PLAN FOR THE INFUSION
OF ENVIRONMENTAL EDUCATION STANDARDS
INTO THE COMPREHENSIVE NATURAL SCIENCE 10 CURRICULUM
AT LINCOLN HIGH SCHOOL

by

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Abstract

Students attending Wisconsin Rapids Public Schools are required to take Comprehensive Natural Science 9 and 10 (CNS 9 & 10) to fulfill their 2-credit science requirement for graduation. These courses were designed to meet all of the Wisconsin Model Academic Standards for science. But they were not specifically written to cover the Wisconsin Department of Public Instruction Environmental Education standards. The purpose of this project was to determine which EE standards were covered within the CNS 10 curriculum, and then to augment the CNS 10 curriculum with activities through which both state science standards and EE standards would be covered. In addition, the activities were shared with the other CNS 10 teachers with the hope that they would also use the activities with their classes. This would ensure that all Lincoln High School students would receive a comprehensive environmental education background before graduating.

Because this project was not intended to produce an entirely new course (and new curriculum), administration approval was readily given. Upon analyzing the current CNS 10 curriculum, the author found that some EE standards were met by all teachers, but most were not.

The writing phase of the project began in the summer of 1999. The author was assigned to teach CNS 10 for the 1999 – 2001 school years. Appropriate activities were developed and implemented. These activities were shared with other CNS 10 teachers on an informal basis. The infusion of EE standards into the CNS 10 curriculum was
continued over the next year and a half, as time permitted.

The method devised for sharing this infusion plan with the other CNS 10 teachers was to conduct an in-service during the beginning of the 2003 – 2004 school year. At that time, the author described the purpose of this project, presented the CNS 10 teachers with classroom materials for conducting the activities, and had them actually complete part of one of the investigations included in this project. Continuing support for the CNS 10 teachers is needed if this plan is to be successful.
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Chapter 1

INTRODUCTION

Purpose: The purpose of this project was to infuse Environmental Education standards into the Comprehensive Natural Science 10 science curriculum at Lincoln High School.

Subproblems:

1. To what extent are EE standards already infused into the 10th grade integrated science curriculum?
2. What approval is needed from the Wisconsin Rapids Public Schools administration for this project?
3. What are characteristics of successful programs already in place?
4. What are some activities or materials that facilitate infusion of EE standards?
5. How can the author convince other science teachers at LHS to adopt the infused curriculum?
6. What will be the most effective way of sharing the completed curriculum?

Limitations:

1. This project does not evaluate the degree of infusion of EE standards at lower grade levels or in other disciplines.
2. This project will not compare the effectiveness of the infused curriculum at teaching EE standards to that of the curriculum currently in place.
3. This project deals with only 10th grade science at LHS.
Definitions of terms/abbreviations:

1. EE = environmental education; that part of education that deals with ecology-related social issues in the environment, and focuses on the development of responsible citizenship behaviors regarding those issues.

2. Integrated science = a thematic approach to teaching science which investigates parts of the real world from the standpoint of all science disciplines, rather than teaching science as discreet unrelated units, such as chemistry, biology, etc.

3. Infuse = the inclusion of ideas or concepts in an existing framework; as it relates to this project, the incorporation of environmental concepts, activities, and examples into existing curricular goals.

4. LHS = Lincoln High School

5. WRPS = Wisconsin Rapids Public Schools

6. CNS 10 = Comprehensive Natural Science 10; the required, integrated sophomore science course at LHS

7. WDPI = Wisconsin Department of Public Instruction

8. Constructivist teaching = a student-centered approach to teaching in which the teacher is the facilitator, guiding the students as they seek knowledge

Assumptions:

1. That EE standards are currently not included in CNS 10

2. That the infused curriculum developed in the project will be approved by WRPS board and LHS administration

3. That other CNS 10 teachers will embrace the infused curriculum
Rationale:

There are two main reasons why this project is important. One is the mandate by the Wisconsin Department of Public Instruction that EE be taught at Wisconsin public schools - a mandate currently not being met. In 1993, Wisconsin established environmental education goals which state, in part, that each school district “develop and implement a written, sequential curriculum plan incorporating instruction in environmental education into all subject area curriculum plans . . .” (WDPI, 1998). WRPS has not done this. The second reason for completion of this project is a belief held by the author that all people should embrace EE goals as part of their lifestyles. Students must be made aware of environmental issues, and be taught the skills with which to deal with the issues. Hungerford (1990) states that “in order for EE infusion to be successful, instruction must go beyond awareness and knowledge”, and must include teaching of issues analysis and citizen action skills.

Even though the WDPI mandate to teach EE is several years old, most students exit high school with, at most, spotty and incomplete instruction in EE. Currently, a minority of teachers, generally science teachers, or others for whom EE is a personal interest or passion provide EE instruction. There is no consistency in EE instruction at WRPS, and no guarantee that a student graduating from LHS has had sufficient exposure to EE goals and standards.

Knowing that CNS 10 instruction only somewhat addresses EE goals and standards, this author feels it is imperative that the entire year-long course consistently reinforces EE goals and standards. Because most WRPS students do not routinely
receive EE instruction it becomes that much more critical that the author do her part to
ensure that at least all CNS 10 classes include EE instruction. In order to accomplish
this, and to convince other CNS 10 teachers to include EE standards in their curricula, the
author designed an infusion plan. Simply adding additional activities to the CNS 10
curriculum may be viewed as a burden to the CNS 10 teachers. A common teacher
concern is that their days are already too full. Monroe (1994) says, “as important as EE
is, teachers tend to see it as just one more thing to squeeze in.” This plan will include
activities that will address both EE standards and Wisconsin state academic standards for
science; it does not increase the workload of the CNS 10 teachers. Since WRPS does not
offer any EE workshops for teachers, it is likely that teachers who hold pre-1985
certification have not had any EE teaching experience. Since one goal of this project is to
convince all CNS 10 teachers at LHS to use this curriculum, an inservice will give the
CNS 10 teachers training in teaching environmental issues investigation.

From a personal perspective, this author realizes that the health of the
environment depends on this and the next generation making responsible choices. Over
the past few decades we have become aware of environmental problems and issues, and
have been able to solve some; many still remain and new ones will surface. This author
feels it is her responsibility to help enable her students to learn to recognize issues,
analyze problems, and develop the skills to help to solve them.

To infuse EE standards into CNS 10 is the main focus of this project. It is also
the intention of the author to convince other CNS 10 teachers at LHS to adopt and use the
infused curriculum.
Chapter 2

REVIEW OF LITERATURE

Rationale for Teaching Environmental Issues:

The principle goal of education is to produce responsible citizens (Hungerford, 1990). This implies that educated citizens will have a general knowledge base concerning the environment in which they live, and it assumes that they will exercise their right to make decisions in a healthy and nondestructive manner. Classroom instruction that addresses EE goals facilitates this educational goal. The EE philosophy emphasizes awareness and knowledge of the environment, the formation of a positive environmental ethic based on knowledge, and fosters citizen action skills and experiences. To be a responsible citizen, one must not only be knowledgeable about, but willing to work toward maintaining a healthy environment, thus ensuring quality of life. In order for a teacher to help students become responsible citizens, EE should be incorporated into the lesson plans whenever possible.

