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A LAB-BASED APPROACH TO TEACHING ENVIRONMENTAL SCIENCE

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ABSTRACT

A LAB-BASED APPROACH TO TEACHING ENVIRONMENTAL SCIENCE

By

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To provide upper level students with an additional science elective, an environmental science course was developed. The purpose of this course was to utilize laboratory experiences to develop ecological knowledge and further environmental awareness. Through hands-on activities, students gained not only scientific knowledge, but also insight to the methods and nature of science itself. While focusing on the ecology of air, soil and water, students also became aware of the impacts humans have on these systems.

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Introduction

Many of our high school students (as well as adults) do not have a deep understanding of applied ecological principles. They do not realize that actions taken today by humans may have detrimental effects in years to come. In order to maintain and improve environmental quality, students need to understand the interrelationships between the natural environment and human activity (Disinger, 1993). Environmental science is a relatively new topic appearing in science curricula, and is often minimized, either for lack of time during the course, or lack of interest by students or instructors. However, this topic provides many opportunities to make learning relevant, through hands-on activities and providing opportunities for critical thinking (Anderson and Shaw, 1999). I feel strongly that we must educate our students about the environmental consequences of our actions, and that science classes are a natural place to discuss these issues and how they affect society as a whole. Science is a major achievement of our civilization, but science and scientists cannot be separated from society and its applications (Osborne, 2000). To that end, I felt it was important to place a higher degree of emphasis on environmental science, and I proposed that we teach it as a separate course in our science department. The goal of environmental education in general is to equip people with the knowledge, attitudes, skills and motivation they need to help resolve environmental issues (Kwong, 1999). Offering an Environmental Science course would provide students with the opportunities to not only learn more about this topic, but also to become more environmentally aware as citizens. Malcolm Plant tells us "The task for environmental education has never been more demanding. It has to appeal to a wider

audience... and give them skills to bring about social and political change in the interests of people and the environment" (1998). The ultimate aim of environmental education is for every citizen to formulate a responsible attitude towards the sustainable development of the Earth. In order to attain this goal, "every educational institution needs adequate arrangements for planning and implementing coherent and progressive programmes of work with appropriate teaching and learning tasks" (Palmer, 1998). Therefore, adding an Environmental Science course would greatly benefit our students as learners as well as citizens and future leaders. This new course was the basis of my research at Michigan State University, where I developed labs that would be used to further student knowledge of ecological concepts.

Students in the high school in which I teach are required to take two years of science. There are three courses offered to incoming freshmen: Honors Biology, General Biology and Integrated Science I. Placement into these courses is based on recommendations of the middle school science teachers – those students that demonstrated high achievement in middle school science are recommended for Honors Biology. Students that request General Biology are to have earned at least a C in their middle school science courses; those that have not experienced a great deal of success in their science classes are recommended for the Integrated Science courses. These students take Integrated Science I as freshmen, and many of them take Integrated Science II as sophomores, thus completing their science requirements for graduation.

Many students in our Biology track take more science classes beyond the required two years. However, these students do not get much exposure to the Earth science

objectives that are tested by the Michigan Educational Assessment Program. In addition, there is a need for an optional third year of science for those students in the Integrated Science tract that are interested in taking more science classes. With these two sets of students in mind, we developed a new Environmental Science course, which was first offered in the 2001-2002 school year.

Adding a new class to our curriculum involved many steps. The inspiration for the course came out of a brainstorming session in the science department, where we were discussing new courses we would like to see added. I worked with the head of the department to develop an outline of the course that we shared with our principal and curriculum director. By examining the current courses offered, we determined what topics and state benchmarks were in need of being further explored. We felt strongly that the proposed Environmental Science course would review benchmarks in which our students were traditionally weak. We then put together a detailed list of all the benchmarks that would be taught and submitted the proposal to our curriculum council who approved the course. I was fortunate to have the backing of the department and my principal to be the one who would develop the curriculum for as well as to teach this course.

Even though the department added this course, no additional funds were provided outside of an allowance to buy textbooks. Therefore, we were challenged from the beginning to gather materials that could be used in laboratories. Many of the activities in the class had to use materials we already had or that were inexpensive enough for me to provide.

The purpose of the new Environmental Science course was three-fold: 1) to offer a third year of science for those students that were not in our Biology track, yet were still interested in science; 2) to provide students with an opportunity in their Junior year to review some of the concepts that would be tested on the MEAP that they may not have retained from their first two science courses; and 3) to provide these students with a hands-on, laboratory-based course that would increase their interest in science as well as allow them to explore some ecological concepts in greater depth than they have had in previous courses. High school students tend to live in the immediate time frame – they do not have the foresight to see how their actions affect others or may affect the environment, not only now but in the future. Students in the Environmental Science class would learn the same basic ecological principles, but the expectation was that they would take this knowledge and apply it to the issues we all face. In each of the major systems studied in the course we also examined the impact humans have on that system. This brought about many debates as to what should be done to reduce negative impacts, and the diverse backgrounds of the students provided us all with different points of view. Steve Goodall tells us that "Education about the environment....and human activities can only provide a common framework within which the moral and values debate takes place" (1994). By providing students with enough background knowledge to make educated arguments, we provide them with connections to formulate possible solutions to environmental problems (Goodall, 1994). Students may become more aware of and active in local environmental issues and initiatives. The field of environmental science is holistic and involves examining not only natural systems but interactions with human

systems (Best, 1994). While studying each of the topics in the class we also kept in mind how humans affect those systems. Terry Bull suggests that environmental education is an inherent part of community education in which students see relevance in environmental issues. The ultimate result of discussing the relationships between humans and the environment would be the enlistment of previously uninvolved people in support of vital environmental causes (1994). By studying these relationships, our students will be more environmentally aware and active.

This is a one semester course with one prerequisite: that the student have completed two years of science. The targeted group was those students that went through the Integrated program, but the students that chose the Biology path were not excluded. Since these students would be taking the course as Juniors or Seniors, it would be a good opportunity to teach the Earth science objectives that the Biology students missed. We also felt that the Integrated Science students would benefit from a review of this material, even though it was included in their freshman and sophomore classes. These students are not always successful academically and may not have retained that information. Many students are not as familiar with concepts in the physical and earth sciences as they are with the life sciences. These students would also benefit from laboratory experiences. Therefore the goal of the course was to incorporate as many relevant labs as possible. Many labs were designed so that the students formulated and answered questions using a variety of sources. I avoided lecturing to provide information. The intention was to have the students ask and answer questions about the topics, experience confusion and work through it. Philip Adey also feels this is a significant way to learn, "...recognizing

puzzlement, uncertainty, and admission of confusion, as far more hopeful pathways to ultimate academic achievement than a neatly filled book of notes" (2000).

Our school has a strong science department that offers many classes at various levels. However, the goal for all our students is the same: that they exit high school as scientifically literate persons who can apply scientific principles to their everyday lives. In the AAAS publication, Science for All Americans, a scientifically literate person is defined as one who

> "...is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes." (AAAS, 1989)

Science education should not just be for future scientists. Rather, the development of scientific literacy is essential to a participatory democracy (Simon, 2000). My intention was to utilize a hands-on approach that would increase the understanding of the key concepts in environmental science. With this knowledge, I hope my students will become more ecologically responsible and gain a global perspective in their daily lives.

Providing students with the opportunity to explore ecological concepts through laboratories will increase comprehension. Labs encourage inquiry which encourages students to construct their own knowledge through investigation (Collette and Chiappetta, 1989). Laboratories provide students with opportunities to think about, discuss, and solve real problems (Committee on Undergraduate Science Education, 1997). In addition, students are able to work collaboratively. Science for All Americans tells us:

"The collaborative nature of scientific and technological work should be strongly reinforced by frequent group activity in the classroom" (1989).

Some of the activities in which students participated were open-ended. Students were given a basic question and asked to gather information to answer the question. I did not delineate specific steps in the scientific method that student were to follow. Rather, I let them choose the direction they would take within their groups. In *The American Biology Teacher*, Guy McPherson says "One danger in discussing the scientific method is the implication that there is a single list of steps, or recipe, that generates reliable knowledge." (2001) This is contradictory to what is taught in many science classes; students are given steps to the scientific method to memorize and reproduce on a test. Students rarely get the chance to actually use the scientific method, or realize that it is a framework to go about conducting a reliable experiment. McPherson does go on to state that "...the widespread use and teaching of the 'scientific method' suggests that this particular approach helps us organize our thoughts about the scientific process." (2001) Science educators argue that science education without practical work fails to reflect the true nature of scientific activity (Watson, 2000). In developing the activities in this unit, I wanted to allow my students to find their own paths of 'doing science' to further contribute to their understanding of science and thus allow them to become more 'scientifically literate.'

For each of the topics covered, students were expected to assimilate the information into their everyday lives. This was easy for the student that is a farmer and works with environmental issues on a daily basis. This was a bit more challenging for

the student that does not have much of a global perspective. Most of the students in the course were interested in some sort of outdoor activity, such as hunting or fishing. These students brought with them an enthusiasm for the content material and they each made valuable contributions from their past personal experiences.

Students were also expected to work in groups to conduct their activities. Rarely were they restricted to working on their own. Many discussions took place among group members as to how to conduct a lab, who would be responsible for what aspects of the activity, and how to evaluate results.

Students are generally weak writers. Many of the labs designed in this class required students to produce written responses. Students were also required to write two formal lab/research reports. These major papers allowed students to improve their written communication skills as well as their content area writing. Writing skills have become more and more important in the MEAP tests in the form of constructed responses. Many of our students struggle with these responses, so attempts were made to help them become comfortable with writing. Students need a lot of practice to develop writing skills that convey information, yet some students may be alienated by focusing too much on scientific language, thus neglecting content. (Jones, 2000) We worked throughout the semester to develop a writing style that was comfortable for students, yet reflected the scientific principles they were studying.

Our school is in a rural setting and the high school has about 635 students in grades 9-12. The Environmental Science class was offered as a semester course and was taught during the fifth period of the six period day. The first semester began with thirteen

students, but only ten remained at the end of the class. One student dropped the course to fulfill a social studies requirement, and the other two dropped out of school completely. Of these ten, three were female and seven were male. The second semester provided a larger group of students, 20 total: 10 boys and 10 girls. The class was originally targeted for lower-achieving students, but both semesters included students with a heterogeneous mixture of abilities. There were students that had gone through the Integrated Science sequence, as well as extremely high achievers that had taken the most challenging courses offered, including Advanced Placement Biology. Student abilities were wide-ranging, from special education students to the salutatorian of that year's senior class. This mixture provided many interesting group discussions. Based on academic performance, students were anonymously categorized into three groups: low, average and high achievers. The lower group had five students, two of whom receive special education services. The middle group contained ten students and five students were considered very high achievers. Due to the small numbers and the lack of materials and textbooks during the first semester, many modifications to the course had to be made. The first semester served as a test course, where activities were tested and modified for use in the second semester. Consequently, only data from the second semester will be used in this thesis.

Implementation

The course was essentially divided into three main units: ecology of water, soil and air. An additional mini-unit on glaciers was incorporated to cover the Michigan Curriculum Framework benchmarks on that topic, as they were not necessarily covered in the other science courses these students would have taken. The nature area behind the school was utilized for many labs. This area includes a pine forest, open field, and the Shiawassee River. This close proximity to the school was very important, as students were able to get out to the site, conduct their labs, and get back into the classroom within the class period of fifty five minutes. This made it easier to put together activities that would allow students to successfully get materials and conduct their investigations.

An outline of the course follows:

Course Outline

I. Introduction to the course – 1-2 periods
   - Expectations, explanation of research, consent form, pre-test, basic ecology discussions (video: The Lorax)

II. Introduction to Scientific Method
   - Activity: Grow some Duckweed
   - 1-2 days for background, set up of duckweed lab, 2 weeks to run lab, 1-2 days to compile lab reports

III. Glaciers – 7 class periods
   - Resources: Great Lakes Atlas, Internet sites
   - Activities
     - Glacier Scavenger Hunt
     - Glacier Flip Book

IV. Air – 15 - 17 class periods
   - Background Information
     - Environmental Science text book
     - Lecture
   - Activities
     - Particulate Lab

    - Ozone video
    - Acid Precipitation Lab
    - Clean Air Act Project

V. Soil: 6 weeks (one marking period)
- Background Information
    - Textbook
    - Lecture
    - Internet sites
- Activities
    - Mining Lab
    - Recycle City Web Activity
    - Soil Filtration lab
    - Recipe for Life Lab
    - Topographic Maps – 3D models
    - Erosion Lab
    - Composting Activity
    - Dirty Little Bugs
    - Cumulative Soil paper

VI. Water: 6 weeks (one marking period)
- Resources
    - Great Lakes Atlas
    - Textbook
    - Great Lakes Fishery video and handouts
    - Internet sites
- Activities
    - Exxon Valdez video & evaluation
    - GLOBE hydrology tests
    - Indoor Water Testing
    - Stream tables
    - Groundwater Lab
    - Great Lakes Fishery video & evaluation
    - Cumulative Water Quality Report

VII. Conclusion of course – one class period (final exam day)
- Post-test, course evaluation

Materials

Holt, Rinehart and Winston's 2000 edition of Environmental Science, by Karen Arms, was chosen for the textbook in this course. This book provided an acceptable readability level and tied in the human impacts on the environment as well as providing

good background information on the topics. Only the sections of the book that were relevant to topics to be studied were used. Instead of having students read assigned pages and then have a teacher-dominated lecture on the material, I developed skeleton outlines of the required reading for students to complete at their own pace (Appendix B). Within a few days of assigning the outline, we would have a class discussion to make sure all students had the necessary information. This opened up opportunities for students to discuss related topics they had questions about, as well as sharing personal stories relating to the material. The more relaxed atmosphere seemed to benefit the wide range of students and made the lower-achieving students more confident and less intimidated by the higher achievers.

In order to cover the material on glaciers and the Great Lakes, I used many Internet sites to gather information for a one-day lecture on this topic. While searching for this information, I came across an on-line Great Lakes Atlas (www.epa.gov/glnpo/atlas/intro.html) that gave outstanding information on the history and ecology of Michigan. The Great Lakes Atlas is also available in hard copy. By contacting the Great Lakes National Program Office, I was able to secure a free classroom set of thirty-five books. I used these for the information on glaciers as well as in our water unit.

Audio-visual aids in this course were limited. Since I did not spend much time in lecture, I did not use many overheads, etc. However, we did utilize video tapes to illustrate some of the concepts and allow students to see how people proposed dealing with ecological problems. One of these video tapes told the story of the Exxon Valdez

disaster (Scientists and the Alaska Oil Spill: The Wildlife, The Cleanup, The Outlook 1992). Ironically, it was published by the Exxon Corporation. This provided an opportunity to discuss the importance of evaluating where information originates. Students also viewed videos on the ozone and Great Lakes Fisheries. The video of Dr. Seuss' The Lorax was also used as an introduction to the course and some basic ecological principles. These videos will be discussed later.

