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TEACHING STUDENTS TO BE ENVIRONMENTALLY CONSCIOUS IN AN INTEGRATED SCIENCE COURSE

By

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ABSTRACT

TEACHING STUDENTS TO BE ENVIRONMENTALLY CONSCIOUS IN AN INTEGRATED SCIENCE COURSE

By

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Intermediate Integrated Science is a course that combines biology, chemistry, earth science, physical science, and environmental science. One of the units recently added to the curriculum is one on air, water, and soil pollution. The objectives for this unit emphasized hands on activities, laboratory experiments, and real world applications. The students were tested on the objectives prior to the unit. During the unit they experienced science through laboratory experiments and activities.

At the conclusion of the unit, a post-test was given that included five multiple-choice questions and eleven short answer questions. This test was identical to the pretest. Interviews of students were also conducted using their ability level on past tests to determine the candidates selected. They were asked identical questions to determine the effect of the unit on students. The material presented was intended to give students skills and practices they could use as they prepare to leave high school. The response from the students based on teacher observations was positive and the students seemed to be enthusiastic about learning. In addition to the enjoyable learning environment provided, the students test scores went from an average of 25% on the pretest to 68% on the posttest.

DEDICATION

I would like to dedicate this paper

and all of the work that went with it

to my child and my future children.

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My students are my reason to keep learning and growing. I hope your curiosity, willingness, and enthusiasm will continue to inspire me.

My family has been very supportive throughout the this program. I would like to thank my mom, Sarah, Jeff, Josh, Emily, and especially my dad, who encouraged me to pursue this degree. It was because of you that I knew I could do this.

Chuck, my editor, proofreader, husband, and biggest supporter, thank you. You understood when I needed to be away and work. You have shared in the happiness of my success and tolerated me in my frustration. I appreciate and thank you above all.

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INTRODUCTION

In the ever-changing world of science education, there are topics that seem to get left behind. This is not because of their lack of importance or interest level, but because most science educators feel that the new material that is being developed, especially in the biological field, needs their attention and that other topics are going to have to go by the wayside (Palmer,1997). Environmental education is a topic commonly found in the back of textbooks, usually relegating them to the end of the curriculum.

The object of this project was to tackle this lack of environmental education being taught in our integrated science course. Along with this objective, additional goals were to teach students skills that they could use in their daily lives and use hands on activities to relay information instead of lecturing. With the environmental objectives that this project covered, hands on activities were instrumental in relaying information. With the idea of improving environmental education, the first task was to find out what environmental education entails.

Joy A. Palmer states the definition of environmental education (EE) as being: " The process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the interrelatedness among man, his culture, and his biophysical surroundings"(1997). This is an area of study that often gets neglected in our study of science at the high school level. Much attention is paid to biology, chemistry, and physics, but environmental science is usually an

afterthought in the curriculum. That usually means that at the end of the school year, if there is time after the "important" material has been covered, there is some discussion of environmental topics. This is not the most beneficial way of teaching students about the environment. In addition, many people view environmental science as being soft, more of a social science than a lab science. This is largely but not entirely untrue. Even though it is a subject of which society should be socially conscious, environmental science uses a variety of field techniques and lab practices, and there are scientific measurements that are taken to analyze a region.

Saying that environmental science should be a social science is not entirely a false statement, however. "Environmental education does not lie exclusively in the field of science education. It is not, and should not be, an 'adoptive child' of this field-something to be co-opted by science teachers alone" (ibid). Because the environment is something that affects all of us, all disciplines, including social sciences, language arts, and mathematics, should discuss the importance of preserving and maintaining the resources we have. This would happen in a perfect world, which it is not. Therefore, the task of providing for environmental education falls on the shoulders of the already overburdened science teacher.