Beginning in the 1930’s, the people of Wisconsin recognized the need for students to be given EE instruction. The decision was made that courses dealing with the conservation of natural resources be taught at all grade levels (WDPI, 1998). In 1983, EE instruction was mandated in Wisconsin. However, for various reasons these mandates have not been fulfilled. A study conducted in 1987 found that, even though state mandates exist, most schools in many states do not include EE in their curricula (Disinger, 1987). Yet, there is support for EE in school curricula by the general public

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and by the students themselves: "the environment is the highest ranked social issue cited by young people" (Zimmerman, 1993). EE is often taught as a separate course, is often inserted into science courses, or is otherwise taught when an individual teacher has a personal interest in environmental issues.

**Barriers to Inclusion of EE:**

The obvious question, then, is – why is EE not included in more schools’ curricula? Four overriding barriers to EE inclusion were found: conceptual (lack of consensus with regards to scope and content), educational (teachers’ own competence and familiarity with content material), logistical (perceived lack of time, funds, and resources for teaching EE), and attitudinal (teacher attitude toward science and EE instruction), (Ham, et. al., 1987). These barriers arose from teachers’ real or perceived lack of knowledge, experience, confidence, support, resources, etc., regarding EE instruction. A common misconception is that EE must be an “add on” to an already full schedule. Teachers perceive EE as one more thing to teach, rather than a method for teaching existing content. Infusing EE can add excitement to a classroom by giving students the opportunity to apply the principles learned in the core curriculum to local, national, or global issues (Monroe, 1994). Besides making learning more fun, infusing EE into one’s instruction will make it more relevant for the student.

Another problem faced by some teachers who wish to include EE is lack of suitable instruction materials (Simmons, 1989). Some national programs exist, like
Project WILD, Project Learning Tree, Project WET, etc., that provide activities which teachers can use in virtually any class, perhaps adapting them to give them local relevance. There are also scores of other EE activity guides available at the Wisconsin Center for Environmental Education at the University of Wisconsin in Stevens Point. Using these resources, a teacher can develop individual lesson plans or whole units or semesters of instruction.

**Inclusion of EE via Infusion:**

If made aware of existing resources, and given training or practice in using them, many teachers are likely to include EE in their classes (Ham, 1988). Many teachers think EE is, or should be, taught in science classes; they view EE as a science-related concept rather than a philosophy or method for teaching other core content. But, the WDPI Guide to Curriculum Planning in Environmental Education (1994) suggests that teachers from all disciplines (subject areas) can and should include EE, with emphasis in the visual arts, health, communication arts, science, and social studies. As stated previously, teachers in many disciplines do not feel prepared to include EE in their curricula. Providing inservice training to help teachers infuse EE into their classes is the key (Wade, 1996, Disinger, 1987). Considering that a major part of EE instruction is to guide students toward learning how to investigate issues, make observations, communicate, solve problems, etc., teachers from all disciplines can and should include EE standards in their lessons. And teachers will, if provided with training (Hungerford, 1990).
Inservice Teacher Training

Wade (1996) found that often an inservice would emphasize what to teach rather than how to teach. A better method is to offer an inservice that promotes a student-centered, constructivist approach to learning. A constructivist approach to teaching has been found to increase student comprehension and enjoyment of science (Lord, 1999).

Because this curriculum will utilize an outdoor teaching site, some resistance may be met to using it. At times, teachers are reluctant to leave the convenience and comfort of the classroom. Simmons (1989) has found that teachers require training in order to utilize "natural settings" in their curricula. She maintains that teachers are unlikely to take their classes outdoors unless they have support in 3 key areas: a) support services (including lesson plans, background information, site visits, and training), b) equipment needs (such as science equipment and field guides), and c) logistical support (extra staff for supervision and transportation). This project has been able to fulfill the first two support needs; no transportation is needed to use the site — it is located on school grounds.

It is clear that teacher training and the availability of long-term support will increase the probability that many of the CNS 10 teachers will adopt this curriculum. Providing access to EE materials and hands-on experience in teaching EE increases teacher involvement in EE (Brimmer, 1995).
SUMMARY

One fundamental goal of education is to produce responsible citizens. Teaching EE goals and standards is an excellent means of attaining that goal. However, this is not being done at most schools. There are many real and perceived barriers to teaching EE — the two most often cited are lack of time and training. Infusion of EE into existing curricula addresses the former concern, and providing ongoing training and support speaks to the latter. A successful implementation plan for inclusion of EE goals and standards into an educational program would infuse EE into the existing curriculum, and provide teachers with the training and support they need to feel comfortable with teaching EE goals and standards.
Chapter 3

METHODOLOGY

A Brief History of Science Education in WRPS:

In 1997, the WRPS science teachers began to re-design the district science curriculum. It was felt that the students needed a more comprehensive knowledge of science, and that the state standards for science were not being met. Historically, the majority of students graduating from LHS had taken only Earth Science as freshmen, and Biology as sophomores. This satisfied their 2-credit science requirement for graduation, but many Wisconsin Model Academic standards for science were not covered.

The result of 3 years of research by the district science teachers was an integrated, 2-year course called Comprehensive Natural Science 9 and 10. This course covers all district and state science standards, but was not written to specifically to cover the Wisconsin Model Academic standards for Environmental Education. Due to the personal interest in EE by some of the contributing editors of the course, some EE standards were met, by chance. Each teacher who teaches CNS 9 or 10 covers the same content and skills. The method by which they teach these is their choice; they may use any activity or resource they wish. The purpose of this project was to analyze the new curriculum to see which standards were consistently covered, and to introduce activities that would meet those standards not met.
Subproblems:

1. **To what extent are EE standards already infused into the 10th grade integrated science curriculum?** Because this author helped write some of the new CNS 10 curriculum, she knew there was some EE instruction included. The author examined the common activities used by all CNS 10 teachers to see which EE standards were covered by all teachers. The CNS 10 teachers routinely share ideas and materials, help each other plan lessons, and post labs and activities in a shared folder, so this information was readily available.

2. **What approval is needed from the Wisconsin Rapids Public Schools administration for this project?** The author presented her project idea to Gus Mancuso, principle of LHS, Sharon Toellner, district curriculum coordinator, and Al Pishke, science department chairman, in the fall of 1999, during a separate meeting with each. (These meetings also fulfilled a requirement for conducting interviews related to the project for a class the author completed – Natural Resources 614.) The author reminded each administrator of Wisconsin’s mandate to teach EE, and cited arguments to describe the benefits of EE instruction. Also, no curriculum funds were requested for the writing phase. The project was basically a revision of the methods by which the standards are to be taught so that they included EE standards. The activities were designed to cover Wisconsin Model Academic standards for science and Wisconsin Model Academic standards for Environmental Education.