New teaching techniques and strategies

I tried to keep lectures to a minimum during this class. I felt the lower-achieving students would not benefit, and the higher level students would be bored. While some lectures were necessary, they were kept to a minimum. Rather, the students were to be responsible for obtaining necessary information. This was done in a variety of ways. When students were expected to gather information from their textbooks, I provided them with a skeleton outline (Appendix B) from the text that they would fill in as they completed the assigned reading. We discussed this information and reviewed the outlines as a class. Since the book provided the right answers, even the lowest level students were able to contribute to the class discussion.

Most of the activities students were asked to do were done in groups. Students chose their own group members, a process that can be both positive and negative. Students initially chose their groups based on social aspects – they wanted to work with their friends. As the semester went on, the group dynamics changed. Students who were concerned about their grades formed groups with others that had a similar work ethic.

During the semester, the Internet was a valuable tool that we used quite often to gather information. Students were given questions and asked to find relevant information on the Internet. Some of these activities were more structured than others. Sometimes I would give them specific sites to access information; other times they would determine where to search for the answers. In both situations, students were allowed and encouraged to share among themselves which sites were the most productive.

Since some of the ecological concepts would be difficult to model in the laboratory, videos provided opportunities for insight on certain topics. Television is a powerful medium that can help students understand science by second-hand experience (Jennings, 1995). The videos used in the course were accompanied by study guides (Appendix C) to increase student retention of the material and keep them on task.

Assessment

The effectiveness of this unit was assessed using four tools: 1) comparison of pre and post tests; 2) student evaluation of the course; 3) teacher observations and 4) informal conversations, both student-to-student and student-to-teacher.

Students were given a pre-test at the beginning of the class and a post-test (Appendix A) at the end. They were told that data would be collected over the course of the semester to be used in my Master's thesis and that their participation in the study was completely voluntary. Students completed a consent form (Appendix A) that offered the option to either allow me to use their data or not, and that there was no penalty for not participating. All of the students returned the forms and indicated I could use their data.

At the conclusion of the course, students were asked to complete an anonymous

evaluation. They were asked to rate the course on a scale of 1-10, and were also asked to list their favorite and least favorite part of the course. Results of the evaluations are shown in Table 3, Figure 1 and Figure 2.

The third and fourth assessment tools were teacher observations and informal conversations among students as well as student/teacher conversations. These yielded insight to the level of understanding students had for the topics studied.

Summary and Analysis of Activities

1. The Lorax (Appendix C)

This video provided an introduction to the course. At the completion of the video, students were divided into groups to discuss the significance of various portions of the tape. Each group had an opportunity to share their conversations with the rest of the class. This was effective in introducing the topics we would be studying and provided an anticipatory set for the semester.

2. Duckweed Lab (Appendix C)

The purpose of this lab was to familiarize students with the basic process of 'doing science.' Students were to utilize the Internet to research duckweed and design a way to grow the plants, then write up the process in a lab report. The lab worked fairly well in that students were able to execute their protocols, and the lab reports provided me with feedback on the type of work I could expect from the students. The lab was effective, as most of the groups were able to keep their duckweed population alive. The lab reports were well done and I was pleasantly surprised with the ability of students to

communicate through writing. The class average on the paper was a 78%, which translates to a C+ on our grading scale.

3. Glacier Scavenger Hunt (Appendix C)

Utilizing the Internet, students were to search for a variety of facts about glaciers, including defining key terms. In this case, I chose the website students were to use: http://nsidc.org/glaciers/index.html. The activity worked well to give the students basic background on glaciers.

4. Glacier Flip Book (Appendix C)

This came from the DEQ website: www.deq.state.mi.us/documents/deq-gsd-info-geology-BU4FB.pdf It is a bit elementary, but did a nice job showing the advance and retreat of glaciers. Students cut out maps, colored them, then stapled them together to make a flip book. When 'flipped,' the book showed the advance and retreat of the glaciers over Michigan. This was a good activity to model glacial movement.

5. Particulate Lab (Appendix C)

This lab was effective in demonstrating the variety of solids in the air. Students sampled sites throughout the school and determined which locations had the highest number of particulates. In addition to sampling around the school, all groups tested car exhaust. The next time I use this lab, I will make transparencies of graph paper to attach to the bottom of the Petri dishes used to collect the particulates. The major problem with this lab was counting the number of particulates in a grid that used regular graph paper. Students performed well overall, earning a class average of 84%.

6. Ozone Video (Appendix C)

Students were given a worksheet to complete while watching *Ozone: The Hole Story*. The aim of the video was to give the cause, effects and solutions of upper ozone depletion. Students did get information from this video, albeit begrudgingly. The video is a bit dry and is best shown in small sections, with discussions on the material wedged in between the video clips. The average score on the worksheet was 88%.

7. Acid Precipitation Lab (Appendix C)

Students simulated the effects of acid rain on seed germination in pinto beans. Each group determined how they would conduct the lab and it worked quite well, not only to allow the students to feel they were 'doing science' but also to allow them to see how detrimental acid rain can be to crops.

8. Clean Air Act Project (Appendix C)

This was adapted from a webquest I found on the Internet. A webquest presents a problem to be solved and guides students by providing them with related Internet sites for obtaining information. The author of the webquest also includes rubrics for assessment. Final assessment on this webquest was in the form of a presentation to the class. Students formed groups that represented special interest groups from a community where a congressman could not decide whether or not to repeal the Clean Air Act. Each group researched the Act and put together a presentation to either support or demonstrate why the Clean Air Act should be repealed. This was an outstanding activity and students produced some fabulous presentations. This activity provided students with some insight to the societal issues science affects.

9. Recycle City Web Activity (Appendix C)

The EPA has a website of a fictional town (Recycle City) that shows how its citizens have worked to reduce pollution by recycling. Students explored the various parts of the town to obtain information to answer questions I had compiled related to resource use. Student performance was assessed by the number of questions for which they were able to locate correct answers. It was a relatively successful activity, as the class average was 85%.

10. Mining Lab (Appendix C)

This lab was in the Environmental Science textbook. Students simulated mining sites by placing Jolly Ranchers in Rubbermaid containers and covering them with soil, leaves, grass and twigs to represent a natural landscape. They traded landscapes with a group that did not know where the candies were buried and each group mined for the 'ore' in the allowed five minutes. Groups were also asked to reclaim the land to show how labor intensive restoration is. The protocol in the textbook used peanuts, but students chose to substitute Jolly Ranchers. Grades were determined by completing the lab and the accompanying questions. This was a successful activity for demonstrating the effects of mining on the land. Students were successful in completing the lab and questions, as the class average was 98%

11. How Safe is our Groundwater? (Appendix C)

Students used various soil types to see which soils are better at filtering groundwater. This integrated knowledge of the water cycle and allowed students to predict and test which soil types would filter out more impurities in the water. Students

were assessed by their answers to the questions accompanying the lab, and the overall score was 88%. This was a rather simple, yet effective activity.

12. Recipe for Life (Appendix C)

Students investigated the composition of soil taken from our nature area. They made shake jars to see the different types of materials in their samples and calculated the percent of clay, loam or sand. This lab was adapted from one I found on the Internet: http://www.cyfernet.org/integrate/iowa/srecipe.html It was fairly effective in introducing students to the different types of soils and their composition, although the average score on the lab was an 82%.

13. Erosion lab (Appendix C)

Students investigated how grass growing in soil affects erosion. It was a simple lab that involved passing water through soil with or without grass growing in it and observing what the water looked like after passing through the samples. The lab demonstrated very well the differences between soils with vegetation growing in them and those that do not.

14. 3D Models of Topographic Maps (Appendix C)

Students were given a section of a topographic map of Shiawassee county, which they were to reproduce as a three-dimensional model of that section using construction paper and packing peanuts. The background information given on topographic maps had to be applied. Students initially struggled with this task, but they eventually caught on and built some accurate models.

15. Composting Activity (Appendix C)

After collecting some background information on composting, students were challenged with constructing the best compost jar of the class. They applied their knowledge of soil ecology to put together materials that would raise the nutrient levels in their jars.

16. Dirty Little Bugs (Appendix C)

This activity allowed students to observe organisms that live in the soil. It was adapted from a lab on the Internet: http://www.uni.uiuc.edu/~dstone/microarthrcollectionandexam.html . Students designed, constructed and used a Berlese funnel. The research, planning and construction portions of the lab worked well. However, not many organisms were present in the litter that students collected.

17. Cumulative Soil Paper (Appendix C)

The purpose of this paper was to tie in all the information that had been discussed in the soil unit. Students did some additional research on decomposition rates and also included the results of their composting activities.

18. Indoor Water Testing Lab (Appendix C)

In this lab, students familiarized themselves with the test kits that they would be using to conduct their water quality tests on the river. Samples used were tap water and a mixture of household plant fertilizer and water. The results of the lab were not very exciting for the students, but they were able to practice using the test kits, which saved us a lot of time in the field.

19. Exxon Valdez video (Appendix C)

The video told the story of the 1989 oil spill in Alaska and the clean up efforts. The scientists that worked on the clean up discussed techniques and procedures used to clean up the spill, as well as how wildlife was affected. Students kept in mind the producer of the video and questioned how effective the clean up process actually was.

20. Great Lakes Fishery video (Appendix C)

This video was produced by the Michigan Sea Grant Extension and tells the story of Michigan's fishing industry. It was a good review of the geologic history of Michigan and focuses on the past, present and future of Great Lakes Fisheries.

21. Water Quality Paper (Appendix C)

This was the cumulative project for the water unit. Students used water test kits to conduct a variety of tests to determine the quality of the water in the Shiawassee River. This information was compiled into a final paper for the water unit. For each test conducted, the students researched the basic chemistry of that test, including how the nutrients could get into the river, their effects on the organisms living in the river, and what the acceptable range for each nutrient would be. After reporting on each of these components, students were to use their data to determine the overall health of the river. Most students expressed surprise that the river is not as polluted as they expected it to be.

Evaluation

This was the first time an Environmental Science course was offered at our school. Therefore, a comparison cannot be made between old teaching styles and new. However, results of the pre-test and post-test (Appendix A) suggest that this was an effective unit, as all students showed improvement. (See Table 1) The average grade on the pre-test was 57%, and the average grade on the post-test was 81%. The average increase in percent correct from the pre-test to the post-test was 24.5%. The post-test was identical to the pre-test with the exception of questions related to plate tectonics. The questions on plate tectonics were excluded from the post-test, as that material was not covered in the second semester. Consequently, the percent scores are more reliable than the raw point scores when comparing the two tests.

Two students have incomplete data in Table 1. Individual #5 did not take the pre-test due to a late schedule change. Individual #21 did not take the post-test because she dropped the course mid-semester.

A comparison of students by ability does not reveal a large difference in pre/post test scores. The group of students with higher academic abilities increased their scores an average of 25.4%, while the average students increased their scores by 22.2%. The group of lower achieving students demonstrated a 25.25% increase, but had the widest range of scores. Two of these students increased by 5%, and one of them had the highest increase at 47%.

Table 1
Pre-Test and Post-Test Results
n = 21

Student	Pre Test		Post Test		% increase
	Raw Score	%	Raw Score	%	
1	19	37	26	52	15
2	37	73	50	100	27
3	31	61	46	92	31
4	37	73	39	78	5
5	--	--	31	62	
6	35	69	45	90	21
7	26	51	41	82	31
8	29	57	46	92	35
9	29	57	45	90	33
10	33	65	35	70	5
11	24	47	40	80	33
12	29	57	36	72	15
13	34	67	48	96	29
14	34	67	46	92	25
15	41	80	47	94	14
16	30	59	38	76	17
17	15	29	36	72	43
18	41	80	48	96	16
19	18	35	41	82	47
20	12	24	24	48	24
21	31	61	--	--	

	Pre-Test	Post-Test
Class Average (raw score)	29.25	40.40
Class Average (percent)	57%	81%
High score (raw/percent)	41 / 80%	50 / 100%
Low score (raw/percent)	12 / 24%	24 / 48%
Number of scores	20	20
Standard Deviation (raw)	8.16	7.36
Standard Deviation (percent)	16.00	14.72

Average % increase from Pre-Test to Post-Test: **24.5%**

Examining average scores on each of the activities evaluated indicated a high level of comprehension and understanding of the topics. Students scored highest on the projects they conducted with an average score of 93%. When examining labs, students scored an average of 85.13%. The third type of activity, papers and written work scored slightly lower with a class average of 84.7%. A breakdown of each activity and the class average for each is shown in Table 2.

Table 2
Scores on each activity
n = 20

Activity	Class Avg (%)
Glacier Scavenger Hunt	84
Exxon Oil Video	96
Particulate Lab	84
Clean Air Act Presentation	93
CAA Group Scores	89
Ozone Video	88
Duckweed Lab	78
Recycle City	85
Mining Lab	98
Acid Precipitation Lab	82
Recipe for Life	83
Erosion Lab	92
Topographic Models	98
Groundwater Lab	88
Dirty Little Bugs	76
Soil Paper	55
Great Lakes Fishery Video	87
Water Quality Project	64

One of the highest scoring labs was the Topographic Models. This was one of the activities students struggled with the most. They had a difficult time visualizing flat maps as three-dimensional models. This is not a topic with which they are very familiar, as most of the land in Shiawassee county is flat. This concept would be easier to demonstrate if I could take my students to the top of a hill and show the corresponding location on the map. Most students were very proud of their models and were pleased they could master a topic that was quite difficult.

The lowest scoring activity was the cumulative Soil paper, where the class average was 54.64%. Of the five students in the lower academic category, only two of them turned in a paper at all, and those two received scores of 43% and 36%. The high achieving students scored an average of 95%. The middle category of students scored an average 37.8% on this paper.

Examining the class average on each assignment may be misleading. These scores are not comparable, as some of the activities carried more weight than others. For example, the Exxon Oil Video was a simple exercise in which students watched a video and filled in answers to a study guide. In contrast, the Clean Air Act Presentation was a large, lengthy project that required a significant amount of research and group work that culminated in a presentation to the class. The Mining Lab was a relatively simple activity, however it encompassed the main theme of the course. The fact that students scored an average of 98% suggests that students had a good understanding of that concept.

Students reported increased knowledge of the topics studied. As the course progressed, lab questions were answered more completely, based on teacher observation. This showed a higher level of understanding and comprehension.

Students were asked to anonymously evaluate the class at the conclusion of the semester. Most ranked the class high on a scale of 1-10. Sixteen of 20 students gave the class an overall rank in the 8, 9 or 10 range. Their comments as to why this was a good class included:

> "It was a fun learning environment. I learned how to use labs I had never done before."
>
> "It had a lot of hands-on."
>
> "I learned from this class."
>
> "It gave more experience in labs. The class was fun and you had to work."
>
> "We were kept busy everyday and I learned a lot throughout the semester."
>
> "It teaches a lot about different topics that relate to the environment."
>
> "I liked all the outdoor stuff and that it is independent."