Science is an ever-changing field. New discoveries and findings are regularly unfolding and, because of that, new content could be added to curricula. This pushes environmental education further and further into the corner. Many students leave their formal education without a complete understanding of the everyday world around them, the world in which they are meant to survive and are meant to make educated decisions that affect the environment every day. James Trefil said, " If you

do not know about something, you don't value it" (in Pool,1991). If our students have not been taught about the environment, they will not value it in the future. We cannot expect the citizens of tomorrow, our students of today, to lead responsible lives and make good decisions that will affect us all if we do not make environmental education a priority today. As Aldo Leopold once said about this topic, "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (1949). This is something that must be taught to students so that they can be the educated citizens society wants making decisions tomorrow.

The State of Michigan has included environmental education benchmarks in the mandated K-12 science curriculum. These benchmarks are scattered throughout many strands, including those related to atmosphere and weather, geosphere, and hydrosphere. One of the goals of this project was to tie together some of these scattered strands into a pollution unit.

Another intent of this unit was to move as far away from lecturing as possible, while still getting the necessary information to my students. I wanted my students to feel empowered and in control of their own education.

> "For the most part, a science class revolves around the discussion of the teacher. The students are left to find interest in a subject being described in a way that may not be exciting. The domination of the teacher-talk in the science classroom does not allow a sense of empowerment on their education. When students start to contribute to the learning of subject material, then they will feel empowered." Ryan Westmascott
> www.uwinnapeg.ca/~cacdemi/science/cp%20in%20science.htm

This is not a new idea in science education. Most science teachers now are focusing on hands on activities and laboratory experiments.

This pollution unit was especially challenging because air pollution, depletion of natural resources and so on are difficult to demonstrate in a classroom. Developing activities for this unit required creativity. The activities were meant to imitate natural processes, show consequential action of choices, and present opportunities for future change. The purpose was to make environmental education more than words on a page or images on a screen or even lecture in a classroom. The purpose was to make it practical to the students (Flicker, 1996).

It is very important to emphasize to students the importance of our environment and how to maintain a healthy balance between industrialism and environmentalism. We spend so much time telling them how awful we are to the environment that we will ruin the world and perish because of it. Unfortunately, we do not spend enough time discussing a sustainable future and appreciation of what we have. This has been the goal of this researcher's project. Teaching the ability to determine what is healthy for the earth, from responsibly using detergents to driving a fuel-efficient car to looking at where political candidates stand on the environmental issues, is the most practical way of getting students to understand the connection between the curriculum material and "real life". Science educators have the responsibility of ensuring that citizens gain the intellectual tools to engage fully in debates and decisions for environmental issues (McComas, 2002).

Changing opinions about the environment is challenging, as it has to do with reshaping values and principles. For example, changing behavior from throwing everything in the trash to recycling and composting is something that takes time and commitment. Taking on this task takes motivation, persistence, and creativity on the

part of the instructor. Environmental education is a field that cannot be successful if educators do not take into account the involvement of motivational, cognitive, and metacognitive aspects of learning (Short and Weissberg-Benchell, 1997). Care for the environment develops over time so it is difficult to change students' values in the short period allotted to a unit. A student's background and home life has a lot to do with his or her incoming attitude about the environment. "Children who have received good care throughout their lives are usually receptive to the idea of "saving" the environment because they are prepared to care ecologically, to care for something other than themselves. Children who have not received adequate care and nurturing are not receptive to the idea of helping something as broad as the environment. They are likely to remain untouched because they may have a hard time connecting with nature, as they are not over the rage of not getting what they needed growing up. They cannot conceptualize themselves as caregivers. Using traditional techniques of teaching and assessment is not likely to get through to these challenged students" (ibid).

The most important focus of this unit was to emphasize to students the value of transferring the skills they learned into the "real world," that is applying the knowledge that they have gained and applying it at home and when they move on from home. This meant the development of everyday life scenarios and activities. Being able to create contextual situations to embed new content skills is a key element in establishing experiences for learning. (U.S. Department of Education, 2002) Most students today want to know why they need to learn something. What good is it going to do them? When are they going to use it in the "real world?"