3. **What are characteristics of successful programs already in place?** The author did
a literature search for an integrated high school science program with EE infused into the curriculum to use as a model for her plan. The search included an ERIC search, a general internet search, and an exploration of the curricula materials that WCEE has on hand. Bound periodicals in the UWSP library were also looked at.

4. **What are some activities or materials that facilitate infusion of EE standards?** The goal of the project was to ensure that sophomores at LHS were exposed to all EE standards while completing CNS 10. Once the author knew which standards were not being covered, she had to decide what would be the best means for covering the “missing” standards. Research indicated that learning in general was best facilitated using a constructivist approach – in other words, the students must be active participants in the learning process. To the author, this translated into finding hands-on projects for the students to design and conduct. The inspiration for appropriate projects came during classes taken for the fulfillment of credit requirements for the author’s master’s degree. While taking some summer school classes, the author was required to design lesson plans that would cover some EE standards. These lesson plans became the basis for the infusion plan found here. Because many of the standards not covered in CNS 10 deal with stewardship and citizen action skills, the lessons chosen to be infused were an excellent fit. The lessons were modified and expanded to address the “missing” EE standards. It was the intent of the author to see that all EE standards would be covered at some time in the year-long CNS 10 course.
5. **How can the author convince other science teachers at LHS to adopt the infused curriculum?** The author described the general goals of Environmental Education to the teachers participating in the inservice, and pointed out that the current curriculum did not meet the goals and standards of EE. She discussed with those teachers her own opinion of the importance of teaching stewardship, in an attempt to persuade them of its importance. Because both activities described in this curriculum utilize an outdoor teaching site east of LHS, the author anticipated some potential resistance. She described her past success in doing the activities with her classes, and gave the teachers in attendance some suggestions for using the materials and equipment efficiently.

6. **What will be the most effective way of sharing the completed curriculum?** In order to reach the CNS 10 teachers in the most efficient manner, the author decided to conduct an inservice before the start of the school year in August, 2003. At this time, her curriculum was written, and materials and equipment were organized. She prepared photocopies of all the background information and student handouts, and set up the LaMotte air quality device. On Tuesday, August 27, the author approached the CNS 10 teachers individually and asked them to attend an inservice meeting the following day. All but one teacher stated that they would be available. On Wednesday, August 28, 2003, the author conducted a 1 1/2-hour teacher workshop at LHS for 5 of the CNS 10 teachers. The author began the presentation with a brief overview of EE goals and standards, and explained that her master’s degree project was to infuse EE standards into the
CNS 10 curriculum. She reviewed the activities currently shared by the CNS 10 teachers that already address the EE standards, and summarized those standards not covered. The project consists of 2 unit plans; all standards not covered previously in CNS 10 are covered in these units.

Two packets of materials, one for each unit, were distributed to the teachers present. A brief summary of each unit was given, and an open discussion was held during which the teachers could ask questions about the plan. A demonstration of how to operate the La Motte air quality device was given, and the feasibility of assembling the Zebra Mussel monitoring devices was discussed.

**SUMMARY**

The author analyzed the existing CNS 10 curriculum to see which EE standards were not currently covered. She also sought approval for her project from her school and district administrators. Once approval was granted, she conducted a search for similar existing integrated high school curricula. The writing phase of the project began, with a search for long-term activities for the CNS 10 students that would meet the EE standards not being met. When the plan was completed, the author requested the presence of the CNS 10 teachers at a voluntary inservice, held on the first Wednesday of the 2003-2004 school year. At the inservice, the author described the significance of her project, the lesson plans she had written, and demonstrated how to use the materials and equipment associated with the plans.
Chapter 4

RESULTS

1. To what extent are EE standards already infused into the 10th grade integrated science curriculum? A complete list of the EE standards is provided in Appendix B. (The standards are categorized as A – Questioning and Analysis, B – Knowledge of Environmental Processes and Systems, C – Environmental Issues Investigation Skills, D – Decision Action Skills, and E – Personal and Civic Responsibility.) It was found that all of the “A” standards – Questioning and Analysis – were thoroughly covered by all CNS 10 teachers, (a requirement of the course is to complete an independent research project). Through some other common activities, standards B.12.10, B.12.13, B.12.15, B.12.21, and B.12.22 are also covered, (the students do research about famous scientists and the human population). While other lessons done by the CNS 10 teachers may meet other EE standards, no common activities are shared by all, so many standards likely are not being covered.

2. What approval is needed from the Wisconsin Rapids Public Schools administration for this project? Approval for the project was obtained in November, 1999, from Al Peschke (science department chair), Gus Mancuso (Lincoln High School principle), and Sharon Toellner (district curriculum advisor) during one-on-one meetings with each.

3. What are characteristics of successful programs already in place?

While many programs were found that addressed EE standards and goals for primary grades and middle school curricula, none were found for an integrated science program
for high school. It was found that using a constructivist approach to teaching is the most effective method for teaching science. Both activities developed by the author use this approach.

4. What are some activities or materials that facilitate infusion of EE standards? The writing phase consisted of finding activities for use in the CNS 10 class. While infusion plans were found for specific courses, all were for lower grade levels than the sophomore level needed here, and none were found for an integrated science course. An air quality testing activity was developed and used in the four sections of CNS 10 taught by the author in the 1999-2000 and 2000-2001 school years to cover many of the EE standards not met. The second plan is a 2-week long bio-monitoring activity that has been developed, but not yet implemented, as the author no longer teaches CNS 10. These plans can be seen in more detail below.

5. How can the author convince other science teachers at LHS to adopt the infused curriculum? During the opening discussion about the lack of coverage of EE standards in the CNS 10 curriculum, the teachers in attendance agreed that teaching stewardship was important. Two of the teachers in particular, Harvey Hayden and Craig Ontl, stated that this is a personal passion. Hayden stated, “Including the citizen action component was very important. This is often missing in many activities.” Ontl called the plans “relevant”, and expressed interest in including more EE standards in his lessons. All in attendance seemed convinced of the importance of teaching EE standards and goals. And, because most of the “leg work” of designing lesson plans, assembling materials, and aligning the lessons to the standards was done, the teachers seemed to be willing to
accept and use the plans. Mary Beth Freeh said, “I like the idea of monitoring Nepco Lake for Zebra Mussels. The students can see for themselves (that Zebra Mussels are present) instead of just taking someone’s word for it.” After hearing about the plans, Andrea Blattler remarked, “Sounds like a simple, interesting activity for students to do, . . . allows students to analyze [by using] the scientific method.” Overall, the response to the infused curriculum plans was positive.