Students seemed to enjoy the hands-on aspect of the course and the independence and freedom to work at their own pace. Almost all students reported learning a fair amount of new material.

Two students ranked the class as a 6, and one as a 7 on the 1-10 scale. Their comments included:

> "This class could have been a lot more complex and involved, but on the other hand it offered a sense of freedom and some responsibility."

"I like the subject. The worst part were the tests. We should have more freedom to make choices about what we work on."

"The labs are what killed me. Way too much work. Assignment after assignment. No breaks."

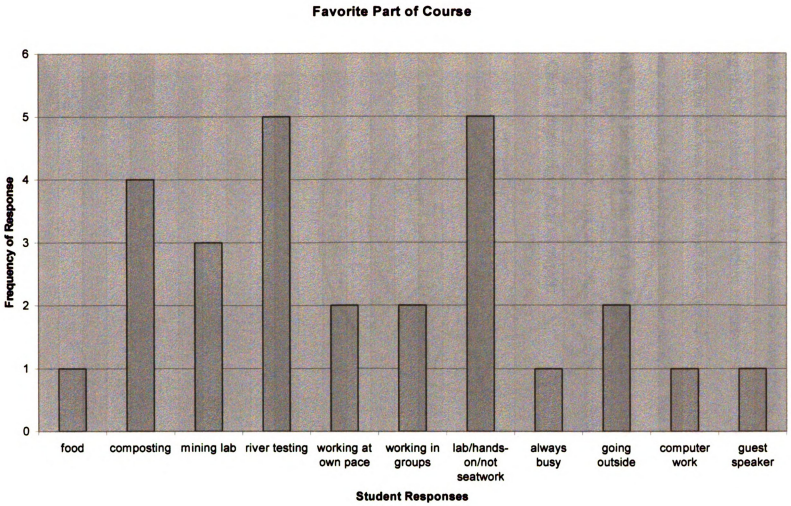
Table 3 shows student responses to the question "On a scale of 1-10, with 10 being the highest score, please rank this class, and explain why you feel that way."

Table 3
Student Evaluation of Environmental Science Class
n= 20

Rank 1-10	Comments
7	The labs are what killed me
10	It was a very fun class
8	Learned some new things – but knew a lot of stuff already
6	This class could have been a lot more complex and involved, but on the other hand it offered a sense of freedom and some responsibility
6	I like the subject but the lessons were rather dull. We should have more freedom to make choices about what we work on.
9	It was a fun learning environment.
10	Because it had a lot of hands-on.
8	Because I learned from this class
8	Because the class was fun and you had to work
8	Good, but not always interesting
8	Very good class, room for improvement very less
10	It was awesome
10	Because it was just awesome
8	Too many labs with not enough time
10	It teaches a lot about different topics that relate to the environment.
8	I loved it and it was very informational.
9	I liked all the outdoor stuff and that it is independent.
9	It was fun and had a relaxed atmosphere
8	I thought it was very good and I enjoyed it very much.

Students were also asked to indicate the best part of the course and the least favorite part of the course. Chart 1 represents student responses to what they felt was the best part of the course.

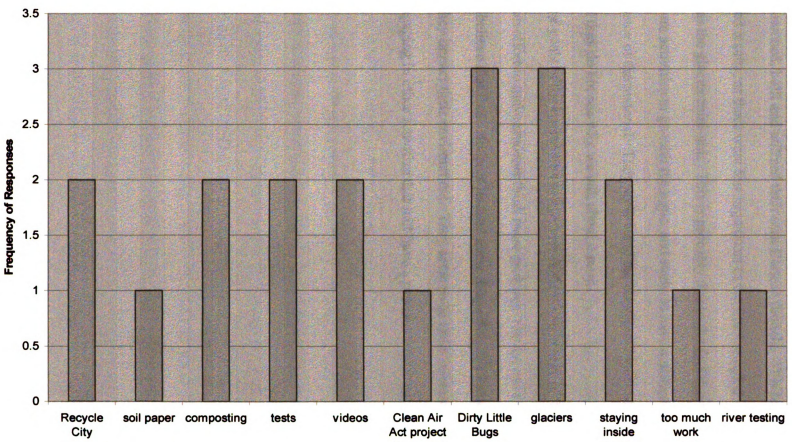
Figure 1


Favorite Part of Course
Frequency of Response
0
1
2
3
4
5
6
food
composting
mining lab
river testing
working at own pace
working in groups
lab/hands-on/not seatwork
always busy
going outside
computer work
guest speaker
Student Responses

Students felt one of the best parts of the class was river testing. This activity involved testing the Shiawassee River for various indicators of water quality. However, the final paper for this unit was one on which they scored very low. Another favorite part of the course was conducting labs and having hands-on activities. One student listed this as "not seatwork," and I interpreted this as having hands-on opportunities.

Students were also asked to respond to what they felt was their least favorite part of the course. Chart 2 summarizes their responses.

Figure 2


Least Favorite Part of Course
Frequency of Responses
3.5
3
2.5
2
1.5
1
0.5
0
Recycle City
soil paper
composting
tests
videos
Clean Air Act project
Dirty Little Bugs
glaciers
staying inside
too much work
river testing
Student Responses

As shown in Chart 2, the least favorite activity was "Dirty Little Bugs." In this lab, students researched, built and utilized their own Berlese funnels. This lab did not yield the expected results, as there were few organisms in the litter sampled. The least favorite topic was the glacier mini-unit. This is probably due to the fact that there were not many hands-on activities to go with the topic, and students have a difficult time seeing the relevance of the material. They understand the historical aspect of the glaciers in Michigan, but they do not see why we talk about it now.

One of the goals of the course was to increase student knowledge of the environment in an effort to make students think more globally. On the basis of informal conversations, I believe that these students learned some things they did not know before, as well as how they impact their environment. They seem to be more interested in recycling and engaging in other activities that will have a positive impact on their environment.

Discussion

The Environmental Science course originated from a casual discussion within the science department in the fall of 2000. We all agreed it would be a worthwhile class, and decided try to add the course to those offered for the 2001-2002 school year. This was a major accomplishment, as there was a great deal of work to be done to design the course and get it approved in time for student registration in the spring. The other members of my department provided support, encouragement and many suggestions that helped the course become a reality. It was easy to decide on the broad topics that would be covered. It was a greater challenge to align topics with the state benchmarks, develop an outline, and go through the incredibly lengthy process of choosing a textbook. I didn't realize what a large task it would be to simply add a semester course. However, the task was completed in time to get approval of the Curriculum Council and offer the course for the next year. In retrospect, this was a valuable learning experience for me, as it allowed me insight to the aspects of scheduling and developing a curriculum. Designing a course from scratch was an enjoyable process and I enjoyed the intellectual challenge.

Environmental Science was taught twice in the 2001-2002 school year. The fall semester provided many challenges, as equipment was lacking and textbooks did not arrive until November. A great deal of time was spent on the water unit, because the weather was ideal for conducting field work. Students were able to explore many questions about water quality, and were able to participate in GLOBE data reporting for hydrology protocols. GLOBE (Global Learning and Observations to Benefit the Environment) is a world-wide hands-on science program in which students collect data and submit it to the GLOBE website. In contrast, the second semester had significantly

less time at the river due to uncooperative weather. The fall semester provides the best opportunities for field work, and that would be the ideal time to offer the course. This course takes students outside frequently, and the weather can present its own set of obstacles. Keeping this in mind, the best time to offer the course is in the fall semester when we have more 'good weather days.' In fact, students in the spring semester encountered some difficulties when conducting their water testing on the river, as the river had flooded and we had trouble getting out to a good testing location.

Even with the differences from fall to spring semester, students in both classes enjoyed the laboratories. Fall semester was a good learning experience for me, as I had not had a class with Juniors and Seniors. The classroom atmosphere was much more relaxed, as discipline was not an issue. While the students were not always motivated to work at a fast pace, the management issues that arise in a Freshman classroom were never a concern. I found myself to be much more relaxed with the students and got to know them better as individuals. This class became my favorite part of the day and was one in which I greatly anticipated.

The second semester allowed us to cover more material. Textbooks and class materials were available the first day and I was better organized. The class was more structured than first semester, but that was necessary due to the larger number of students. The units were conducted in a different order than the first semester, largely due to weather and anticipated opportunities for field work.

I believe that the unit on soil was the best unit of the class. Students had not spent much time on these concepts in their previous classes, so they more learning took place. Land use was incorporated into this unit, as was the information on topographic maps.

This may have been the more enjoyable unit, because it had the most laboratory opportunities. This was the second major unit in the course, and the weather was tolerable for many days outside.

The weakest unit was that on air quality. There were fewer laboratories in this unit, and more information was disseminated through lecture. Students signed up for the class expecting to spend a great deal of time outside. However, this unit was taught in January. It was not conducive to being outside at that time! Consequently, the bulk of this unit was taken up working on the Clean Air Act project. This project required more pencil-paper type tasks, but students were able to work in groups which made it more tolerable for them. Students were given grades based on their presentations at the culmination of the project. Some groups put together elaborate PowerPoint presentations that were most impressive. They also had an opportunity to grade themselves and the members of their group. Students preferred this assessment to a written test.

The water quality paper was another assignment on which students did not score well. A possible explanation for the poor scores was the final assignment for the 9 juniors that remained in the class after the seniors had left, and they were not as committed to producing high-quality work as they had been earlier in the year. In short, they wanted to begin their summer vacation early, and they were not as interested in school work in general.

This course had many successes and room for improvement. Because students were working at different paces, it was difficult to have a whole class discussion in post-lab sessions. This is an aspect of the course that should be improved – I think students would gain a deeper understanding of the topic if they could hear about the problems,

successes and insight of the other groups. This will be a difficult problem to overcome, due to the diverse nature of the students in the class. However, a possible solution would be to set aside part of a class period each week and allow students to share this information with each other. Students that had mastered a problem could give suggestions to those struggling with the task at that time. This would allow students to share their experiences and discuss concepts. Another issue to be further explored is that of staying on track during long-term labs. The more motivated students were able to stay on task during long labs. However, the less motivated, easily distracted or unorganized students experienced difficulty during the on-going labs. They procrastinated until right before the lab was due and often did not have complete observations or data.

Students in the spring were less motivated to complete assignments or to produce quality work. While this is inevitable to a certain degree in most classes, this was a major factor in the last few weeks of the course.

Another issue to be improved is that of writing major papers. Rather than use tests as assessments, two of the units culminated in large papers. Students did not score well on these assignments, and use of these papers may need to be re-examined.

The final issue that was difficult to overcome was the lack of funding for the course. The school did buy a set of thirty textbooks, but there was no additional funding for equipment. Consequently, many of the activities used simple, common materials that students could bring in from home or that we could inexpensively build in the classroom.

Despite these obstacles, there were many successes. The hands-on labs were enjoyable for both students and instructor. They allowed students to explore the ecological concepts in-depth and they enjoyed being out of their seats, going outside, and

discussing results with each other. The active nature of the course also lent itself to a more relaxed, flexible structure within the classroom. If students needed to go outside to collect materials for their lab, they were allowed to do so without adult supervision. The trust between student and teacher allowed them more privileges than they experienced in other classes. Many students commented on how much they enjoyed the freedom afforded to them in this class.

Another success of this course was that students enjoyed 'doing science.' Some of these students had only experienced labs of the 'cookbook' variety and were not aware of the true nature of science. The open-ended labs led students through the scientific process of posing a question and trying to find the answers. They learned that investigations sometimes must be modified from the original plan and that results obtained are not always those that are expected.

Some of the successes we experienced were unexpected. One of these was the development of interpersonal relationships among students. Since the class was comprised of such a heterogeneous mix, there were students working side by side with people with whom they would not have normally worked. This provided many opportunities for interactions and discussion among groups. The relaxed atmosphere also allowed me to get to know my students better and I enjoyed many of the discussions in which we engaged. I was pleasantly surprised at how much I enjoyed working with older students. Before implementing Environmental Science, I had taught mainly freshmen and sophomore level classes. Even though some of the students in Environmental Science challenged my classroom management techniques, I still found myself looking forward to the class each day. The Juniors and Seniors had developed a higher level of

maturity and were readily able to see how the topics studied applied to real-life situations. This made my role of guiding them through the course material and activities very enjoyable.

An additional bonus was the increase in my personal knowledge. The new course provided me with the opportunity to research and delve deeper into ecological concepts that interest me. Learning along with my students was a refreshing experience.

When examining the class as a whole, I feel very strongly that the hands-on approach produced a higher degree of learning, based on teacher observations. These observations indicated students were engaged in groups, working toward a common goal, and they were enjoying learning new material. Many students came into our classroom each day eagerly asking "What do we get to do today?" They displayed a great deal of enthusiasm and interest – they couldn't wait to check on whatever lab they had on-going at the time. The course was unique in the number of hands-on and on-going activities students experienced. They also responded well to the responsibility and freedom afforded to them that they had not experienced in other classes.

As previously mentioned, the course was first offered in the fall semester with a very small group of students. We worked through the material together and were able to have many productive discussions. Enrollment in the second semester was twice that of the first – word had gotten out that this was an enjoyable class. Many students attempted to enroll in the class for the second semester, but were restricted by the Guidance Office. Having a larger group was beneficial in many aspects, but the wide variety of motivation levels was somewhat more difficult to deal with. I had to work much harder to keep all students engaged than I did in the fall semester, especially as the weather got warmer and

summer vacation loomed. The students that did not score well on the final few assignments admitted that it was not due to difficulty or struggling with understanding concepts; they just were not interested in school work.

Working in groups was one of the aspects of the class that was cited as enjoyable. Students were able to form their own groups, which sometimes caused them to spend too much time talking about non-relevant topics. The long-term labs and relaxed atmosphere contributed to this. However, I was able to get to know my students better and gather much more information on their progress and attitudes toward the course in these informal conversations. Most groups were made up of students of similar abilities. As the semester progressed, students moved away from selecting groups based on social issues. They began to group themselves with others of similar work ethic. Those students that wanted to receive a good grade found each other, and those that did not care much about their grades also found each other. I did not observe negative comments among the students regarding this change; rather they all seemed to get along quite well, regardless of their academic goals. In addition, one student found himself working alone on a few labs, as the other class members got tired of his lack of contributions to the group. He eventually realized he had a responsibility to the success of his group. I believe a collaborative learning approach was beneficial with these students, as they were relaxed and seemed to enjoy the class more than they would if they were forced to work on their own.

As a result of this course, students have an increased knowledge of the environment and the ways in which we affect it. This is demonstrated by the increase in post-test scores and the high scores received by students on activities. Teacher

observations also noted understanding of key environmental concepts. Students have a better understanding of the practical application of the scientific method and know that it is not just a series of steps to be memorized. Rather it is a process to be used to work through questions. They have acquired tools to help them improve their communication through writing and have become more analytical, critical thinkers. These students have moved closer to becoming scientifically literate contributors to society.