Being able to put benchmarks and standards into an everyday life context is one of the best and easiest ways of relating those standards to students. William F. McComas said, "Even the most basic study of ecology has the potential to affect students' understanding of the interaction of science and society. The larger view is that study of environmental demands, permits, and encourages students to apply what they have learned in addressing problems, in allocating resources and in gaining a rich view of the interplay of science and society" (2002). This allows students the opportunity to use what they have learned.

The area in which I teach is mostly rural with many families working in agriculture or as factory workers. There is a constant challenge in our district to encourage higher learning because education beyond high school is not a priority for many families, as observed by this researcher. However, this area is very close knit with many families having a significant history in the area. Rural school communities offer more cohesive groups of parents, teachers, and community members. Those close ties can help encourage the collaboration process between school and home. It is through this type of continued dialogue, shared commitment, and community vision that meaningful accessible content can become a reality for more students (Sayler, 2002). Within this community, an emphasis on environmental education could greatly affect students. Most students will graduate and live in this area. With an increased awareness of environmental issues, they may be more likely to choose different types of pest control for their crops, drive more fuel-efficient vehicles, and educate the people around them about sensitivity to the environment.

There are many variables that affect a student's environmental knowledge. Students who come from homes of lower socioeconomic status tend to have less knowledge of the environment than students who come from higher socioeconomic homes (Gambo and Switzky, 1999). Other factors in environmental knowledge include number of science classes taken and gender. Males scored significantly higher on assessment of environmental knowledge than females (ibid). One of the reasons this researcher went into science education was to be a role model for young women. Helping them to increase their scientific knowledge and educate them to the possibilities of scientific careers was also a goal of this project.

Teachers who are excited about what they are teaching excite their students and inspire them to love science. Teachers who are well versed and enjoy teaching a particular content typically have a wider variety of approaches to employ in making the content accessible to students. Teachers with a deep understanding of content can generate a greater variety of approaches as well as applications to the child's real world (U.S. Department of Education 2002). Using a variety of teaching techniques has really been a challenge to bring the idea of varying techniques to life during the pollution unit because changing traditional ways of lecture and worksheet teaching is not readily accepted by other teachers, students, and parents in my district. Incorporating invigorating ideas is challenging because sometimes those ideas are met with doubt. Although lip service is often paid to the idea of project-oriented learning that simulates "real world" experiences, we live in an educational system that tends to limit individual initiative by encouraging conformity and control. Teachers and pupils (and society, too) deserve better than that (ibid). Using tools and

activities that change the pace of the class and letting the students explore and experience on their own is invigorating, not only for the students, but for the teacher as well.

Environmental education gives students the opportunity to use principles they have learned in other science classes. They need to use a higher level of comprehension to be able to synthesize and apply the other domains of science, such as biology, ecology, and earth science. This integration shows students how to interconnect different areas of science, such as interspecies relationships, energy flow in an ecosystem, and gauging the impacts of humans on the environment. (McComas, 2002)

Environmental science impacts students in ways that few other subjects can. It encourages the student to apply what they have learned in addressing environmental issues by gaining a rich view of the interplay of science and society (ibid).

Even the federal government has recognized the importance of environmental education. In 1970, President Nixon signed a law requiring environmental education be taught in schools.

> "Environmental education means an education process dealing with man's relationship with his surroundings and includes the relationship of population, pollution, resource allocation and depletion, conservation, transportation, technology, and urban and rural planning to the total envision" (United States Public Law 91-516).

This law states that environmental education is vital to the education of our children as well as the future of our country. This initiative gained even more ground in 1990,

when another law for environmental education was passed, United States Public Law 101-619.

> "An effective response to complex environmental problems requires understanding of the natural and built environment, awareness of environmental problems and their origin (including urban areas) and skills to solve problems. Development of effective solutions to environmental problems requires a well educated and trained professional workforce" (United States Public Law 101-619).