6. **What will be the most effective way of sharing the completed curriculum?** Five CNS 10 teachers attended the teacher workshop conducted by the author on August 28, 2003. Some of the teachers were unaware that we owned the La Motte air quality device, and expressed interest in using it. The teachers agreed that the infusion plan presented did a thorough job of covering EE standards, as well as Wisconsin state science standards. The teachers at the workshop were well versed on the Zebra Mussel issue, and were aware of its presence in Nepco Lake. As a result of the discussion about assembling the monitoring device, it was decided that some of the science lab interns could probably produce some of the apparatuses, enabling several CNS 10 teachers to do the activities at the same time.
SUMMARY

The author has developed a CNS 10 curriculum package that covers all EE standards that were not currently addressed with the existing curriculum (Appendix C). The curriculum consists of two units that include research conducted by the students, analysis of data and experience in problem solving, and the carrying out of action plans developed by the students. She has also shared her plan with other CNS 10 teachers at her school, with the hope that they, too, will embrace the EE philosophy and include EE instruction in their CNS 10 classes.
It is clear that EE standards are not being taught to the extent to which they should be. Infusion into an existing curriculum may be the easiest way to ensure that the standards are covered. Many Wisconsin schools districts are currently facing budget constraints, so to introduce an entire new (required) course is not likely to be acceptable to most school boards. The problem, then, is how to get the standards taught.

Teachers tend to be reluctant to change an established curriculum. The reasons for this vary; lack of time is probably one of the most common reasons. Insufficient training or preparation is another, as this causes discomfort with a new curriculum. Other reasons for the reluctance to change could be lack of interest in or opposition to the new curriculum. Developing a core of support and ensuring ready access to materials and training should increase receptivity to change.

The degree to which an existing curriculum is changed also determines the extent to which it will be accepted. While most teachers would balk if required to re-write an entire course, asking them to amend a small part of it may be acceptable. And, if the writing, planning, and assembling of materials has been done, many teachers would embrace the new plan if it meets the standards that they must teach.

Research shows that how you teach greatly affects student outcomes. A constructivist approach to EE can enhance student learning and enjoyment. Many of the EE standards require that the student analyze data, solve problems, and take action on an issue. These skills are facilitated with a constructivist approach to teaching, rather than
using the traditional teacher-centered approach. Constructivist classrooms foster "thinkers with emerging theories about the world" (Cantrell, 1994), and give students experience in group work. Infusion of EE standards into an existing curriculum, using a constructivist approach to develop activities, is likely to increase student environmental literacy. When successful, this method can help prepare students for responsible membership in society, the ultimate goal of schools.

This author recommends that individuals for whom environmental education goals are important take the lead in implementing those goals into their curricula. In light of current budget constraints, it is unlikely that many school districts will initiate a move toward teaching the EE standards in new courses; writing new curricula and adding new courses is costly. So it is the opinion of this author that individual teachers must develop appropriate curricula using the standards as guidelines to ensure exposure of our students to environmental education goals and standards.

It is also recommended that districts improve EE instruction by identifying teachers with experience in teaching EE standards and goals, and giving those individuals the opportunity to share their knowledge with their peers. If funds are not available for new courses, release time for professional development workshops could be allocated. Or, funds could be provided for a part-time EE coordinator position – someone to provide ongoing support for teaching EE goals and standards.
BIBLIOGRAPHY


Bibliography, cont.


Internet resource:

APPENDIX A

Wisconsin's Model Academic Standards for Science

A. SCIENCE CONNECTIONS

Content Standard
Students in Wisconsin will understand that there are unifying themes: systems, order, organization, and interactions; evidence, models, and explanations; constancy, change, and measurement; evolution, equilibrium, and energy; form and function among scientific disciplines.

These themes relate and interconnect the Wisconsin science standards to one another. Each theme is further defined in the glossary following the science standards.

Performance Standards
By the end of grade twelve, students will:

A.12.1 Apply* the underlying themes* of science to develop defensible visions of the future

A.12.2 Show* how conflicting assumptions about science themes* lead to different opinions and decisions about evolution*, health, population, longevity, education, and use of resources, and show* how these opinions and decisions have diverse effects on an individual, a community, and a country, both now and in the future

A.12.3 Give examples that show* how partial systems*, models*, and explanations* are used to give quick and reasonable solutions that are accurate enough for basic needs

A.12.4 Construct* arguments that show* how conflicting models* and explanations* of events can start with similar evidence*

A.12.5 Show* how the ideas and themes* of science can be used to make real-life decisions about careers, work places, life-styles, and use of resources

A.12.6 Identify* and, using evidence* learned or discovered, replace inaccurate personal models* and explanations* of science-related events

A.12.7 Re-examine the evidence* and reasoning that led to conclusions drawn from investigations*, using the science themes*
B. NATURE OF SCIENCE

Content Standard

Students in Wisconsin will understand that science is ongoing and inventive, and that scientific understandings have changed over time as new evidence is found.

Performance Standards

By the end of grade twelve, students will:

B.12.1 Show* how cultures and individuals have contributed to the development of major ideas in the earth and space, life and environmental, and physical sciences

B.12.2 Identify* the cultural conditions that are usually present during great periods of discovery, scientific development, and invention

B.12.3 Relate* the major themes* of science to human progress in understanding science and the world

B.12.4 Show* how basic research and applied research contribute to new discoveries, inventions, and applications

B.12.5 Explain* how science is based on assumptions about the natural world and themes* that describe the natural world

C. SCIENCE INQUIRY

Content Standard

Students in Wisconsin will investigate questions using scientific methods and tools, revise their personal understanding to accommodate knowledge, and communicate these understandings to others.
Performance Standards

By the end of grade twelve, students will:

C.12.1 When studying science content, ask questions suggested by current social issues, scientific literature, and observations* of phenomena, build hypotheses that might answer some of these questions, design possible investigations*, and describe results that might emerge from such investigations

C.12.2 Identify* issues from an area of science study, write questions that could be investigated*, review previous research on these questions, and design and conduct responsible and safe investigations to help answer the questions

C.12.3 Evaluate* the data collected during an investigation*, critique the data-collection procedures and results, and suggest ways to make any needed improvements

C.12.4 During investigations*, choose the best data-collection procedures and materials available, use them competently, and calculate the degree of precision of the resulting data

C.12.5 Use the explanations* and models* found in the earth and space, life and environmental, and physical sciences to develop likely explanations* for the results of their investigations*

C.12.6 Present the results of investigations* to groups concerned with the issues, explaining* the meaning and implications of the results, and answering questions in terms the audience can understand

C.12.7 Evaluate* articles and reports in the popular press, in scientific journals, on television, and on the Internet, using criteria related to accuracy, degree of error, sampling, treatment of data, and other standards of experimental design

D. PHYSICAL SCIENCE

Content Standard

Students in Wisconsin will demonstrate an understanding of the physical and chemical properties of matter, the forms and properties of energy, and the ways in which matter and energy interact.
Performance Standards

By the end of **grade twelve**, students will:

**STRUCTURE OF ATOMS AND MATTER**

D.12.1 Describe* atomic structure and the properties of atoms, molecules, and matter during physical and chemical interactions*

D12.2 Explain* the forces that hold the atom together and illustrate* how nuclear interactions* change the atom

D.12.3 Explain* exchanges of energy* in chemical interactions* and exchange of mass and energy in atomic/nuclear reactions

**CHEMICAL REACTIONS**

D.12.4 Explain* how substances, both simple and complex, interact* with one another to produce new substances

D.12.5 Identify* patterns in chemical and physical properties and use them to predict* likely chemical and physical changes and interactions

D.12.6 Through investigations*, identify* the types of chemical interactions*, including endothermic, exothermic, oxidation, photosynthesis, and acid/base reactions

**MOTIONS AND FORCES**

D.12.7 Qualitatively and quantitatively analyze* changes in the motion of objects and the forces that act on them and represent analytical data both algebraically and graphically

D.12.8 Understand* the forces of gravitation, the electromagnetic force, intermolecular force, and explain* their impact on the universal system

D.12.9 Describe* models* of light, heat, and sound and through investigations* describe* similarities and differences in the way these energy* forms behave

**CONSERVATION OF ENERGY AND THE INCREASE IN DISORDER**

D.12.10 Using the science themes*, illustrate* the law of conservation of energy* during chemical and nuclear reactions

**INTERACTIONS OF MATTER AND ENERGY**

D.12.11 Using the science themes*, explain* common occurrences in the physical world
E. EARTH AND SPACE SCIENCE

Content Standard

Students in Wisconsin will demonstrate an understanding of the structure and systems of earth and other bodies in the universe and of their interactions.