APPENDICES

APPENDIX A

Letter of Consent, Pre-test and Post-Test

January 21, 2002

To: Parents of/Students enrolled in Environmental Science
From: Mrs. Norris, Instructor
RE: Collection of data from students

Dear Students and Parents:

During the next few months, we will be studying various topics that deal with the environment. As part of my master's program through Michigan State University, I have designed a laboratory-based approach to teach these concepts.

In order to evaluate the effectiveness of this unit, I will be using pre and post tests, student surveys, journal entries, as well as lab and homework assignments. These assignments will be a required part of the course for all students; I would like your permission to use data from these assignments for my master's thesis. **At no time will any student's name be used in, or connected to the thesis.** Student privacy will be protected to the maximum extent allowable by law.

Please fill out the bottom portion of this letter and return to me by Friday, January 25, 2002. If you choose to allow me to use your student's data, you may change your mind at any time by notifying me in writing. There is no penalty to the student for denying permission to use their data. Your decision will not affect your student's grade in any way. Please remember that all assignments are a required part of the Environmental Science course, regardless of whether or not data is to be collected from those assignments.

Thank you for you time and consideration. If you have any questions or concerns, please contact me at the High School (989) 743-3441. Participants with questions about their role and rights as a subject of research should contact David E. Wright, Ph.D., chair of the University Committee of Research Involving Human Subjects at Michigan State University, (517) 355-2180.

Sincerely,

Nicole H. Norris

____ I give Mrs. Norris permission to use my data collected from this class. I understand that my name will not be used, and all student data will remain confidential.

___ I do not wish for Mrs. Norris to use my data from this class. I understand that I will not be penalized for choosing to withhold my results.

_____ _____
Student Date

_____ _____
Parent/Guardian Date

Environmental Science
Pre-Test
Winter 2002

Multiple Choice
Please choose the best answer to complete each statement.

1. _____ A thick ice sheet that slowly covers a wide area of land is a(n) _____.
   a. glacier b. esker c. plate d. headwall

2. _____ A map that has contour lines showing elevations is a ____ map.
   a. relief b. geological c. topographic d. county

3. _____ The undisturbed solid rock found beneath loose surface material is ____.
   a. glacial till b. striations c. bedrock d. drift

4. _____ Glacial striations are _____ left on bedrock.
   a. depressions b b. rocks c. fossils d. scratches

5. _____ Depressions in glacial deposits left by melting ice blocks that later filled with water are _____.
   a. moraines b. glacial caves c. kettle lakes d. bogs

6. _____ A mound, ridge or other accumulation of glacial till is a _____.
   a. moraine b. icefall c. snow line d. tarn

7. _____ Accumulations of unsorted, unstratified mixtures of clay, silt, sand, gravel and boulders are referred to as _____.
   a. randkluft b. glacial till c. moulin d. niche glaciers

8. _____ Boulders that were carried great distances by glacial ice and are different from the bedrock or soils of their new home are called _____.
   a. drumlins b. erratics c. eskers d. kames

9. _____ The glaciers pushed a lot of soil from the _____ peninsula to the _____ peninsula.
   a. upper, lower
   b. lower, upper
   c. eastern, western
   d. western, eastern

10. _____ Which of the following best describes the flow of water through the Great Lakes?
    a. Erie → Michigan/Huron → Ontario → Superior → Atlantic Ocean
    b. Atlantic Ocean → Erie → Superior → Michigan/Huron → Ontario
    c. Superior → Michigan/Huron → Erie → Ontario → Atlantic Ocean
    d. Michigan/Huron → Superior → Ontario

11. _____ The part of the Earth we live on is the _____.
    a. crust b. mantle c. inner core d. outer core

12. _____ Compression, tension and shearing are all causes of _____.
    a. earthquakes b. subduction c. plate boundaries d. glaciers

13. _____ The theory that explains the movement of continents is _____.
    a. plate tectonics b. natural selection c. Wegener's farce d. none of the above

14. _____ Rain or snow that is more acidic than unpolluted rainwater is _____.
    a. base rain b. acid rain c. ozone rain d. plain rain

15. _____ Which of the following is evidence of continental drift?
    a. physical fit of continents
    b. fossil evidence
    c. glacial evidence
    d. all of the above are evidence of continental drift

16. _____ An area of land that drains into a lower lying body of water is a _____.
    a. headwater b. tributary c. watershed d. basin

17. _____ The abiotic components of soil are those that are _____.
    a. living b. non-living c. decaying d. none of these

18. _____ Which of the following are types of rock?
    a. metamorphic, metallic, minerals
    b. igneous, sedimentary, fossils
    c. sedimentary, igneous, fossils
    d. metamorphic, igneous, sedimentary

19. _____ The introduction of chemical, physical or biological agents into the water that degrades the quality of the water and affects the organisms that depend on it is ____.
    a. water purification
    b. water pollution
    c. water reclamation
    d. water eutrophication

20. _____ Pollution discharged from a single source, such as a factory is _____ pollution.

a. general b. nonpoint c. point d. thermal

21. _____ Pollution that comes from many sources rather than a specific site is ____ pollution.

a. general b. nonpoint c. point d. thermal

22. _____ The increase in concentration of toxins along the food chain is _____.

a. biological magnification
b. pathogen passing
c. natural eutrophication
d. artificial eutrophication

23. _____ Water that contains an abundance of nutrients is said to be _____.

a. abiotic b. biotic c. eutrophic d. depleted

24. ____ The type of pollution that results when excessive amounts of heat are added to a body of water is _____.

a. thermal b. nutrient c. cooling d. pathogenic

25. _____ The _____ occurs when carbon dioxide and other atmospheric gases prevent heat from escaping into space.

a. troposphere b. ozone depletion c. ozone formation d. greenhouse effect

26. _____Planned management of habitats and natural areas is _____.

a. preservation b. conservation c. recycling d. carrying capacity

27. _____ Selective cutting involves _____.

a. cutting all of the trees in a forest and then reseeding
b. cutting all of the trees of one species and leaving the rest
c. cutting the mature trees in a forest and leaving the rest
d. cutting the young trees in a forest and leaving the rest

28. _____What is one advantage of clear cutting?

a. It is the cheapest way for companies to harvest trees.
b. It enables the ecosystem to return to normal.
c. It aerates the soil, allowing it to regenerate.
d. It brings light to the heavily shaded plants of the forest floor.

29. _____Which choice best defines "wilderness?"
   a. any non-urban area
   b. any national park or monument
   c. any land protected from development and human impact
   d. any land with hiking trails

30. _____ Planned management of habitats and natural areas is _____.
   a. preservation b. conservation c. recycling d. carrying capacity

31. _____ What is a possible result of overgrazing?
   a. most of the grass dies off
   b. the soil is eroded
   c. the land is invaded by shrubs or cactuses
   d. all of the above

32. _____ In _____ mining, machines clear away large strips of the Earth's surface.
   a. refuse b. open-pit c. strip d. cave

33. _____ The condition caused by not consuming enough necessary nutrients is _____.
   a. satiation b. malnutrition c. gluttony d. none of the above

34. _____ Periods when rainfall is less than average are called _____.
   a. droughts b. salinization c. subsistence d. famine

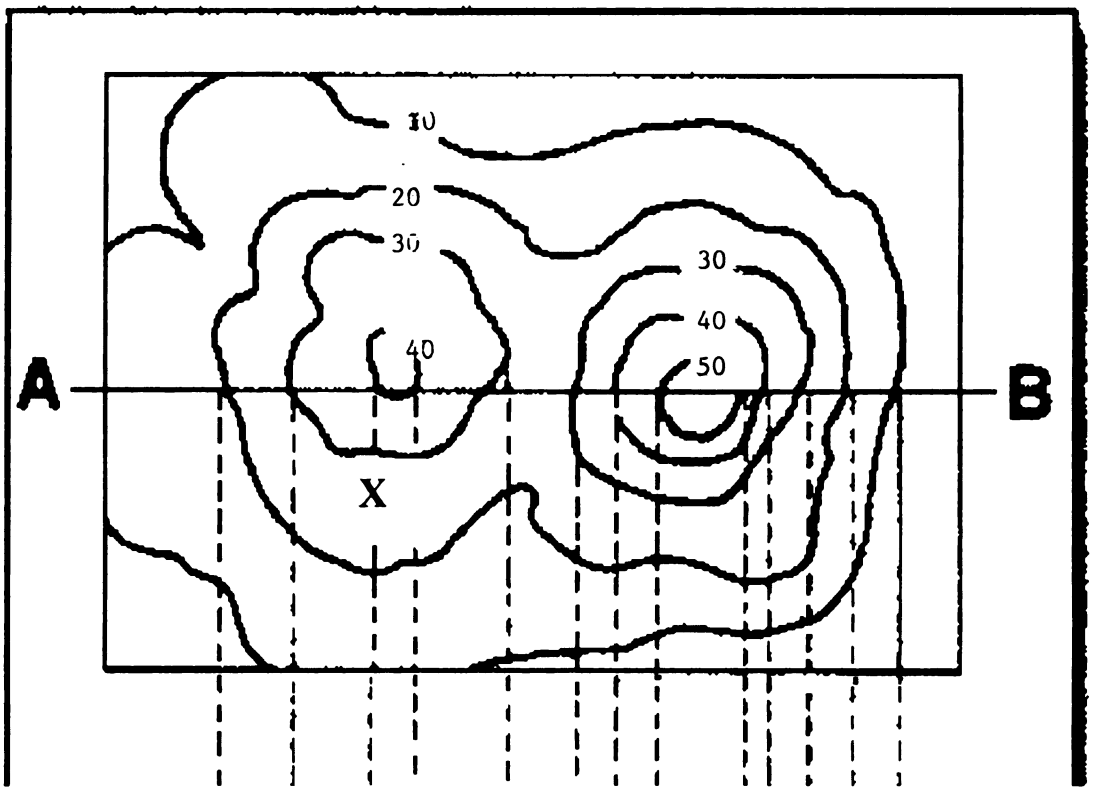
35. _____ The loose surface layer of soil where most plant roots grow is the _____.
   a. surface litter b. topsoil c. zone of leaching d. subsoil

36. _____ Which is the best description of how long it can take to form a few centimeters of soil?
   a. less than 10 years
   b. 10-50 years
   c. 50-200 years
   d. thousands of years

37. _____ The wearing away of topsoil by wind or water is _____.
   a. desertification b. erosion c. salinization d. all of the above

38._____ Air pollution resulting from chemical pollutants, particulates and sulfur dioxide is
   a. smog b. fog c. greenhouse gases d. ozone depletion

39. _____ Rain or snow more acidic than unpolluted rainwater is _____.
   a. base rain b. acid rain c. ozone rain d. a good thing



40. Which is higher, hill A or hill B? _____

41. Which is steeper, hill A or hill B? _____

42. How many feet of elevation are there between contour lines? _____

43. If you were standing on the ground at point X, looking at this landscape, what would it look like? Please illustrate using a sketch of the two hills.

44. Please explain how the Great Lakes were formed:

45. How does plate tectonics explain features of the Earth's surface?

46.How do human activities affect the quality of water in the hydrosphere?

47. Give one factor that affects the rate of decomposition in a compost pile. Please explain how it affects the rate.

48. Please give a brief explanation as to how soil is formed:

Environmental Science
Post-Test

Multiple Choice
Please choose the best answer to complete each statement.

1. _____ A thick ice sheet that slowly covers a wide area of land is a(n) _____.
   a. glacier b. esker c. plate d. headwall

2. _____ A map that has contour lines showing elevations is a ____ map.
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   a. glacial till b. striations c. bedrock d. drift

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5. _____ Depressions in glacial deposits left by melting ice blocks that later filled with water are _____.
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8. _____ Boulders that were carried great distances by glacial ice and are different from the bedrock or soils of their new home are called _____.
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   e. upper, lower
   f. lower, upper
   g. eastern, western
   h. western, eastern

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    f. Atlantic Ocean → Erie → Superior → Michigan/Huron → Ontario
    g. Superior → Michigan/Huron → Erie → Ontario → Atlantic Ocean
    h. Michigan/Huron → Superior → Ontario

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20. _____ The _____ occurs when carbon dioxide and other atmospheric gases prevent heat from escaping into space.
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a. preservation b. conservation c. recycling d. carrying capacity

22. _____ Selective cutting involves _____.
e. cutting all of the trees in a forest and then reseeding
f. cutting all of the trees of one species and leaving the rest
g. cutting the mature trees in a forest and leaving the rest
h. cutting the young trees in a forest and leaving the rest

23. _____What is one advantage of clear cutting?
e. It is the cheapest way for companies to harvest trees.
f. It enables the ecosystem to return to normal.
g. It aerates the soil, allowing it to regenerate.
h. It brings light to the heavily shaded plants of the forest floor.

