental education curriculum and personal decision-making on the part of the student. The

ICT should be an integral part of fostering the ideals of environmental literacy by providing real and virtual, web-based opportunities for students to become actively involved in local and worldwide environmental problems.

Principle Five: *The ICT must be a living technology that uses input from area schools and community to create a dynamic platform that is relevant and useful to students.*

Education that integrates a curriculum around a study of place inspires stewardship and civic responsibility (Sobel, 2004). School-community relationships are critical in developing environmental connections and real world science applications. In order to teach the attitudes and skills needed for environmental education, contributions from community members and schools to create the information meets the objectives of environmental literacy. The ICT should reflect the communication and partnerships to create a relevant, up-to-date platform that students will see as important and teachers will find as a pertinent tool.

INFORMATION AND COMMUNICATION TECHNOLOGY AT WORK

ICT gives visualization of environmental systems as well as the dynamic interaction of humans in that system (Fauville et al., 2014). Rather than attempt a very sophisticated platform, I decided to start with a basic ICT that would help students visualize St. Cloud Wastewater Treatment facility and encourage questions about it. This ICT is only the beginnings of a tool I hope to one-day design for the community to promote environmental literacy. The ICT I chose and built that uses the guiding principles to lay the foundation of environmental literacy is a virtual tour of the St. Cloud Wastewater Facility using the web based presentation technology called Prezi.

Prezi is a "cloud based presentation software tool for presenting ideas on a virtual canvas. It uses flow of images, video, text and other media that work together to present ideas, lessons, and visions" (Prezi, 2014). I chose this tool for multiple reasons. The Prezi presentation is different from a slideshow. It moves, the user can zoom in and out, and it looks more like a tour. I wanted the technology to be user friendly and available free to all the schools. There are three options with additional benefits of the program for a fee. The City of St. Cloud intends to purchase the Pro option, which allows the creator to manage privacy settings and be able to edit on and offline. Teachers can have access to the presentation by signing up for the free educational account or watching it on the City of St. Cloud Wastewater Treatment website. They can also have access to an editable version of the presentation to manipulate the tour to fit the needs of the age group or subject matter. I used the guiding principles to assist in the production of the Prezi presentation, also taking into consideration the knowledge gained from looking at multiple Information and Communication Technologies used in education.

The virtual tour begins by asking general questions that can be used by teachers to get students to answer them in writing or to facilitate oral discussions. Questions like the one on the screen shot below can help students to become aware of how they interact with the environment. It supports positive attitudes towards the environment (Principles One and Two). It also fosters higher-order thinking skills by making students think about the environment as a system instead of individual pieces.

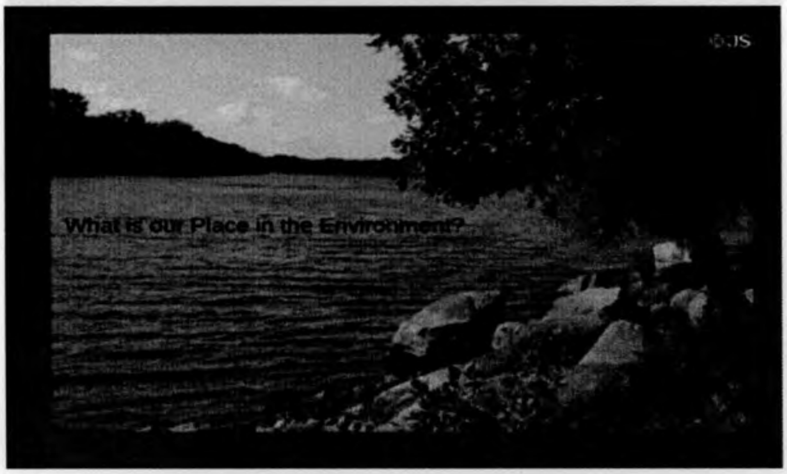

Figure 1

Question: What is Our Place in the Environment?

The second screen shot is that of a water cycle presentation that connects environmental concepts with human interactions through a visual representation (Principle Three). Using the flow of water, students can link an environmental system to the local community using connected science (Principle Five).