Performance Standards

By the end of grade twelve, students will:

ENERGY IN THE EARTH SYSTEM

E. 12.1 Using the science themes*, distinguish between internal energies* (decay of radioactive isotopes, gravity) and external energies (sun) in the earth’s systems and show* how these sources of energy have an impact on those systems

GEOCHEMICAL CYCLES

E.12.2 Analyze* the geochemical and physical cycles of the earth and use them to describe* movements of matter

THE ORIGIN AND EVOLUTION OF THE EARTH SYSTEM

E.12.3 Using the science themes*, describe* theories of the origins and evolution* of the universe and solar system, including the earth system* as a part of the solar system, and relate* these theories and their implications to geologic time on earth

E.12.4 Analyze* the benefits, costs, and limitations of past, present, and projected use of resources and technology and explain* the consequences to the environment

THE ORIGIN AND EVOLUTION OF THE UNIVERSE

E.12.5 Using the science themes*, understand* that the origin of the universe is not completely understood, but that there are current ideas in science that attempt to explain its origin
F. LIFE AND ENVIRONMENTAL SCIENCE

Content Standard

Students in Wisconsin will demonstrate an understanding of the characteristics and structures of living things, the processes of life, and how living things interact with one another and their environment.

Performance Standards

By the end of grade twelve, students will:

THE CELL

F.12.1 Evaluate* the normal structures and the general and special functions* of cells in single-celled and multiple-celled organisms

F.12.2 Understand* how cells differentiate and how cells are regulated

THE MOLECULAR BASIS OF HEREDITY

F.12.3 Explain* current scientific ideas and information about the molecular and genetic basis of heredity

F.12.4 State the relationships between functions* of the cell and functions of the organism as related to genetics and heredity

BIOLOGICAL EVOLUTION*

F.12.5 Understand* the theory of evolution*, natural selection, and biological classification

F.12.6. Using concepts of evolution* and heredity, account for changes* in species and the diversity of species, include the influence of these changes on science, e.g. breeding of plants or animals

THE INTERDEPENDENCE OF ORGANISMS

F.12.7 Investigate* how organisms both cooperate and compete in ecosystems

F.12.8 Using the science themes*, infer* changes in ecosystems prompted by the introduction of new species, environmental conditions, chemicals, and air, water, or earth pollution

MATTER, ENERGY AND ORGANIZATION IN LIVING SYSTEMS

F.12.9 Using the science themes*, investigate* energy* systems* (related to food chains) to
show* how energy is stored in food (plants and animals) and how energy is released by digestion and metabolism

F.12.10 Understand* the impact of energy* on organisms in living systems*

F.12.11 Investigate* how the complexity and organization* of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy* used to sustain an organism

THE BEHAVIOR OF ORGANISMS

F.12.12 Trace how the sensory and nervous systems* of various organisms react to the internal and external environment and transmit survival or learning stimuli to cause changes in behavior or responses

G. SCIENCE APPLICATIONS

Content Standard

Students in Wisconsin will demonstrate an understanding of the relationship between science and technology and the ways in which that relationship influences human activities.

Performance Standards

By the end of grade twelve, students will:

G.12.1 Identify* personal interests in science and technology, implications that these interests might have for future education, and decisions to be considered

G.12.2 Design, build, evaluate, and revise models* and explanations related to the earth and space, life and environmental, and physical sciences

G.12.3 Analyze* the costs, benefits, or problems resulting from a scientific or technological innovation, including implications for the individual and the community

G.12.4 Show* how a major scientific or technological change has had an impact on work, leisure, or the home

G.12.5 Choose a specific problem in our society, identify* alternative scientific or technological solutions to that problem and argue it merits
H. SCIENCE IN SOCIAL AND PERSONAL PERSPECTIVES

Content Standard

Students in Wisconsin will use scientific information and skills to make decisions about themselves, Wisconsin, and the world in which they live.

Performance Standards

By the end of grade twelve, students will:

H.12.1 Using the science themes* and knowledge of the earth and space, life and environmental, and physical sciences, analyze* the costs, risks, benefits, and consequences of a proposal concerning resource management in the community and determine the potential impact of the proposal on life in the community and the region.

H.12.2 Evaluate* proposed policy recommendations (local, state, and/or national) in science and technology for validity, evidence, reasoning, and implications, both short and long-term.

H.12.3 Show* how policy decisions in science depend on social values, ethics, beliefs, and time-frames as well as considerations of science and technology.

H.12.4 Advocate a solution or combination of solutions to a problem in science or technology.

H.12.5 Investigate* how current plans or proposals concerning resource management, scientific knowledge, or technological development will have an impact on the environment, ecology, and quality of life in a community or region.

H.12.6 Evaluate* data and sources of information when using scientific information to make decisions.

H.12.7 When making decisions, construct a plan that includes the use of current scientific knowledge and scientific reasoning.
APPENDIX B

Wisconsin’s Model Academic Standards for Environmental Education

A. QUESTIONING AND ANALYSIS

Content Standard

Students in Wisconsin will use credible research methods to investigate environmental questions, revise their personal understanding to accommodate new knowledge and perspectives, and be able to communicate this understanding to others.

Performance Standards

By the end of grade twelve, students will:

A.12.1 Identify questions that require skilled investigations* to solve current problems* cited in literature, media, or observed through personal observations

A.12.2 Suggest possible investigations* and describe the results that might emerge from the investigations*

A.12.3 Evaluate personal investigations* and those of others, critiquing procedures, results and sources of data and suggest improvements to the investigations*

A.12.4 State and interpret their results accurately and consider other explanations for their results

A.12.5 Communicate the results of their investigations* to groups concerned with the issue*

B. KNOWLEDGE OF ENVIRONMENTAL PROCESSES AND SYSTEMS

Content Standard

Students in Wisconsin will demonstrate an understanding of the natural environment and the interrelationships among natural systems.