24. _____Which choice best defines "wilderness?"
e. any non-urban area
f. any national park or monument
g. any land protected from development and human impact
h. any land with hiking trails

25. _____ Planned management of habitats and natural areas is _____.
a. preservation b. conservation c. recycling d. carrying capacity

26. _____ What is a possible result of overgrazing?
e. most of the grass dies off
f. the soil is eroded
g. the land is invaded by shrubs or cactuses
h. all of the above

27. _____ In _____ mining, machines clear away large strips of the Earth's surface.
a. refuse b. open-pit c. strip d. cave

28. _____ The condition caused by not consuming enough necessary nutrients is _____.
a. satiation b. malnutrition c. gluttony d. none of the above

29. _____ Periods when rainfall is less than average are called _____.
a. droughts b. salinization c. subsistence d. famine

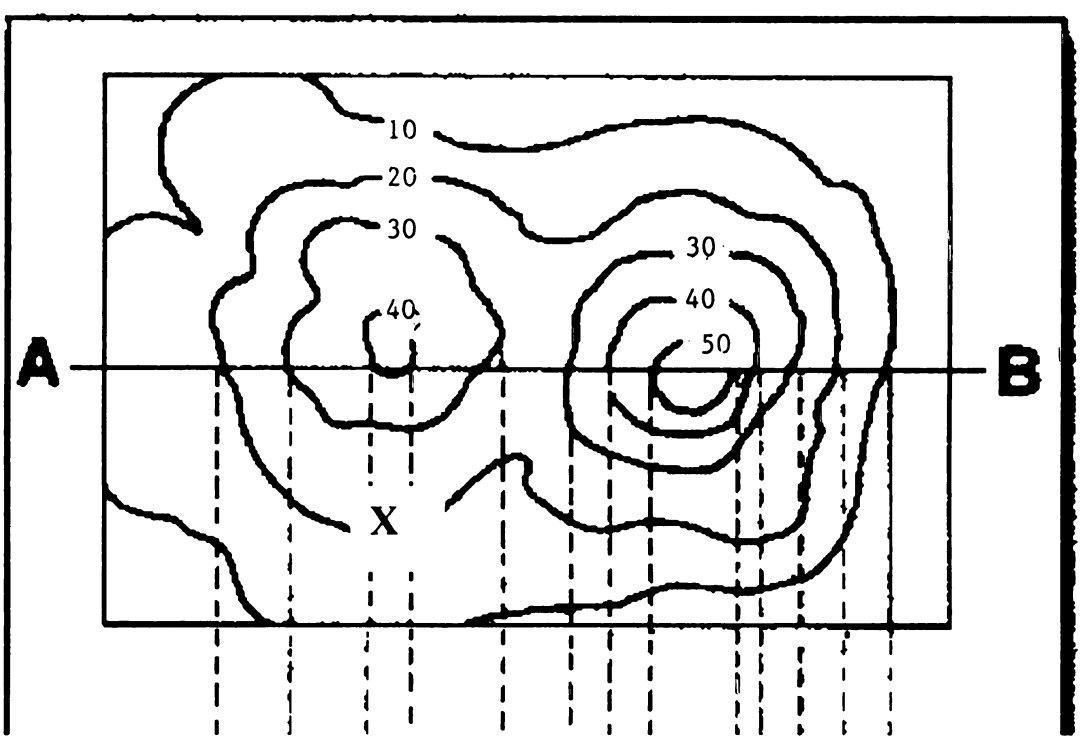
30. _____ The loose surface layer of soil where most plant roots grow is the _____.
a. surface litter b. topsoil c. zone of leaching d. subsoil

31. _____ Which is the best description of how long it can take to form a few centimeters of soil?
e. less than 10 years
f. 10-50 years
g. 50-200 years
h. thousands of years

32. _____ The wearing away of topsoil by wind or water is _____.
a. desertification b. erosion c. salinization d. all of the above

33._____ Air pollution resulting from chemical pollutants, particulates and sulfur dioxide is
a. smog b. fog c. greenhouse gases d. ozone depletion

34. _____ Rain or snow more acidic than unpolluted rainwater is _____.
a. base rain b. acid rain c. ozone rain d. a good thing



35. Which is higher, hill A or hill B? _____

36. Which is steeper, hill A or hill B? _____

37. How many feet of elevation are there between contour lines? _____

38. If you were standing on the ground at point X, looking at this landscape, what would it look like? Please illustrate using a sketch of the two hills.

39. Please explain how the Great Lakes were formed:

40.How do human activities affect the quality of water in the hydrosphere?
41. Give one factor that affects the rate of decomposition in a compost pile. Please explain how it affects the rate.

42. Please give a brief explanation as to how soil is formed:

APPENDIX B

Skeleton Outlines

I – Environmental Science Text Chapter 6
II – Great Lakes Atlas Chapter 1
III – Great Lakes Atlas Chapter 2
IV – Environmental Science Text Chapter 8
V – Environmental Science Text Section 5.3

Chapter 6: Air

6.1: What Causes Air Pollution?

- clean air consists mostly of _____ & _____ gases
  - also has small amounts of:

- unhealthy levels of harmful substances = _____
  - can be solids, liquids, gases

- most air pollution is the result of _____
  - natural sources:

- _____ = put directly into air by human activity

- **secondary pollutant** =

Primary Air Pollutants

pollutant	description	primary sources	effects	% of pollution
carbon monoxide				
nitrogen oxides				
sulfur dioxide				
volatile organic compounds				
particulate matter				

- over 1/3 of air pollution comes from:

- Clean Air Act gives the EPA authority to regulate automobile emissions
  - decreased lead in gas
  - catalytic converters clean exhaust gases

- can decrease air pollution by driving less
- examples of non-gas cars:

- List contributions to air pollution from the following:
  - car interior -

  - body & frame -

  - fuel tank -

  - exhaust -

- Describe how a catalytic converter works:

- Industrial Air Pollution
  - industries and power plants burn fossil fuels to generate energy

    - releases _____ into air

    - some use _____ which produce toxic fumes

    - methods for controlling pollution:
- thermal inversions
  - usually circulating air in the atmosphere keeps pollution levels reasonable
    - sun heats Earth and nearby air
    - warm air rises, carrying pollutants into atmosphere
- explain how a thermal inversion traps pollutants near the earth's surface:

- smog
  - = smoke & fog
  - results from:

- main cause =

6.2: Effects on Human Health

- Air pollution causes health problems
    - Those most susceptible:
- Chronic bronchitis =
    - Main irritants =
- Bronchial asthma =

- Emphysema =

- Major cause of lung cancer =
    - Other contributors to lung cancer:

Indoor Air Pollution

- Americans spend about _____% of their time indoors
- List 6 indoor air pollutants and their sources:

- Explain **sick building syndrome**

- Radon =
    - Sources of radon:
    - Action in lungs:

- Asbestos =
    - Used in:
    - Effect on the body:

1. Describe some possible health effects of air pollution

2. Explain what causes indoor air pollution and how it can be prevented

6.3: Acid Precipitation

acid precipitation =

Explain how acid rain results from burning of fossil fuels:

Acid precipitation has a pH value of less than _____.

Effects of acid precipitation on ecosystems

- effects on lake pH –
- effects on aluminum in soil surrounding lake –
- effects are the worse during which season? why?
    - effects of acid shock on fish, reproduction
- efforts to counteract effects of acid precipitation –
- effects on forest ecosystems-
- Most acid precipitation in New England is produced:
- Which agreement did the U.S. **not** sign? When? What did this agreement require?
- Which agreement did the U.S. sign? When? What did this agreement require?
- Will the current international agreements be enough to control the acid precipitation problem? Explain:

1. **Explain what causes acid precipitation**

2. **Explain how acid precipitation affects ecosystems**

3. **Describe ways countries are working together to solve the problem of acid precipitation**

Chapter 1 Introduction: the Great Lakes

1. List the 5 Great Lakes
2. The Great Lakes contain approximately _____ cubic miles of water.
3. Do the Great Lakes contain the most freshwater on the Earth? Explain.
4. List 4 sources of pollution that contaminate the Great Lakes.
5. What happens to the pollutants that enter the Great Lakes?
6. What is retention time? Which lake has the longest retention time
7. How did settlement and exploitation affect the ecosystem of Michigan?
8. Which lake showed the first evidence of eutrophic imbalance? When?
9. Explain how toxic contaminants can magnify as they move up the food chain.
10. What are ecosystem indicators?

Great Lakes Atlas

Chapter 2 Natural Processes in the Great Lakes

1. Describe what happened during the Precambrian Era:
2. In between glaciers, there were interglacial periods. What are these?
3. What is an aquifer? What type of sediments make up an aquifer?
4. Has the uplift of Michigan stopped? How will this affect the Great Lakes in the future?
5. What are the 3 factors that affect the weather in the Great Lakes basin?
6. How do the lakes affect the climate of the land near them?
7. What is the greenhouse effect? How have humans affected it?
8. How could warmer climates affect the lake levels?
9. Describe the hydrologic cycle.
10. What happens to sediments carried in surface runoff?
11. List and describe the 4 types of wetlands in the Great Lakes basin
12. What benefits to wetlands provide?
13. During which season are the lake levels usually lowest? Highest?
14. What is wind set-up?
15. What is stratification? What causes it?
16. Define hypolimnion, epilimnion, thermocline and describe each.
17. Describe lake turnover and how it happens.
18. Why is lake turnover important to water quality?
19. What is a thermal bar? How are they related to concentrated pollutants?
20. Describe the food chain of the Great Lakes

Chapter 8: Land

8.1 The City

1982: California began studying land use. They discovered that in 8 years, about _____ acres of productive farmland, rangeland and woodland were converted into towns and cities.

_____% of Americans live in urban areas, and by 2025, almost _____ of the world population will probably live in cities. However, urban dwellers need non-urban land and resources.

- _____ = growth of cities as people move from rural to urban areas
- List one problem with urbanization:

- _____ = all the things a society builds for public use
  - examples:

- _____ = lack of adequate infrastructure in overpopulated cities

- _____ = development that spreads out around cities; is one consequence of the urban crisis

- _____ determines where people will live, work, places for roads, malls, etc.
-
- Mass Transportation = buses, subways, trains
  - Benefits of mass transportation:

    - Drawbacks to mass transportation:

- Open Spaces (in cities, etc) = parks, trails, gardens, etc.
  - Benefits to the environment:

8.2 How We Use Land

Harvesting Trees

- for paper, lumber, space for farming, etc

- _____ = clearing trees and not replacing them

- Methods of Harvesting
  1. _____ = removing all trees from an area
     - Consequences:

  2. _____ = harvest mid-aged to mature trees
     - Consequences:

- Reforestation =

- Protecting Forests – governments are trying to improve reforestation, decrease destructive harvesting, begin tree-planting programs

Ranching

- Range consists of grasses, shrubs that are tolerant of grazing
  - These grasses decrease erosion – see root system pg 208

  - Overgrazing =
    - can lead to **desertification**

Maintaining the Range
1. Improve Grazing

2. Range Improvement

Mining

Types of mining:
1. open-pit mining =

2. strip mining =

Effects of mining (list at least 5)

How to decrease damage from mining:

8.3: Public Land in the United States

- 1st national park =
  - there are about 55 National parks in the U.S.

_____ % of US land in publicly owned
  - this land is managed by:

  - problems with multiple-use management

_____ = area in which the land & ecosystems it supports are protected from all development

  - ecological benefits to wilderness areas:

  - problems in wilderness areas:

  - controls to these problems:

5.2 Freshwater Pollution

1. Why are the former Soviet-bloc countries some of the most polluted?

2. _____ is the introduction of chemical, physical or biological agents into water that degrades the quality of the water and affects the organisms that depend on it.

3. What is point pollution? Give 3 sources of point pollution.

4. What is nonpoint pollution? Give 3 sources of nonpoint pollution.

5. Why is point pollution easier to eliminate than nonpoint pollution?

6. What is the major cause of pollution in the Pigeon River in Cocke County N.C.?

7. What is dioxin? What types of problems does it cause?

8. What would happen if the mill was forced to comply with the EPA changes?

9. Did the 1989 changes affect the people working at the mill? Did they affect the water quality?

10. Which do you think is more important – protecting the environment or protecting people's jobs? Explain.

11. Explain how a wastewater treatment plant works.

12. List some diseases caused by drinking water polluted with pathogens.

13. Draw a diagram showing how the biological magnification of a pollutant in an aquatic ecosystem may result in endangerment of a species.

14. How does nutrient-rich fertilizer cause fish kills?

15. How does thermal pollution disrupt aquatic ecosystems?

16. Why is groundwater so difficult to clean up?

17. Is bottled water always safer to drink than the public supply of water?

APPENDIX C

Labs, Activities, Projects

I – The Lorax
II – Duckweed Lab
III – Glacier Scavenger Hunt
IV – Glacial Flip Book
V – Particulate Lab
VI – Ozone Video
VII – Acid Precipitation Lab
VIII – Clean Air Act Project
IX – Recycle City Web Activity
X – Mining Lab
XI – Soil Filtration Lab
XII – Recipe for Life
XIII – Erosion Lab
XIV – Topographic Models
XV – Composting Activity
XVI – Dirty Little Bugs
XVII – Soil Paper
XVIII – Indoor Water Testing Lab
XIX – Exxon Valdez Video
XX – Great Lakes Fishery Video
XXI – Water Quality Paper

The Lorax

While watching this video, please complete the questions below. We will be using them in a class discussion.

1. Why was the Once-ler called this?

2. What natural resource did the Once-ler find?

3. What was the Once-ler's product? What was this used for?

4. What did the Once-ler invent to increase thneed production? Did this have positive or negative consequences?

5. Was "biggering" better for everyone?

6. How did the production of thneeds affect the truffula trees?

7. How were fish and swans affected by the manufacturing of thneeds?

8. Why did the Once-ler's business fail?

9. What must happen for the Lorax and his animals to return?

10. How does this video relate to the "real world?"

Duckweed!

Scientific name: _____.

Your group will receive some duckweed. Your challenge is to find the best conditions for growing this plant. The group that gets their duckweed to grow the best will be declared the winners and their names will forever be remembered in Environmental Science legacy.

Today your task is to form your groups and gather information on this plant. You may use any resources you choose; however, we have the computer lab reserved for your class both today and tomorrow. You will use this information to design an experiment to grow your duckweed. Helpful information might include factors such as where the plants occur naturally, pH ranges of the water, amount of sunlight required, temperature ranges, etc.

Once your group has their plan, please write out the steps of your experimental procedure. Things you might want to consider are length of exposure to light, type of light, temperature, etc. Each member of your group must keep their own copy of the steps, and you also need to turn one copy in with the names of all group members. Once your plan has been approved, you will gather your materials and begin your experiment!

At the conclusion of this experiment, you will each write up individual lab reports. Please follow the basic outline below:

- Introduction
- Hypothesis
- Materials
- Procedure (write out in a numbered list of steps)
- Data (include daily observations)
- Discussion and conclusions
    - Do you accept or reject your hypothesis and why
    - Include improvements to your procedure and what your next steps might be

Glacier Scavenger Hunt

Environmental Science

Please go to http://nsidc.org/glaciers/index.html and click on The Glacier Story. This will give you an overview about glaciers. It is a good introduction to this material. After going through the 9 pages of The Glacier Story, please move around the rest of the website to answer the questions below.

1. _____ % of land area is covered by glaciers.

2. A glacier is:

3. An Ice Age is:

4. How many Ice Ages have occurred in the past 750,000 years?

5. How is a glacier formed? How long does it take?

6. Why do glaciers move? Is the movement rapid or slow?

7. If all land ice melted, sea level would rise approximately _____ meters worldwide.

8. Why does glacial ice often appear blue?

9. How long has the Antarctic ice sheet been in existence?

10. Explain the following components of a glacier:

    - Ablation area –
    - Equilibrium –
    - Crevasses –
    - Medial moraines –
    - Lateral moraines –
    - Terminal moraines –
    - Terminus –

11. How many square kilometers in the United States are covered by glaciers?

12. How many square kilometers on the Earth are covered by glaciers?

13. Continental masses of glacial ice & snow expanding over 50,000 square kilometers are _____.

14. Ice sheets that extend over the sea and float on water are _____.

15. Ice sheets less than 50,000 square kilometers are _____.

16. In 1953 the Kutiah Glacier in Pakistan averaged _____ meters per day, which is the record for the fastest glacial surge.

17. How do glaciers affect the land? Give an example of a glacial landform caused by erosion.

18. How do scientists use glaciers to learn about climate change?

19. How many miles has Alaska's Columbia Glacier receded in the last 20 years?

Extra credit: At what rate does Alaska's Columbia Glacier move into the sea?