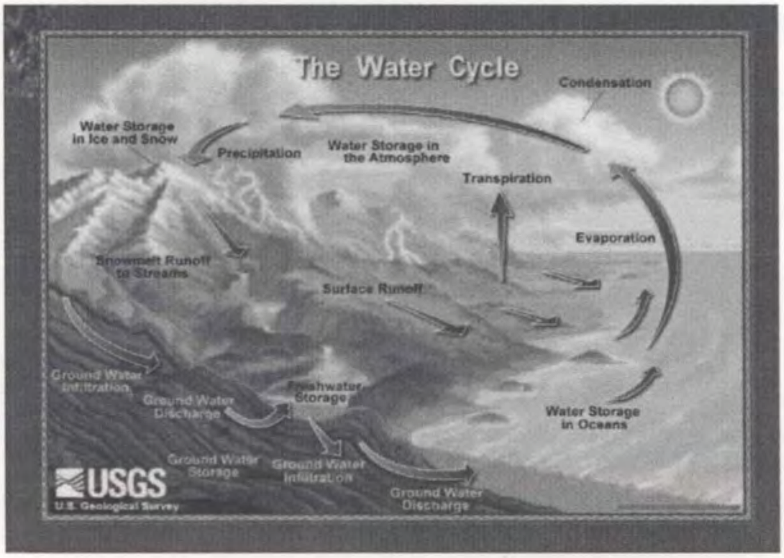

Figure 2

Water Cycle Presentation

In designing the tour, I took into account what teachers in the St. Cloud School District wanted in order to assist them in teaching about wastewater and environmental science. The tour (see Figure 3) gives a visual representation of the facility and a description of the treatment at each stage, and includes chemical, biological, and physical science concepts that the facility uses. Real science and a community environmental resource can help connect students using place-based education (Principle Five).

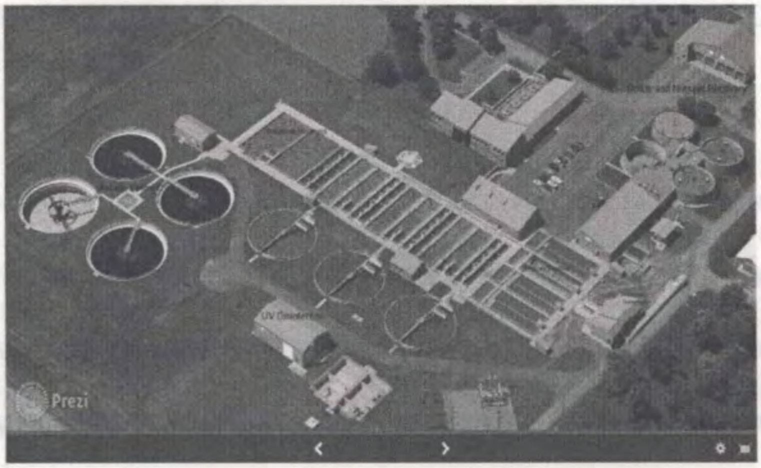

Figure 3

Visual Representation of the Water Treatment Facility

The last piece of the virtual tour (Figure 4) asks the question "What Can you do to Help Clean the Water?" This question can be the beginning of active environmental participation and helps form ideas for solving community water issues (Principle Four).

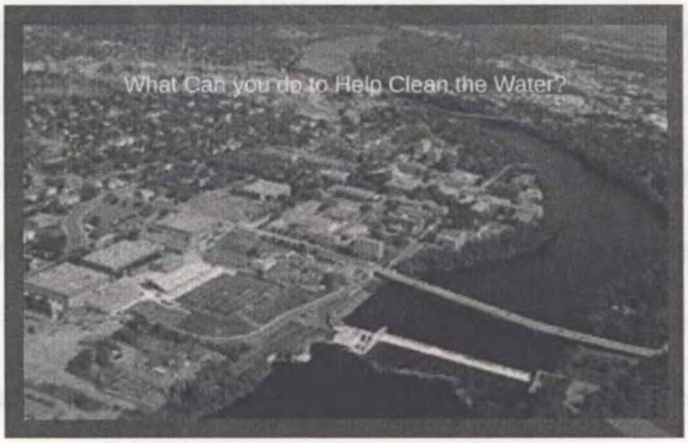

Figure 4

What Can You Do to Help Clean the Water?

NEXT STEPS IN THE ICT AND COMMUNITY OUTREACH

Successes

The main purpose of developing the ICT is to connect St. Cloud schools with a free community resource that uses real environmental science to solve issues that affect systems in our community. I received very positive feedback from local teachers of the importance to create a partnership to promote environmental literacy and sense of place in St. Cloud. The Prezi, as a prototypical ICT, starts the conversation of EE. In the near future, I would like to showcase the virtual tour to the teachers and ask for comments on how to improve the presentation and what additions they would like to see in terms of grade level, science concepts, and environmental literacy. The interactivity of the Prezi is mainly dependent on the teachers, but used more frequently, further features could be added such as videos and simulations.