Performance Standards

By the end of grade twelve, students will:

B.12.1 Evaluate the relationship of matter and energy* and the flow of energy* in natural, managed, and built systems
B.12.2 Describe the value of ecosystems* from a natural and human perspective; e.g., food, shelter, flood control, water purification

B.12.3 Evaluate the stability and sustainability* of ecosystems* in response to changes* in environmental conditions

B.12.4 Analyze the factors that determine the number of organisms that can exist in a given area

B.12.5 Analyze the past and current trends in ecosystem* degradation and species extinction

B.12.6 Predict population responses to changes* in environmental conditions

B.12.7 Evaluate the importance of biodiversity*

B.12.8 Relate the impact of human activities in ecosystems* to the natural process of change, citing examples of succession*, evolution*, and extinction

B.12.9 Evaluate ways in which technology has expanded our ability to alter the environment and its capacity to support humans and other living organisms

B.12.10 Identify and evaluate multiple uses of natural resources* and how society* is influenced by the availability of these resources

B.12.11 Assess how changes in the availability and use of natural resources* (especially water and energy* sources) will affect society and human activities; such as transportation, agricultural systems, manufacturing

B.12.12 Evaluate the environmental and societal costs and benefits of allocating resources in various ways and identify management strategies to maintain economic and environmental sustainability*

B.12.13 Analyze how different political and governmental systems manage resource development, distribution, consumption, and waste* disposal

B.12.14 Investigate how technological development has influenced human relationships and understanding of the environment

B.12.15 Describe changes* in the rates of human population growth in various societies and the factors associated with those changes* related to economic and environmental sustainability

B.12.16 Analyze how natural resource* ownership and trade influences relationships in local, national, and global economies
B.12.17 Explain the concept of exported/imported pollution;* e.g., smoke stacks, watersheds, and weather systems

B.12.18 Analyze cause and effect relationships of pollutants and other environmental changes* on human health

B.12.19 Illustrate how environmental quality affects the economic well-being of a community

B.12.20 Describe the risks of producing pollutants

B.12.21 Research the roles of various careers related to natural resource* management and other environmental fields

B.12.22 Research individuals who have made important contributions to the field of resource management

C. ENVIRONMENTAL ISSUE INVESTIGATION SKILLS

Content Standard

Students in Wisconsin will be able to identify, investigate, and evaluate environmental problems and issues.

Performance Standards

By the end of grade twelve, students will:

C.12.1 Compare the effects of natural and human-caused activities that either contribute to or challenge an ecologically and economically sustainable* environment

C.12.2 Explain the factors that contribute to the development of individual and societal values*

C.12.3 Maintain a historical perspective when researching environmental issues*; include past, present, and future considerations

C.12.4 Identify strengths and weaknesses of different approaches to investigating an environmental issue* and identify some of the assumptions for each approach

D. DECISION AND ACTION SKILLS

Content Standard

Students in Wisconsin will use findings from environmental issue investigations to develop decision-making skills, and to gain experience in citizen action skills.
Performance Standards

By the end of grade twelve, students will:

D.12.1 Identify a variety of approaches to environmental issues*, evaluate the consequences of each, and select and defend a position

D.12.2 Evaluate reasons for participation or nonparticipation in an environmental activity in the home, school, or community

D.12.3 Describe the range of political and legal options available to resolve an environmental probable*; state for each the costs, benefits, and limitations of effectiveness in practice; select and defend the best option

D.12.4 Describe the rights and responsibilities of citizenship in regard to environmental problems* and issues*

D.12.5 Develop a plan to maintain or improve some part of the local or regional environment, and enlist support for the implementation of that plan

D.12.6 Identify and analyze examples of the impact beliefs* and values* have on environmental decisions

D.12.7 Analyze political, educational, economic, and governmental influences on environmental issues*, and identify the role of citizens* in policy formation

D.12.8 Use cost-benefit analysis to evaluate proposals to improve environmental quality

D.12.9 Describe the regulatory and economic approaches to improving the environment and explain the advantages and disadvantages of each

E. PERSONAL AND CIVIC RESPONSIBILITY

Content Standard

Students in Wisconsin will develop an understanding and commitment to environmental stewardship.

Performance Standards

By the end of grade twelve, students will:

E.12.1 Articulate their personal beliefs* regarding their relationship to the environment

E.12.2 Write a plan of action based on personal goals of stewardship* for an economically and ecologically sustainable* environment

E.12.3 Take action in regard to environmental issues* in the home, school, or communities
CNS 10 – Air Quality

This series of activities introduces the student to a variety of types of air pollution, and involves the student in both qualitative and quantitative air-quality testing. This lesson is best suited for the “Natural Systems and Cycles” unit, as it deals with matter cycling and impact of humans on the environment. The activity includes discussions about the effects and sources of pollution, detects the general air quality of an area using lichens as an indicator species, and measures the amount of several kinds of air pollutants, using the LaMotte Air Pollution detector. The lesson will require at least five 50-minute class periods.

These standards are covered by this lesson:


Objectives: at the end of this lesson, the student will be able to –

- list selected air pollutants & describe their sources
- describe the affect of air pollutants on the environment and human health
- perform air quality testing procedures
- collect, interpret, analyze, and share data
evaluate data collection methods for reliability and accuracy

identify 3 different kinds of lichen – crustose, foliose, fruticose – and classify the environmental conditions that foster their growth

describe the symbiotic relationship of lichen

define indicator species

**Are You Lichen the Air Out There?**

**Background Information:**

Because lichens obtain most of their water and nutrients from the air (unlike plants that rely on substrate for the majority of their elemental needs), these organisms are prime collectors of air borne pollutants. Heavy metals, gasses, and acid rain all effect lichens in one way or another.

People use lichens for many things. Some of these products include perfume, dye for Harris Tweeds, model train kits (the trees), antibiotic creams, and litmus paper. Reindeer eat lichens found on the tundra, and lichens aid in primary succession.

**Identifying types of lichens and Measuring lichen growth on trees:**

Use the student activity pages titled “CNS Lichen Study”, pages 41, 42, & 43.

**Use of LaMotte Air Quality Detector:**

A brochure explaining how to use the detector is included in the case. It is a battery-operated device through which the air to be tested is bubbled. Chemical tests are
performed on the water, after a prescribed length of time. The device tests for these materials: ammonium, chlorine, carbon monoxide, nitrogen dioxide, hydrogen sulfide, and sulfur dioxide. Testing times range from 20 minutes to 40 minutes.

Day 1 & 2

Using a variety of methods, the students will learn about gasses produced by industry and combustion, (such as CO, NO2, SO2, CO2, HS, NH4, O3, etc.) This may be accomplished with a teacher-led discussion, web search, textbook or other print media readings, video, oral reports, etc. The student should be able to describe several kinds of air pollutants, as well as the effects those pollutants have on the environment. Discuss possible sources and types of pollution in the area. The discussion/research should also include these topics – matter cycling, formation of acid rain, global warming.

Display the LaMotte Air Pollution detector. Describe how it works. (It tests for these pollutants: ammonia, chlorine, carbon monoxide, nitrogen dioxide, hydrogen sulfide, and sulfur dioxide.) Assign a small group of reliable students to set up the monitoring device on the sidewalk north of LHS, and have them collect samples over the next two days.