These laws make it mandatory for environmental standards to be taught to all students in order to produce a productive workforce. Even with these laws in place, there is little being done in the State of Michigan to encourage environmental education. In a survey of state level environmental education programs in 1997, it was stated that Michigan was only developing a state environmental education advisory board, and the only thing they had developed was an environmental education association (Kirk et al, 1997). Since then, things have not gotten much better. Today, of sixteen other states reported on, only four had environmental education initiatives being developed (Ruskey et al, 2001). With the treasure of the Great Lakes and the industry that is flourishing on their shores, it would seem as though environmental education would be an integral part of the state curricula. Without it, we are risking the loss of priceless natural treasures.

IMPLEMENTATION

At Central Montcalm High School we have two required science courses and there are many state objectives that both Integrated Science classes are expected to address. The curriculum of the second, Intermediate Integrated Science, was recently added to during a "fine tuning" of the entire science curriculum during the 2000-2001 school year. The additions included the environmental objectives included in this unit. Many of these naturally fall into groups because they are very similar in content. These groups are usually called units and post-tests are used to assess the objectives.

As a result, a new unit was developed in the Intermediate Integrated Science course. This unit, referred to as the pollution unit, was primarily taught using handouts, without any laboratory experiments or activities. The objectives from the pollution unit came from three benchmarks in three different strands of the State of Michigan Science Standards and Benchmarks.

- Strand: Ecosystems
  - Benchmark: All students will analyze how humans and the environment interact.
    - Objective: Explain the effects of agriculture and urban development on selected ecosystems.
- Strand: Atmosphere and Weather
  - Benchmark: All students will analyze the relationship between human activities and the atmosphere.
    - Objective: Explain the impact of human activities on the atmosphere and explain ways that individuals and society can reduce pollution.
- Strand: Geosphere
  - All students will analyze effects of technology on the earth's surface and resources.

- Evaluate alternative long-range plans for resource use and by-product disposal in terms of environmental and economic impact.

Although they come from different strands, they all seemed to tie into human effects on the environment and pollution. As a science department, we decided that we could put them together in a single unit.

The pollution unit is usually covered after a unit on water pollution in which we use a SEPUP module (a boxed lab kit published by Lab-Aids) called Fruitvale, giving the students a general idea about water pollution in terms of chemical pollutants. The goal of the pollution unit was to expand on that knowledge and increase awareness of different types of water pollution in addition to air and land pollution. It was a very short unit because we did not have any activities and the interest level of the students was very low. The other integrated science teacher and I took the approach of "the quicker we get through this material, the better." Therefore, I undertook the project of transforming the pollution unit to be a more educational unit and one that was more interesting to the students.

Central Montcalm High School is a mostly rural school that serves four small communities: Stanton, Sheridan, Sidney, and Fenwick. We teach a four by four block, meaning that students have four classes every day for nine weeks, with classes lasting eighty-five minutes apiece. Intermediate Integrated Science (IIS) is the second level of science and our highest required course in terms of difficulty of material. Students must pass Basic Integrated Science before they take IIS and are required to take two more science credits (two nine-week sections) for graduation, which can include biology, chemistry, and physics for the advanced students or

current events science, animal science, and global science for students who are not interested in pursuing a science related career. IIS is primarily a sophomore class with a few juniors and seniors. During the 2002-2003 school year, I taught five sections of Intermediate Science and one section of global science (an environmental science course), a class for juniors and seniors. I used the unit described in this paper in both courses. Although IIS is a prerequisite for global science, there were activities and experiments from IIS that had never been done by the global science students. I felt it would be interesting to collect additional data about these activities from an older, more educated group of students.

We did not use a book during the pollution unit and the lecturing was kept to a minimum. The students obtained their information through activities and from experiments. After interviewing students at the end of the unit, I found that they enjoyed this method of learning and hoped to have more units taught this way. Most of the materials used in labs and activities were purchased at the local supermarket and hardware store, which made them seem very practical to the students and helped them to relate what the class was doing to their everyday lives.