Glacier Flip Book

Glacial Lakes around Michigan FLIP BOOK construction tips

Materials you will need:

__The flip-book page, printed out
__Crayons, markers, or colored pencils
__Scissors
__Stapler

Here's what to do:

__Color in the drawings. It is easier to color the sheet before you cut the pictures out.
__Cut out the six pictures by cutting along the solid lines. Make sure the paper is straight across the bottom.
__Stack the pages, face up, in numerical order. The figure numbers are from MI DEQ GSD Bulletin 4 Glacial Lakes around Michigan – for the more info go to http://www.deq.state.mi.us/gsd/freepaga.html
__Staple the stack of pictures together with one staple at the very top.
__Hold at the top and flip the pages from back to front.

Watch as the glaciers move over Michigan!

Some questions to consider

__What happens when you stack the pictures in ascending order (from 6 to 11)?
__What happens when you stack the pictures in descending order (from 11 to 6)?

- Figure 6: The retreating ice front halted and built the Valparaiso-Charlotte-Ft. Wayne Moraine. As the ice left this position the first known lakes began to form. (about 14,500 years ago)
- Figure 7: Advancing temporarily, the glacier almost forced Early Lake Chicago out of its basin. The Lake Border Moraine was built at this time. (about 14,000 years ago)
- Figure 8: After making one last strong re-advance, the ice front halted and built the most prominent topographic feature in the region, the Port Huron Moraine. (about 13,000 years ago)
- Figure 9: Lake Algonquin stage was initiated when the Trent valley outlet was dammed by a local readvance. (about 11,000 years ago)
- Figure 10: The lakes were drained down to extreme low levels when the retreating ice front uncovered a sea level outlet at North Bay. (about 9,500 years ago)
- Figure 11: With the ice burden gone, the earth's crust in the northern part of the region began to rise. When the North Bay outlet rose to the same level as the Port Huron and Chicago outlets, the Nipissing Great Lakes were born. (about 6,000 to 4,000 years ago)
-

Michigan Department of Environmental Quality ,
Geological Survey Division (GSD)
P O Box 30256, 735 E Hazel Street
Lansing, Michigan 48909-7756
Web http://www.deq.state.mi.us/gsd

Figure 6: About 14,500 years ago

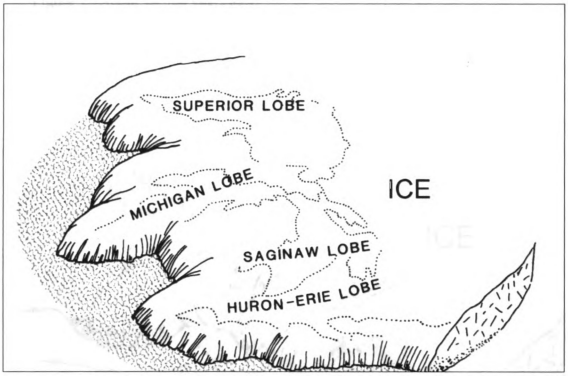


Figure 7: About 14,000 years ago

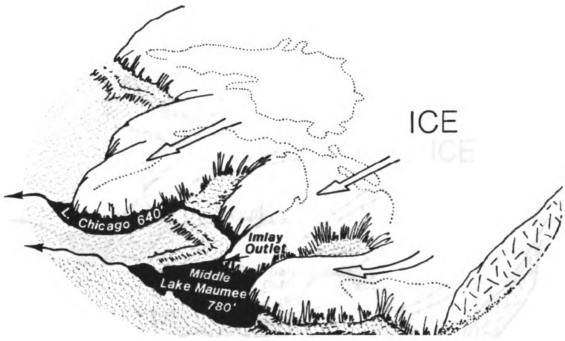


Figure 8: About 13,000 years ago

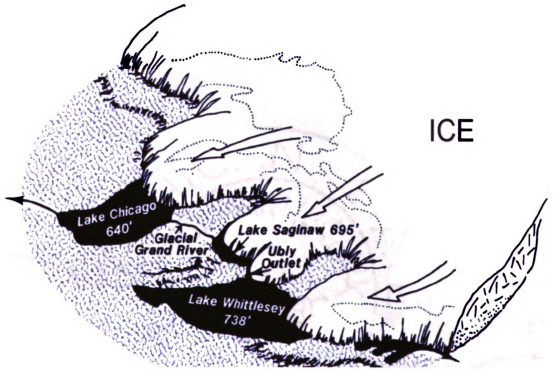


Figure 9: About 11,000 years ago

Figure 10: About 9,500 years ago

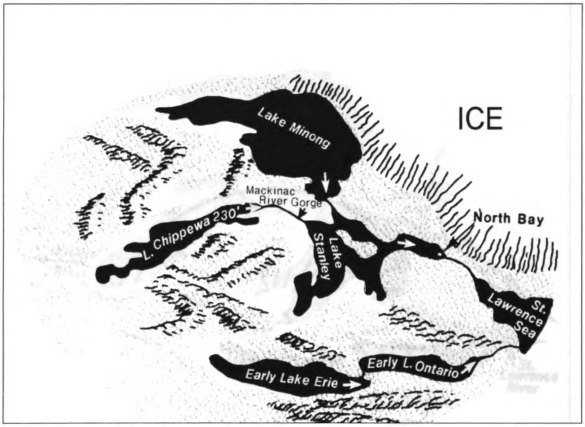
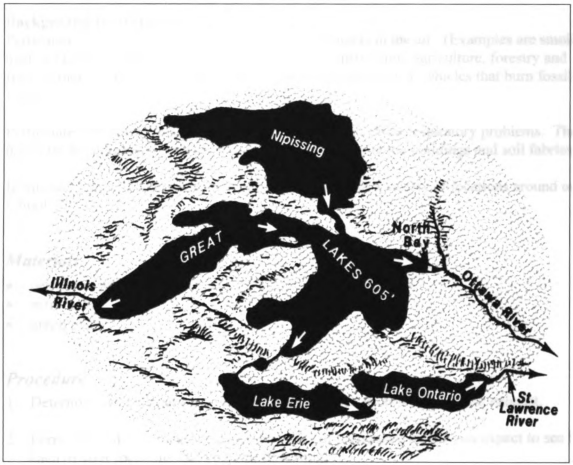


Figure 11: About 6,000 to 4,000 years ago



Particulates in the Air
or
A Particularly Solid Lab

Background Information
Particulates are tiny particles of liquid or solid pollutants in the air. (Examples are smoke, dust, acid droplets) Most particulates come from construction, agriculture, forestry and fires. Other contributors include industrial processes and motor vehicles that burn fossil fuels.

Particulates can form clouds that decrease visibility and cause respiratory problems. They have also been linked to cancer, and can corrode metals, erode buildings and soil fabrics.

In this lab, you will determine the level of particulates in a variety of locations around our school.

Materials
- petroleum jelly
- petri dishes
- graph paper

Procedure
1. Determine which locations you will be testing. All groups will test car exhaust.

2. Form a hypothesis about the expected levels of particulate matter you expect to see in each of your locations that you will be testing.

3. Get approval for your testing locations, then write your hypotheses in the data table.

4. Cut circles of graph paper to fit under your petri dish.

5. Spread a thin layer of petroleum jelly onto the bottom of the petri dish.

6. Label your dish with name, date and location.

7. Place your dish in the location to be tested, and return to the classroom.

8. The entire class will be going out to the parking lot to test car exhaust together.
   - each group needs to expose their petri plate to car exhaust for 15 minutes

9. For each location, you will count the number of particles in 20 randomly selected squares using a binocular stereomicroscope, or a monocular microscope using the 5x objective lens.
10. Calculate an average number of particulates per square, and record in your data table. Please also write your average number on the board.

11. Compare the results of the other groups. Generate a bar graph of the results of all locations tested (use your own car data) and determine if there is a pattern in the number of particulates counted.

12. Please answer the questions after the data table, and staple your graph to this lab before turning in.

Data Table

Location	**Hypothesis**	**Average # of particulates**
Car		

1. Were your hypotheses correct? Explain:

2. Which location that you tested had the highest number of particulates? Why do you think this is?

3. Which location out of all that were tested had the lowest number of particulates? Why do you think this is?

4. Were there any differences in particulate levels from different vehicles? Propose a reason for any differences that might occur:

Ozone Video

Ozone: The Hole Story

1. Chlorofluorocarbons are abbreviated _____.
2. What happens when CFCs escape?
3. _____ out of 6 people will develop melanoma.
4. What happens to the following UV radiation?
   a. UVC: _____
   b. UVB: _____
   c. UVA: _____

5. How does New Zealand protect the children?
6. How could plants be hurt by UV?
7. Why is there probably a hole over Antarctica?
8. _____ is the element which is damaging to the ozone.
9. _____% drop over the South Pole of ozone, but, they had found it there _____.

10. What does sulfur do to ozone?
11. One of the largest users of CFCs is the _____. They use it for:
12. How has the automobile industry helped with the problem of CFC usage?
13. The "good ozone" is in the _____.
14. The ozone is worst during what time of the day?
15. Clean air characteristics with the rose and the tomato:
    a. rose looks:
    b. tomato looks
16. Smog air characteristics with rose and tomato:
    a. rose looks:
    b. tomato looks:

Acid Precipitation Lab

Objective
Design and conduct an experiment to test the effects of acid rain on the germination rates of seeds. Within your experimental plan, you should include a control as well as testing varying levels of acidity, up to and including full strength acetic acid.

Materials Available

petri dishes	paper towels	vinegar
water	pinto beans	pH paper

other materials may be available upon request

Your Task
Within your group, formulate a hypothesis regarding the effects of acid rain on seed germination. Then design an experiment to test your hypothesis. Once you feel you have a solid experimental plan, have your plan reviewed and approved by your instructor. Complete the Hypothesis, Materials, and Procedure portions below before presenting your plan for approval.

Hypothesis:

Materials:

Procedure:

Once your plan has been approved, go ahead and set up your experiment. Be sure to label all your Petri dishes, etc. with your group name, date and acidity levels. Use the space below to make a data table where you will record your **daily** observations.

Post-Lab:
After you have completed your experiment, please complete the sections below.

Results
In paragraph form, please discuss the results of your experiment. Attach a graph of the germination rates/growth for each of your various setups.

Analysis/Conclusions:
In paragraph form, please discuss whether you accept or reject hypothesis, why you feel you got the results you did, possible problems/improvements in your procedure, and future directions you could take with this concept.

Clean Air Act Project

Adapted from Internet Webquest shown below, which was copied from the original web site (url). Only the first three pages of the webpage are copied here. I used my own rubrics for grading that differ from the author's.

Should the Clean Air Act of 1990 be Repealed?

Introduction | Task| Process | Resources | Evaluation |Conclusion | Teachers Page

A WebQuest created by

Angela Y Northern
McDowell Adult Education Center
Columbus, Indiana

Introduction

Congressman Icant Deside has to decide whether to vote for or against the repeal of The Clean Air Act of 1990. One of the biggest issues in the debate for or against the repeal of this act is Acid Rain. The congressman make an informed decision that will reflect the views of the majority of his constituents. In order to gather information about the views of his community members, Congressman Icant Deside has called for a town meeting. Your team will need to make a presentation at this meeting in order to convince the Congressman to vote to the benefit of your group.

The Task

Your congressman is a very busy man and he hasn't taken the time to look at The Clean Air Act since it was put into effect in 1990. (He missed the vote that changed the Act in 1997).

Your team will represent an individual interest group at the town meeting. Some of the smaller groups have decided to combine efforts to allow for stronger representation at the town meeting.

Your Interest Groups:

The Local PowerPlant (coal burning plant; employs 30% of the town population.
The Local Paper Mill (pulp mill, employs 20% of the town population)
The Tree Farmers/Loggers (supplies the paper mill, employs 10% of the town population)
Health Care and hospitals (employs 10% of the town population)
Transportation (Over-the-road trucking, bus stations & Taxi services, employs 20% of the town population)
The Local Environmental Group (nonprofit group, wants to improve the world for our children)

Your job will be to prepare a presentation that answers the following questions.

What Exactly does the Clean Air Act of 1990 say? How does the act impact your interest group?
(Make this simple-Icant Deside doesn't need a lot of detail)
What were the major changes made in 1997? Did they have any major effects on your group?
Explain Acid Rain and its causes and effects. How does your group contribute to Acid Rain?
Use statistics to detail the success or failure of the Clean Air Act of 1990 in relation to Acid Rain.
Your interest groups stand as to whether Congressman Icant Deside should vote for or against the repeal of the Clean Air Act of 1990.

The Process

You will be given 2 weeks to prepare for your presentation. Use the following time line as a basis for your project.

Day 1:	Form teams, Develop Team Charter, brainstorm ideas for research
Day2:	Split research topics among group members, begin researching
Day3-6:	Complete Research
Day 6-8:	Produce Presentations
Day9-10:	Presentations

Resources

Use the weblinks below to prepare your presentation. You need not use all sites, but you may want to explore all sites in order to choose the best. You may use any other print resources available.

Include a bibliography of any sources that you use.

The Plain English Guide to the Clean Air Act of 1990	Acid Rain Maps 1994-1997	Acid Rain Maps 1998
Acid Rain: A Student's First Sourcebook	Acid Rain Information & Activities	EPA Environmental Effects of Acid Rain
USGS Primer on Acid Rain	USGS On-line data	EPA Acid Rain Page
USGS-Coal Information	Paper Pulping Information	Forestry Information
Transportation Information	Trucking and Pollution Control	Health and Acid Rain

Clean Air Act Project

Group Member Evaluation

Your name: _____

Please rate your team member and yourself. 4 is the best rating, 0 is the lowest. Be fair in your evaluations and select a rating for each quality. List your team members and yourself in **alphabetical order!!!**

Member 1: _____

• cooperated with group members:	4	3	2	1	0
• contributed to the investigation	4	3	2	1	0
• completed assigned tasks	4	3	2	1	0
• stayed on task	4	3	2	1	0
• attitude during investigation	4	3	2	1	0
• want them on your team for next project	4	3	2	1	0

Total points for this person: _____

Comments:

Member 2: _____

• cooperated with group members:	4	3	2	1	0
• contributed to the investigation	4	3	2	1	0
• completed assigned tasks	4	3	2	1	0
• stayed on task	4	3	2	1	0
• attitude during investigation	4	3	2	1	0
• want them on your team for next project	4	3	2	1	0

Total points for this person: _____

Comments:

Member 3: _____

• cooperated with group members:	4	3	2	1	0
• contributed to the investigation	4	3	2	1	0
• completed assigned tasks	4	3	2	1	0
• stayed on task	4	3	2	1	0
• attitude during investigation	4	3	2	1	0
• want them on your team for next project	4	3	2	1	0

Total points for this person: _____

Comments:

Member 4: _____

• cooperated with group members:	4	3	2	1	0
• contributed to the investigation	4	3	2	1	0
• completed assigned tasks	4	3	2	1	0
• stayed on task	4	3	2	1	0
• attitude during investigation	4	3	2	1	0
• want them on your team for next project	4	3	2	1	0

Total points for this person: _____

Comments:

Member 5: _____

• cooperated with group members:	4	3	2	1	0
• contributed to the investigation	4	3	2	1	0
• completed assigned tasks	4	3	2	1	0
• stayed on task	4	3	2	1	0
• attitude during investigation	4	3	2	1	0
• want them on your team for next project	4	3	2	1	0

Total points for this person: _____

Comments:

Clean Air Act Project

Product Evaluation

Group name: _____

Group members:

Your final product will be evaluated based on the following categories. Each category will be rated on a scale of 0 to 5; 0 meaning that you did not meet the objective, and 5 meaning you completely met the objective.