Homework assignment: find out the effects of these pollutants and their sources: sulfuric acid, sulfur dioxide, nitric acid, hydrogen fluoride, ozone, nitrogen dioxide, sulfur dioxide. The Miller text *Environmental Science* has this info in chapter 9, or other sources may be used.

Form a hypothesis that addresses this question: What is the quality of the air in the area surrounding Lincoln High School?
Day 3

Present the background material about lichens to the students. Have several examples of crustose, foliose, and fruticose lichens available for their examination. Give them practice identifying the three types of lichens. Discuss the fact that most fruticose lichens are very sensitive to air pollution, and can be used as an “indicator species” to detect the presence of air pollution in an area. Crustose lichens are the least sensitive, and foliose are moderately sensitive.

The students will measure the relative numbers of the three types of lichens found in the small woods located to the east of Lincoln High School. They will use this data to determine the basic air quality around the school.

Day 4

Compare data found by the class from both the lichen measuring and the LaMotte detector, and rank the air quality of the area. Ask the students which monitoring method is the most accurate and reliable. Discuss the probable reasons for the data found: If any pollutants were found, what are their possible sources? Can you verify this? If no significant pollution was detected, what can you conclude about the emissions from the local industries?

Day 5

Assessment:

The students will compose and word-process a lab report that describes the activity
procedures, data, and results. They will write a conclusion statement that addresses their original hypothesis. They should also answer these questions: What kinds of lichens were found at this site? What were their sizes? Based on this data, how would you assess the air quality at this site? What kinds and concentrations of air pollutants did the LaMotte Air Quality device find? Based on this data, how would you assess the air quality at this site? Compare the results of the two types of testing. Are the results the same or different? If different, how do you account for this? Which method do you think is the more accurate and reliable? Why? How could you verify your results?

Go to the computer lab so the students can type their papers.

Extension: Offer this activity as enrichment for advanced students, or as extra credit:

- Where else in the city would you like to test the air quality? (Do it)
A lichen is a fungus and an alga living together. Each helps the other. The fungus provides the alga with water, shelter and minerals. The alga does photosynthesis, providing both with food. The relationship is called mutualism or symbiosis.

Because lichen generally grow on walls, rocks or tree trunks above the ground, they absorb many chemicals from the air. They are long-lived and slow growing, so chemicals found in the air accumulate in their tissue. This makes them ideal indicators for air pollution.

Lichens can be used to test for sulfates, nitrates, ozone and other gases, as well as many heavy metals including lead, iron and mercury. The Wisconsin DNR has set up lichen monitoring sites in Marathon County and in Port Edwards to test for mercury emissions.

There are 3 main classes of lichens:
1. **Crustose** – a flat, sometimes powdery lichen that spreads over the surface of the rock or tree it grows on. Can be orange, yellow, brown, gray or black.

2. **Foliosed** – a somewhat taller or thicker lichen that crustose with lobed or leafy edges that stick up from the surface on which they grow. Generally green.

3. **Fruticose** – lichen that looks like tiny branches or bushes; the tallest of the three lichens. Generally green.

Fruticose lichen are the most sensitive to air pollution. In areas of heavy air pollution, no fruticose lichens will be found. The lichens that are least sensitive to air pollution are the crustose.
In this lab, you will observe the types and relative amounts of lichens in a local area to determine air quality.

**Directions:**
Go to your designated area. Locate at least 3 places where lichens are growing, at about ___ m above the ground. Identify the lichens there as crustose, fruticose, or foliose. Place a clear grid gently over each of the lichen growths and trace the area that the lichen covers. Use black marker for crustose, blue for foliose, and green for fruticose. Count the number of squares that each type covered. Record the area.

**DATA:**

<table>
<thead>
<tr>
<th>Type of Lichen</th>
<th>Location # 1</th>
<th>Location # 2</th>
<th>Location # 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crustose</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foliose</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruticose</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Compile class data for the entire area on the overhead.

- Total area covered by crustose = __________________
- Total area covered by foliose = __________________
- Total area covered by fruticose = __________________

Enter the locations of lichens on the “Master” map. What do you think is the general air quality of this site?
LICHEN GRID
CNS 10 – Bio-monitoring

This is a two-week activity in which students investigate the life cycle of Zebra Mussels, their impact on US waterways, debate various technologies proposed to eradicate them, and develop and conduct an action plan for a local lake. For specific background and student pages associated with this activity, see Appendix A – “Bio-monitoring – Invasion of Exotics”.

Science Objectives: At the completion of this lesson, the student will be able to:

- Define exotic species
- List several examples of exotic species in the US and Wisconsin
- Describe the impact of exotic species on the environment
- Propose possible solutions / technologies for ridding a habitat of exotic species

General Objectives: At the completion of this lesson, the student will be able to:

- Use the internet to search for information
- Weigh the risks and benefits to the environment of application of various technologies
- Debate the pros and cons of specific action plans
- Develop an action plan for solving an environmentally sensitive problem

The Wisconsin State Academic Standards for Science covered by this plan are:

- A.12.1, -5, -7; B.12.4, -5; C.12.1, -2, -3, -6; D.12.11, -12; E.12.4; F.12.7;
- G.12.3, -4, -5; H.12.1, -2, -3, -4, -5, -6, -7
The Wisconsin State Academic Standards for Environmental Education covered by this plan are:

A.12.1, -5; B.12.3, -4, -5, -6, -7, -8, -9, -11, -12, -16, -17, -19, -20;
C.12.1, -2, -3, -4; D.12.1, -2, -3, -4, -5, -6, -7, -8, -9; E.12.1, -2, -3

**Bio-monitoring – Invasion of Exotics**

**Day 1**

Begins with introductory discussion to discover what an exotic species is, then moves into the computer lab for a web-quest.

Teacher-led discussion of what an exotic species is, with descriptions of examples from around the world (i.e. rabbits in Australia, kudzu in southern US). Ask students for any examples they know of personally (they usually know about Asian beetles in Wisconsin Rapids and Gypsy moths).

Students will do a web-quest to search for eight or more examples of exotic species in Wisconsin. Brainstorm ideas for key words to be used in the search (exotic species, invasive species, non-indigenous species); discuss websites that may be most useful – like the Wisconsin Dept. of Natural Resources or University of Minnesota Sea Grant.

Encourage students to look for plants and animals for their list.
Day 2 & 3

After a discussion of the previous day’s findings, the students will concentrate on a specific exotic species - Zebra Mussels, using a variety of media to answer a series of questions about them.

Students will use the Internet and vertical files to find this information:

1. Describe the life style of the Zebra Mussel; how they reproduce, where they live (indigenous to what part of the world?), what they eat, etc.

2. How and where did they first arrive in the US?

3. Where in the US are they located now? How have they spread?

4. Describe the impact they have on lake water and aquatic industries.

5. Find, describe and rate three methods for controlling their spread.

All items’ responses should be in complete thoughts and sentences, and references must be given.

Day 4

Round-table discussion of the information found about Zebra Mussels.