Challenges and Solutions

I had a difficult time finding an ICT that was interactive, free, and available without additional program downloads for both the city and area schools. In the future, I would like to have access to a program that can be built without the needs of an IT department and interactive without requiring additional software or cost to schools.

After meeting with grades 7-12 teachers, it was apparent that each grade level and science discipline wanted something different with the ICT. It was difficult to meet the needs of every teacher, and a virtual tour was the only common request.

They had many ideas to fit the needs of their grade level and discipline. Middle school teachers made suggestions for using technology such as iPads to make movies of the facility to answer questions students had about wastewater treatment. The high school chemistry teacher suggested using their Vernier probes and software to test water chemistry parameters in river water, drinking water, and wastewater. In order to best accommodate individual schools, I would like to specialize the outreach program by grade level through the guiding principles. All teachers wanted a speaker to come into the classroom more than they wanted the technology of the facility. They thought it was important to make a real world connection with people that work in environmental science careers in order for the students to see how humans interact with water systems and the steps taken to help conserve the environment. They also suggested that an actual tour at the facility would be more beneficial to students so they could experience, with all their senses, the process in which wastewater is cleaned and the real science behind it, although the teachers realize that this may not be available to them because of bussing and time restraints. The use of an ICT would likely work in parallel with personal connection in the classroom or at the facility.

My ultimate goal with this project is to build an ICT for the St. Cloud Public Utilities department that includes the water plant, wastewater facility, wastewater collection and water distribution, storm water, and the hydroelectric plant. All facets of the department have one thing in common—the Mississippi River. St. Cloud is reliant on the river, but the community does not seem to tie the natural water system they live with to that of human interaction and dependency. It is of utmost importance to teach future citizens of St. Cloud, and surrounding areas, the importance of the river and its function in the community.

CONCLUSIONS

The essence of my argument for the paper is that there is disconnect between science concepts and the application of those concepts in the real world. In order to develop students into citizens aware of their natural surroundings and capable of making decisions based on evidence and in the best interest of the environment, fundamental knowledge of science and higher-order thinking skills should be an important framework in the education system. A strong environmental education program in schools supports the merits of environmental literacy by teaching the interdependence of natural systems, human interaction, and the roots in the local community and real world (Simmons, 2000). Pedagogy connecting science to daily life and community resources, as well as encouraging questioning, best fits the concept of authentic learning.

Students in the 21st century have access to an enormous amount of Information and Communication Technologies for a completely new range of learning experiences and investigations (Fauville et al., 2014). These resources can aid in promoting environmental literacy through following the guiding principles as detailed in the literature review. I believe schools can benefit from the use of a local resource to build relationships, gain real world science comprehension, and take advantage of the technology that exists today and in the future.

In the researching and writing of this paper, it is apparent to me that the educators I interviewed are eager to make school-community relationships happen. They see the big picture of environmental education and want to find ways to incorporate the ideals to fit into the MN Academic Standards in Science. They also recognize the importance of technology use and competence. but see it more as a tool to assist in the teaching of the environment. Human interaction in the community and natural spaces are the genuine environmental education.

Children will inherit many of the environmental challenges in the future. It is essential for society to build the knowledge and skills they need to tackle those issues. Environmental literacy does not just happen; it involves everyone who cares about our Earth and the sustainability of our future to foster the ideas that our surroundings are precious and fragile, and that concern for the environment is a civic duty.

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APPENDIX

Google earth
http://serc.carleton.edu/introgeo/google_earth/how.html

Ecokids
http://www.ecokids.ca/pub/games_activities/index.cfm

Citizen Science- United Stated Geological Survey
http://education.usgs.gov/index.html

Discovery Education
http://www.discoveryeducation.com/search/page/-/-/lesson-plan/environment/index.cfm

Environmental Protection Agency
http://www2.epa.gov/education

PhET Interactive Simulations
http://phet.colorado.edu/en/simulations/category/new

Science Museum of MN
http://www.smm.org

Minnesota Pollution Control Agency
http://www.mpca.gov

Hands on the Land
http://www.handsontheland.org

Minnesota Rural Water Association
http://www.mrwa.com/links.html

Stearns County Soil Water Conservation District
http://www.stearnscountyswcd.net/

MN Department of Natural Resources
http://www.dnr.state.mn.us/education/ee/programpartners.html

Sharing Environmental Education Knowledge
http://www.seek.state.mn.us/index.cfm