Category 1: Did you answer the questions?

- What exactly does the Clean Air Act of 1990 say? _____
- What were the major changes made in 1997? _____
- Explain acid rain and its causes and effects _____
- Use statistics to detail the success or failure of the CAA of 1990 in relation to acid rain _____
- Your opinion as to whether the CAA should be repealed or not _____

Total points for category 1: _____

Category 2: Presentation

- All members participate _____
- Speakers address audience, maintain eye contact, able to be heard _____
- Presentation made in natural, logical order _____
- Presentation is informative – all part of topic covered _____
- Presentation is interesting, creative _____
- Sources are documented (bibliography) _____
- Presentation included conclusion _____
- Bonus points (wow factor) _____

Total points for category 2 _____

Recycle City Webquest

Please go to the following website: *http://www.epa.gov/recyclecity/*
Look at the map of Recycle City and click on the Southeast section. You will remain in this area to answer the questions below. Please move around this section and search for information. There are many places to visit, such as Widget Manufacturing, etc. All answers can be found in the Southeast section.

1. _____ Another name for a doodad is this.

2. _____ New 'peanuts' for packaging are made from this.

3. _____ Major source of waste in industry

4. _____ Widget workers saved this many millions of pounds of wood by collecting wooden pallets, and reused or resold them.

5. _____ Instead of throwing out broken widgets, customers may return widgets for

6. _____ These were installed in smoke stacks to catch harmful exhaust from the factory.

7. _____ If 100 widget workers carpool, over 2 weeks, ___ pounds of carbon dioxide will be prevented from entering the atmosphere.

8. _____ A higher octane fuel uses more of this than a lower octane fuel.

9. _____ Putting the car's gas cap on tightly will reduce this type of pollution.

10. _____ Oil filters are made up of ____.

11. _____ The steel can be _____ from the oil filters.

12. _____ One million gallons of fresh water would be contaminated from just ____ of oil dumped.

13. List 3 maintenance tips which will help the car run better and help the environment.
    a.

    b.

    c.

14. _____ These two toxic substances are found in oil.

15. _____ These are the rays blocked from the earth by ozone.

16. _____ This 'eats' oxygen atoms which destroy ozone.

17. _____ Ground level ozone

18. In this city, leaks in gasoline storage tanks are detected. How do they know there is a leak?

19. List at least 2 things you can do with old tires instead of throwing them out:

20. List one pro and one con for electric cars:

21. _____ This is used in packaging, animal bedding, paper bags. It may be recycled and reused too.

22. _____ Environmentally friendly color

23. Name 3 ways in which Maria's Market is helping the environment:

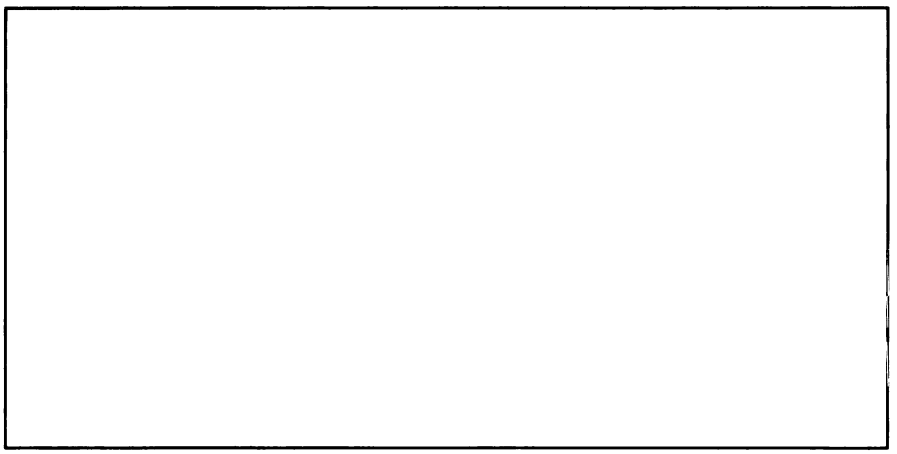
Mining for Peanuts

See background information on pg 222 in your textbook.

Create a model site

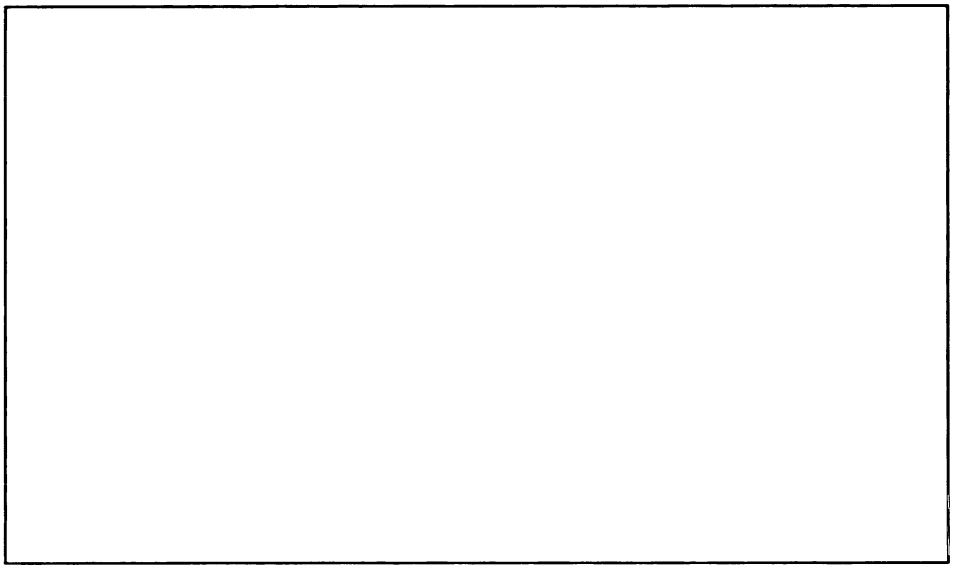
1. Place a layer of sand on the bottom of your pan.
2. Distribute 5-10 peanuts on the sand, either clustered together or randomly spread apart. In the space below, record how many peanuts you deposited and make a sketch of their arrangement.

Arrangement of peanuts



3. Cover the peanuts with a layer of soil.
4. Add grass, etc to simulate a natural landscape.
5. Using a digital camera, insert a picture of your landscape in the space provided below.
6. Trade mining sites with another student group. Do not tell the other students how many peanuts are in your landscape, or where they are buried.

Landscape before mining



Mine for Ore

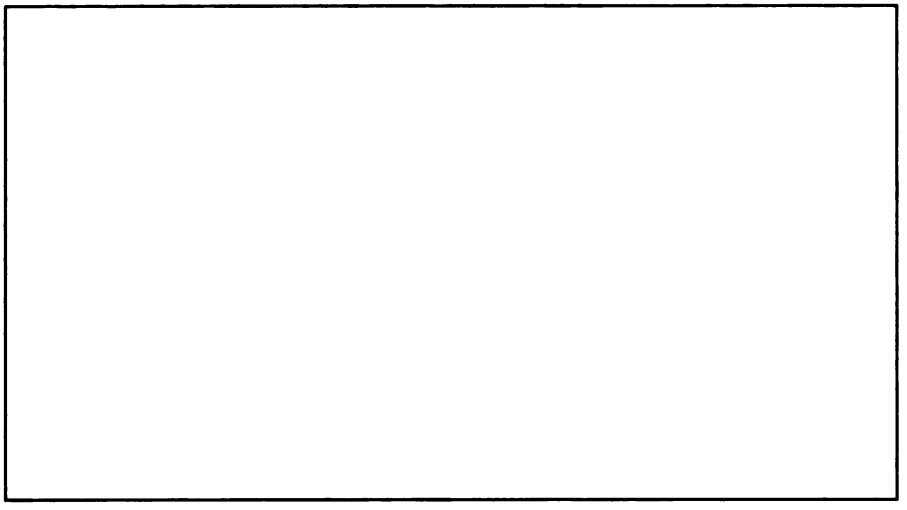
7. Your group operates a mining company. Make a sign out of an index card and place in your landscape.
8. You will have 5 minutes to extract as many peanuts, or "ore" as you can from the simulated landscape. Your goal is to extract as much ore as possible, while causing the least amount of environmental damage. You need to locate, dig and process the ore. Use a straightened paper clip to probe for the ore, use a plastic knife to dig for the ore and use your fingers to separate the shells from the ore. Caution: the shells from the peanuts represent hazardous wastes from mining and processing the ore. Do **not** use your teeth to remove the peanuts from the shells! The shells must not be deposited back in the landscape. Record how many peanuts you extracted.

Reclaim the Land

9. You will have 5 minutes to restore the land to its original condition. At the end of the 5 minutes, evaluate the difficulty of restoring the site. Please return the landscape to its original group.

10. When your original landscape is returned to you, take a picture of it and evaluate how well the land has been restored.
11. Insert your picture in the space provided, then please answer the questions.

Post-Mining Landscape



Questions

Please answer these questions completely and thoroughly!

1. How badly was the land damaged by mining?

2. How many peanuts did the mining company find? How many were buried?

3. How much waste was produced?

4. How do you think this simulation compares with actual mining operations?

5. Based on your experience, how expensive do you think reclamation activities are compared with the expense of extracting the ore?

6. What guidelines would you give to new miners prior to this activity so that they do less environmental harm?

7. What is your opinion of this lab? Include good and bad parts to the activity, please.

How Safe is our Groundwater?

In many parts of the United States, drinking water is supplied by underground wells. In fact, more than 130 million Americans get their water from underground water supplies. Although this water varies in quality, it usually comes directly from the ground clean and safe to drink – at least it has in the past. In recent years, however, there have been more and more reports of polluted groundwater.

In this lab, you will explore how layers of the earth act as a filter for groundwater. You will make models of the Earth's natural filtration system and test their efficiency at filtering out various substances. While most of the substances you will be testing are not dangerous to human health, they will help you explore how safe our groundwater supplies are from surface contamination.

Materials

250mL beakers (5)	graduated cylinder	thumbtack
wax pencil	stirring rod	gravel
glucose solution	glucose test paper	soil
red food coloring	paper cups (4)	ruler

Procedure

1. Obtain four beakers and label as follows
   A. glucose – 5mL
   B. soil – 5 mL
   C. food coloring – 5 drops
   D. water - control
   E. other

2. Fill the beakers two-thirds full with clean tap water. Then add to each beaker the contaminant listed on its label. Stir each mixture thoroughly. These mixtures will represent surface water.

3. Make observations on each beaker and log observations in Data Table

4. Set the beakers aside and make 4 separate ground filtration systems. Use a thumbtack to poke 6 holes in the bottoms of the paper cups. Then fill each cup with layers of gravel, sand and soil as shown below. Be sure to make all 4 models identical. Leave at least 2 cm of space between the surface of the soil and the top of the cup.

   These cups represent the earth through which surface water percolates on its way to underground water supplies.

5. Predict how well the filters will clean each water sample. Record your predictions in your data table. Then pour each surface-water mixture through an earth-filter model into a clean beaker.

6. Once each water mixture has been filtered, observe the resulting "groundwater." In your data table, record your observations.

7. Repeat the above steps with another substance you are interested in testing.

8. Answer questions after recording all observations in your Data Table.

Analyzing Results

1. Was the glucose still present after filtering? Could you see it?

2. Was the soil removed from the water by filtering? Was the food coloring removed? How do you know?

3. What was your "other" test material? Was it filtered out of the water? How do you know?

4. How accurate were your initial predictions? Explain.

5. What conclusions can you draw from this filtration experiment?

6. What generalizations can you make about what substances will or will not be filtered by the natural percolation of surface water down through the earth?

7. What precautions do you recommend for keeping groundwater clean?

Data Table

Contaminant	Appearance (before filtering)	Prediction: How well will the sample be cleaned?	Resulting Groundwater

A Recipe for Life

All soil comes from the same basic recipe, however, amounts of the different ingredients can vary widely from one place to another. The main components of soil are the minerals. The minerals are made up of clay, sand, silt, gravel, and stones. The next ingredients in soil are water and air. Organic material is the last component. This is made up of dead plant and animal matter such a leaf litter, along with billions of living organisms that you cannot see such as bacteria and nematodes.

Materials (per group)

- 3 Quart jars with lid - clear plastic, if possible
- Three different soil samples - from different areas like forest, grassland, agriculture field
- Water
- Liquid soap
- Measuring spoons
- Newspaper

Procedure

1. Spread each soil sample out on a separate newspaper. Remove any large sticks, trash and large rocks. Break up any clods.
2. For each soil sample, fill a quart jar one-fourth full with soil. Label the jars.
3. Add water until the jar is ¾ full.
4. Add one drop of liquid soap to the jar and close the lid.
5. Predict what you think will happen to each jar. Which things will be at the bottom-settling out first-and which materials will be at the top before the jar actually settles out completely. Please write your predictions below:

6. Shake the jar vigorously for a minimum of one minute.

7. Let the jar stand for several minutes.
8. Examine the jar and write down your observations.

Reflecting

Which material settled out first and last?

How did this match your predictions?

How long did it take for the soil to settle out?

Did some samples settle out faster than others? Why do you think this happened?