As a large group, the class will compare information about Zebra Mussels, to ensure a broad-based understanding by all students about how they live and their impact on
surface water (discuss the tremendous filtering capabilities and how that changes the aquatic wildlife). Be sure they understand how they are spread from one waterway to another. Discuss competition with indigenous species, and depletion of habitat by the Zebra Mussels.

Arrange students in small groups (3 to 5 students) to discuss and compare control methods they have found. Each group should choose the best method / technology for controlling Zebra Mussels. They must be able to defend their choice based on effectiveness and efficiency. Consideration must also be given to the effect the control method will have on the ecosystem. Each small group should submit a one-page summary of their decision. This information will come from their research; students must include references.

**Day 5, 6 & 7**

Build and set up a Zebra Mussel monitoring device.

A diagram of a submergible monitoring apparatus can be found at [http://www.siue.edu/OSME/river/ZebraMussel/Zebrariver.htm](http://www.siue.edu/OSME/river/ZebraMussel/Zebrariver.htm) (see diagram page VIII)
This is an optional exercise. Students will assemble the device according to instructions, and place one (or some) in Nepco Lake. This will also allow the class to investigate a variety of aquatic organisms found in a local lake. Zebra Mussels have been found in Nepco Lake in Wisconsin Rapids. If the device is used there, the students may actually see live Zebra Mussels.
In lieu of actually monitoring the lake for the mussels, local media reports or direct contact with the DNR may be used to confirm their presence. In any case, this would be necessary if none are found on the device. Set up a schedule for reliable students to periodically check the device, gather samples, and observe them in class. Organisms are readily observable with dissecting microscopes. A record should be kept of any organisms found. Aquatic life forms can be identified using pond life handbooks found at LHS. Discussion of healthy aquatic life indicator species is appropriate at this time.

Day 8

Students will set up a “town board” meeting to discuss what should be done about the presence of Zebra Mussels in Nepco Lake.

Re-assemble the students in the small groups used on day 4. Appoint (or elect) a town chairperson. Each group reviews possible intervention/control methods, discusses the pros and cons of the methods, and chooses the one they think would be most feasible for Nepco Lake. They will prepare a presentation of their decision for the chairperson and select a spokesperson. The town chairperson should decide the format and length of the presentations, and advise the presenters.

Day 9

Presentations will be made, after which the chairperson will select the best control method.
Each group’s spokesperson makes his or her presentation of their choice of Zebra Mussel control. Presentations should be factual, with references given. Criteria for selection are: feasibility for this area, cost, probability of success based on prior success, availability of materials, and least damaging to the environment. These criteria may be modified to suit the needs of the group.

**Day 10**

The class will develop and carry out an action plan appropriate for their abilities and resources available.

Assessment: Individual participation in presentations and the action plan will be used as assessment.

As a culminating activity, the class will develop an action plan that they can carry out to inform the community of the Zebra Mussel problem. If one of the control methods that a group has presented is within their means, they will do it. If not, some possible actions may be to produce and hang informative signs near area waterways, letters to the editor, contact local lakes associations to persuade them to take action, etc.

**Background Information About Zebra Mussels in the Great Lakes Region**

Since the introduction of the Zebra Mussel into Lake St. Claire in 1986, the tiny mollusk has succeeded in invading the freshwater systems of a total of 19 states (1). As often occurs when exotics enter new ecosystems, they have found abundant food and few
predators. Under these conditions, their populations explode. In addition to lacking natural checks, Zebra Mussels have been quickly and efficiently transported to many lakes and streams in the U.S. by human activity.

The life-style of the Zebra Mussel is well suited to the Great Lakes region. After hatching, Zebra Mussels begin life as tiny, free-swimming larvae, propelled by cilia. After about three weeks, they settle down on the bottom, or some other surface, attaching to it by “byssal threads”. During this stage, they feed by filtering phytoplankton and other suspended solids out of the water, depositing “pseudofeces” on the bottom of the lake or river in which they live. They are sexually mature at one year, grow up to about 5 centimeters in length, and, in the U.S., live about three years (2,4). Besides having plentiful nutrient supply in the Great Lakes region, the Zebra Mussels also find sufficient calcium in the water for shell formation. They can attach themselves to virtually any substrate, including sandy bottoms, aquatic plants, arthropods, pipes, boats, beer cans, etc. Few native species prey on the Zebra Mussel.

Rapidly growing populations of Zebra Mussels have negatively impacted the ecosystems they have invaded. For instance, they severely alter an ecosystem’s food web by using up the food supply of native species. In some places, amphipods (scuds, etc.) formerly made up approximately 70% of the biomass of the system; when measured in 1998 the amphipods were absent!(3) This amounts to wiping out the base of an entire food web. The results are decreased numbers of perch, alewives, bloater, and smelt, and possibly trout and salmon, too. All are dependent in, some way, on the smaller organisms for food
Zebra Mussels have clogged intake pipes for municipal drinking water, disrupted electric power generation, and taken over pipes of industrial plants. They are found by the thousands in and on dams and locks. The cost to industry and sport fishing has been tremendous.

Not everyone views the Zebra Mussel invasion with trepidation. Mark Sagoff contends that the filtering ability of Zebra Mussels, (up to a quart a day (4), can actually improve an ecosystem. Water clarity in some lakes, especially Lake Erie, has greatly improved. Some native aquatic plants, not seen for decades, have recently returned. These plants require sunlight to penetrate the water in order to live. Solids suspended in the water prevented the infiltration of enough sun. With clearer water provided by the Zebra Mussels, the plants have re-established themselves. This, in turn, provides cover for hatchlings (5). So, the Zebra Mussel might actually improve (some) fishing.

Sagoff argues that the uproar over exotics is more often a controversy about aesthetics rather than science. He states that most of the time introduced species actually increase biodiversity rather than decreasing it (with island ecosystems being the exception). And that most of our crops and livestock are exotics; virtually all plants and animals produced for food in the U.S. are not native species. What, then is the criterion for deciding when an exotic is good or bad?

Introduced species may often increase the biodiversity of an ecosystem. When that happens, the system is probably not endangered, as increased biodiversity almost always
translates into increased stability. However, in the cases where biodiversity is decreased, the exotic is a threat. The indigenous species have evolved over millions of years with a particular system’s components (biotic and abiotic). A sudden and dramatic change in that system could be disastrous. It’s not known how Zebra Mussels could ever be controlled in the Great Lakes region, but it would probably benefit the region if they were. The fact that Lake Erie is once again clear is insufficient reason for welcoming the Zebra Mussel. There are better ways of providing clear water. It is most disturbing that they have impact at the base of the fed web. This means that they will affect every organism in the ecosystem, either directly or indirectly. The good will most likely not outweigh the bad.

References sited in “Background Information About Zebra Mussels in the Great Lakes Region”

1) http://www.enn.com/enn-news-archive/1996/03/031296/03129614.asp

2) http://www.enn.com/enn-news-archive/1998/05/051598/zebra.asp


4) http://www.siue.edu/OSME/river/zebralc.html