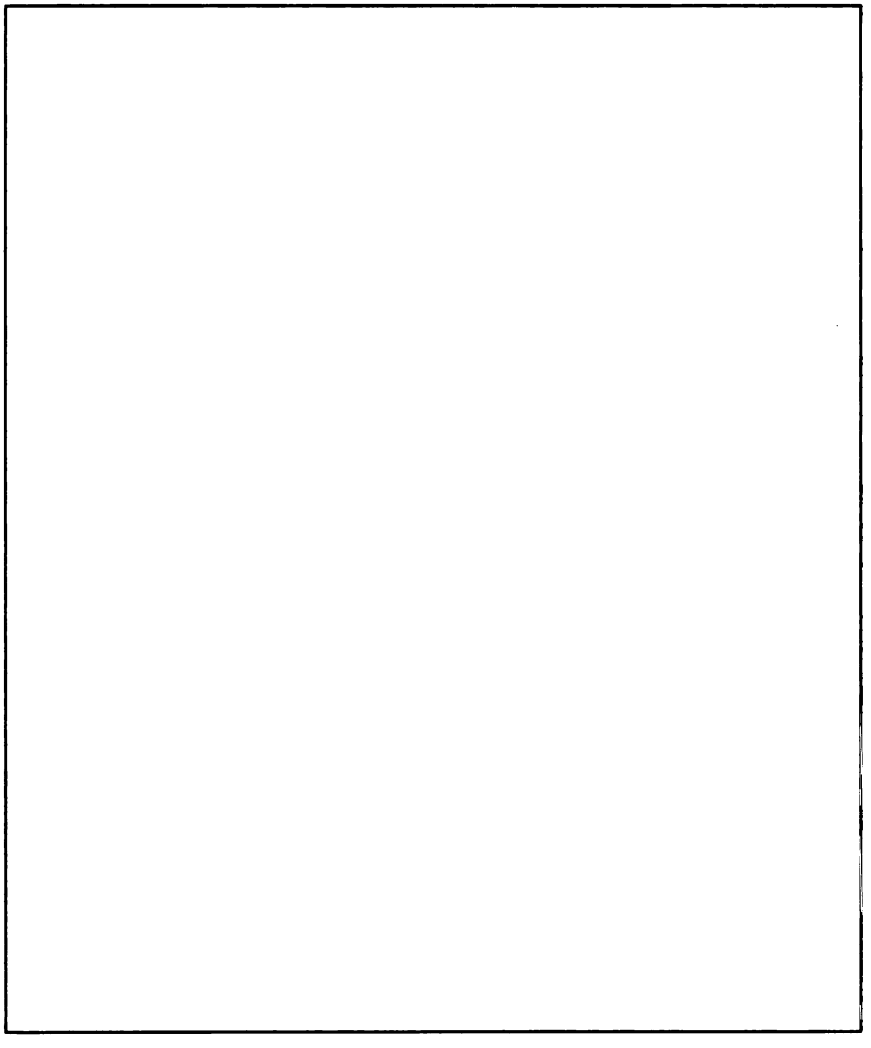
How many layers are in each jar? Is the same amount of each layer in each of the jars? (Go compare with the other groups)

Which soil would be better for growing plants? Why do you think this?

What other things did you find in the soil samples?

Did some samples seem to have more signs of life than others?

Draw your shake jar in the space below. Please include the measurement (in centimeters) for each layer.



Determine the percentages of each soil type you have in your shake jar.
Percent sand = depth of sand divided by depth of total soil

Percent silt = depth of silt divided by depth of total soil

Percent clay = 100 minus the percent sand plus silt.

These percentages are all volume percentages. Convert these to percent weight by multiplying the percentage of sand by 1.19, percentage of silt by 0.87 and the percentage of clay by 0.94. These numbers are the weight ratios of bulk density compared to average bulk density of the material.

Now use the chart below to determine the soil texture of your sample:

Soil Classification	Clay Soil	Loam Soil	Sandy Soil
Percent clay	40-100%	7-27%	1-10%
Percent silt	0-40%	28-50%	1-15%
Percent sand	0-45%	23-52%	85-100%

How would you classify your soil?

Applying

Observe the three types of soil further. Write down your observations.

- How does each one feel?
- How heavy is each one?
- What color is each type?
- Pack a sample of each soil in a coffee filter and hold it over a bucket. Pour equal amounts of water into each filter. Which soil allows the water to move through the quickest?

Activity Source

Iowa State University Extension. Sustainable Agriculture and Wildlife: Piecing Together a Habitat Puzzle. Extension Distribution Center Order # EDC-3. www.extension.iastate.edu/Pages/pubs

Soil Erosion Lab

Environmental Science
Spring 2002

Focus Question: Does plant material affect the amount of soil eroded by water?

Materials

- 2 plastic tubs (Ziploc disposable containers)
- shovel
- 1 liter beaker
- catch pans

Procedure

1. Poke drainage holes in the bottom of your tubs. There should be enough to allow water to drain through the container at a fairly quick rate.

2. Obtain soil samples that will fit in your container. One of these should have plenty of grass/plant material growing in the sample, and the other should be free of plant material. Be sure these fit into your container!

3. Hold one of your containers of soil over a catch pan, and carefully pour 1 liter of water through the soil sample. Be sure to adjust your rate of pouring to allow the water to drain through your sample. It is important that all the water travel through the soil, not spill over the sides of your container!

4. After the water has drained through the soil sample, pour it from the catch pan into another beaker. Label the contents of this beaker, and set it aside.

5. Rinse your catch pan to be sure there is no soil left in it.

6. Repeat steps 3 and 4 with your second soil sample.

7. Thoroughly clean and dry your catch pan.

8. Record your observations of the water in your beakers in the data table on the next page.

Soil Sample	Appearance of water	Amount of solid matter in water
Containing Plant Material		
No Plant Material		

1. Was there any difference in the appearance of the water that was poured through the two soil samples? Explain.

2. Did one of the soil samples have more soil erode than the other? Explain.

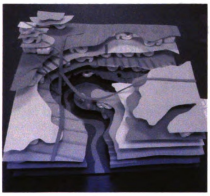
3. How does having plant growing in the soil affect the amount of erosion that may occur?

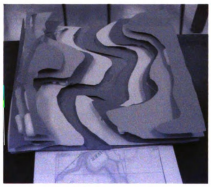
Topographic Models

Purpose
The purpose of this project is to convert a section from a topographic map into a three dimensional model of the landscape.

Materials
- Topographic map
- Construction paper
- Scissors
- Rubber cement
- Packing peanuts

Procedure
1. Refer to the examples below to see what your finished product should look like.
2. Use the background information from yesterday's discussion to interpret the contour lines on your map. You will be converting your map into a vertical model.
3. You will have three class periods to construct your model. You will also have the option to display your model in this year's Educational Showcase.





Composting Lab

In this lab, you will be making a mini-compost pile and competing against the other groups in the class to see who can make the best compost. Winners will be treated to dirt cake!

Materials

- Jar (peanut butter jars work the best)
- Thermometer
- soil test kits
- soil, sticks, grass, etc

Procedure

1. Poke holes in the lid of your jar
2. Fill your jar about 1/3 of the way with soil from the location of your choice.
3. Add to your jar sticks, grass, leaves....whatever your group thinks will produce the best compost. (Remember what makes a good compost pile!)
4. Mix up your jar, adding water if you feel you need it.
5. Draw a picture of your jar in the space below, including a description of the materials inside the jar.

6. Take an initial measurement of nitrogen, phosphorous and potassium levels in your jar using the soil test kits. Record these values in your notebook; you will be reporting them in your final paper.
7. Make daily observations on your jars. Be sure to smell the contents! You should test nutrient levels weekly throughout the experiment.
8. Your write up of this lab will be incorporated into your final paper for this unit. Be sure to keep track of all observations!

"Dirty Little Bugs"
or
Microarthropods in the Soil

This purpose of this activity is to allow you to see the types of organisms that live in the soil. The equipment you will be using is called a Berlese funnel – however, it will be up to you to construct this apparatus and use it to extract arthropods from leaf litter. This lab is divided into 4 parts – please be sure to complete each section!

I. Internet Search

Use the Internet to learn about construction and function of a Berlese funnel. Gather as much background information as you can. Please list the web addresses where you found your information:

1.
2.
3.
4.
5.

What is a Berlese funnel?

How does a Berlese funnel work?

What is the purpose of using a Berlese funnel?

**You will also need to identify organisms collected. While on-line, look for information on identifying these organisms.

II. Construction

Within your group, decide on a construction plan. Once your plan is approved, you may begin construction. Please draw a detailed, labeled sketch of your proposed funnel below:

III. Collection & Extraction

Use a shovel to collect a sample of leaf litter and place in a Ziploc bag. Return to the lab and place your sample in your funnel set-up. (If there is not enough time, you may place your sample in the refrigerator until the next day.) Be sure your funnel setup is secure enough to remain set up overnight!

IV. Observation of Specimens

Once the allotted time has passed, disassemble your funnel and observe the organisms in your jar of alcohol. Use either a dissecting scope or the scanning lens of a monocular microscope to identify the organisms in your sample.

Please sketch these organisms in the space below. For each organism, please include a name, and the number of individuals that were in your sample.

V. Analysis of Lab

1. How many different types of organisms did you find?

2. Which seemed to be the most common organism collected within the class? The least?

3. What purpose do these organisms serve?

4. Does the Berlese Funnel Technique give a good sample of organisms that live in the soil? Explain:

5. What types of organisms might be missed when using this technique?

6. Evaluate your procedures for this lab. Please include the positive aspects, as well as what could be improved upon.

Environmental Science
Spring 2002

Cumulative Soil Paper

Please use resources to answer the questions below as completely as possible. Each question should be answered with at least 2-3 paragraphs!

Include a bibliography at the end of your paper, listing the resources you used to find these answers. (Hint: you may want to start with your textbook!)

1. How is soil formed?

2. What determines the amount of nitrogen, potassium and phosphorous in soil?

3. Where in the world is the decomposition rate the fastest? Where in the world is the decomposition rate the slowest? What determines the decomposition rate?

4. Is the decomposition rate of our sites always the same? What factors might lead to variations? What is the difference in the decomposition rate on December 18th and June 18th?

5. Give a complete overview of your composting activity. Include your procedure, observations and data tables.

Indoor Water Testing Lab

Using the LaMotte kit provided, you will be determining the quality of the Shiawassee River. Please read all instructions carefully, and follow them closely. Please record your results for each test conducted in the data table below.

Ammonia nitrogen present/absent	**Cyanide** present/absent
pH value:	**Iron** present/absent
Chlorine present/absent	**Nitrogen** present/absent level:
Chromium present/absent level:	**Phosphorous** present/absent
Copper present/absent	**Silica** present/absent
	Sulfide present/absent

Based on the results above, write a paragraph discussing the "pollutant level" in the Shiawassee River:

Scientists and the Alaska Oil Spill

The Wildlife, The Cleanup, The Outlook

Produced by: _____

The 1989 Valdez Oil Spill (3/24/89) was the largest in US history. About _____ million gallons of oil spilled when the tanker ran aground on Bligh Reef.

List 4 types of scientists brought in to help with this mess:

There were 2 major areas of concern:
1.

2.

Helping Wildlife

- what effect did the oil have on the otters?

- what method was used to clean the otters?

- list some things the scientists monitored in the otters to see if they were recovering:

- what other animals were examined and/or treated?

Removal of Oil from the Environment

- Describe the first/most widespread cleanup technique used:

- After the oil hardened, how did they attempt to remove it?

- What is bioremediation?

- Explain the process of bioremediation:

Assessing the Outlook

- What did the pink salmon harvest indicate?

- What did the follow up visits by scientists show?

Please give your overall opinion of this film:

The Life of the Lakes: The Great Lakes Fishery
Video Questions

Section 1 - Great Lakes Fisheries: The Present
Tape length: about 13 minutes:

- Start of tape to Sandra Andrews (MSU) quote: "Anytime you consume any food you need to be concerned about risks, and that's the same with fish – no more than any other food. You just need to know the facts before you consume the fish."

1. How many fish species are in the Great Lakes and their tributaries? Does this variety and diversity surprise you? Why or why not?

2. What type of habitats do fishes use for spawning?

3. Describe the Great Lakes food web. How are humans a part of Great Lakes food webs?

4. What is a fishery? What do tribal fisheries and other commercial fisheries have in common?

5. What is the total economic impact of the Great Lakes sport fishery? What jobs are created by the sport fishery?

6. What aspect of fish consumption is currently a major issue?

Section 2 – Great Lakes Fisheries: The Past
Tape length: 15 minutes

- Start: Female narrator: "The Great Lakes fishery has faced this and many other challenges throughout its history. As the glaciers...."
- Stop: Male narrator: "And now the lake trout is reproducing naturally in Lake Superior and, to a lesser extent, in Lake Huron. But it has a long way to go before regaining its former prominence.

1. How old (geologically speaking) is the Great Lakes basin?

2. How did the first European settlers perceive the fish supply? What techniques were used to catch fish in the late 1600s and early 1700s?

3. What activities of the increasing number of settlers have on the Great Lakes fish populations?

4. What were some of the earliest fisheries management practices used?

5. When and how did the sea lamprey arrive in the lakes upstream from Lake Ontario? How did it affect fisheries?

Section 3 – Great Lakes Fisheries – the Recent Past
Tape length: about 8 minutes

- Start: Female Narrator: "Restoration of the lake trout hasn't been the only challenge and goal for fisheries scientists and managers. With the lake trout in jeopardy and other species no longer living in the lakes, the ecology of the Great Lakes was altered again. By the 1960s...."
- Stop: Male Narrator: "Today, the success of Lake Erie's walleye fishery is almost as world-famous as its near-collapse."

1. What other challenges became serious through the 1960s and early 1970s for Great Lakes fisheries?

2. How did resource management agencies respond to the invasion of the alewife?

3. What threats to water quality in the Great Lakes became obvious in the 1970s?

4. How can humans reduce their exposure to fat-soluble organic contaminants such as PCBs in fishes?

5. How much is known at present about the effects of fish contaminants on humans?

6. What threatened water quality and fisheries in Lake Erie in the late 1960s and 1970s? How were these problems addressed? What was the result?

Shiawassee River
Water Quality

The purpose of this investigation is to gather information on the substances in the Shiawassee River and use that information to develop a conclusion on the overall quality of the river. Please follow the directions below thoroughly!

General Information

- You may work in groups of 3-4, but each person will be responsible for writing your own report.
- Be sure to follow proper safety precautions at all times! You will be working with chemicals that have the potential to cause harm.
- Follow directions!
- Your final report is due the day of your final exam.

Procedure

1. Use the LaMotte test kits to run the following tests:
    1. carbon dioxide
    2. pH
    3. chlorine
    4. ammonia nitrogen
    5. copper
    6. sulfide
    7. dissolved oxygen
    8. phosphate (2 tests)
    9. nitrate (2 tests)
    10. hardness: magnesium, calcium, total

2. Research: for each of the tests you are conducting, you will need to include information on each of the following. This should take 1-2 paragraphs per test.
    a. test results (include units)
    b. acceptable range of this substance in the water (at what level does it become a pollutant)
    c. how does this substance get into the river
    d. impact on water quality

3. Conclusion: Based on the information you have gathered, give an overall evaluation of the quality if the Shiawassee River. (This is the whole point of the lab!)

Grading Rubric

1. Cover page – 5 points
    - Include a title, your name, and the names of the rest of your group members.

2. Introduction – 5 points
    - General description of the lab, purpose of the lab, and what you did during the lab.

3. Data Table – 20 points
    - Include each test you conducted and the results of each test. Be sure to include units each test was measured in.

4. Discussion of each test – 40 points
    - For each test result, include the acceptable range of this substance in the water, how it gets into the river, it's impact on water quality
    - Should be 1-2 paragraphs per test

5. Conclusion – 20 points
    - Based on your research and test results, what is your assessment of the overall quality of water in the Shiawassee River.

6. Resources – 10 points
    - Include all sources used in your research of these tests.

7. Extra credit – will be awarded for "wow factor" – including diagrams, etc.

Total points possible: 100

**This is a large assignment – please treat it as such
**Due date: the day of your final exam.

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