The unit required sixteen school days. During the first nine-week marking period, it was the last unit in the quarter. I planned it so that it would end with two days left to review for the midterm exam. Unfortunately the class and I experienced the typical adage about the best-laid plans. During the months of September and October, our school experienced a series of bomb threats. Three of those threats happened in the middle of the unit, one of which was during one class's posttest.

Because of the threats, some planned activities were cancelled and others were shortened. This was very disappointing to everyone.

DAILY LESSON PLAN OUTLINE

Everyday I started my class with a warm-up activity to prepare them for the class and to review material that we covered in the previous class. Next we start the day's activities and at the end of the class we review the day's objectives. The two semesters had slightly different daily schedules due to extenuating circumstances. The original schedule is below with the alterations due to unforeseeable which are in parentheses. The activities with asterisks are new activities that I developed. There are examples of all student activity sheets in Appendix A.

Day 1	Pre-test
	Discussion of natural water flow and effect of construction
Day 2	Activity: Effect of Construction on Water Flow*
Day 3	Set up Fertilizer Fun lab*
	Pesticide Peril lab* (ruined first semester and done day 5)
Day 4	Test soil, air, and water samples (Day 5 during first semester)
Day 5	Analyze data from Day 4
	Web search: Waste on the Web* (day 4 first semester)
Day 6	Discussion on recycling
	Recycle Cycle lab
Day 7	Field trip to landfill and recycle center (first semester day 8 and 12, second semester day 8-landfill speaker)
Day 8	Discussion of field trip

	Activity: Paperclip Polymer Production (both semesters day 7)
	Start Trash Bash
Day 9	Trash Bash*
Day 10	Are they Natural or Fake? Lab (day 11 first semester, day 9 during second semester)
	Discussion of biodegradable plastics
Day 11	Activity-Why Recycle?
	Altering the Course of Resource Use* (day 10 and 11 first semester, second semester day 12)
Day 12	Discussion of environmental and economic impacts of pollution
	Sorry Air Pollution Game* (first semester Day 13, second semester day 10)
Day 13	Discussion of pollution cleanup and reduction methods
	Activity: What's Happening? (did not do first semester, second semester day 11)
Day 14	Trash Bash presentations (also speaker first semester, day 13 second semester)
	Analyze fertilizer lab (alternative activity on day 14 during second semester)
Day 15	Hand out review sheet (shortened to day 14 first semester)
	Review
Day 16	Posttest (Had to finish the next day because of bomb threat first semester)

The schedule evolved because of the bomb threats, snow days, assemblies, and other conflicts. In our school and in the general structure of the educational system, it is a good idea to have a long-term plan, but an even better idea to be flexible with your plan. Because of this, the flow of the assignments and topics that were presented did not occur in the order that would have been the most logical, but an effort was made to keep them tied together.

LABORATORY EXPERIMENTS AND ACTIVITIES

Summary and Analysis

Effect of Construction on Water Flow

During this activity (Appendix A-I), I wanted the students to come away with the understanding that when contractors place buildings in an area, they have to take into consideration the natural water flow of an area. It was supposed to fulfill the urban development portion of the ecosystem benchmark. They observed this by creating a landform in an aluminum pan and watching the way that the water flows. Then they placed "buildings" in the landform in different locations to see how they affect water flow. The object was to place buildings in a way that influenced the water flow the least.

In addition, we altered some of the landform pans so that root systems would be modeled. Screens were placed in half of the landform pans to simulate the presence of root systems and no screens placed in the others. Some of the questions on the worksheet (Appendix A-I) related to whether or not the student's landform pan contained root systems.

The activity went very well. The attempt during the first block of the first semester was difficult because, even though I had practiced it many times, the materials I was using in class were slightly different than the ones used to develop the activity. I made some adjustments to the construction of the landform pan and added some additional questions to the worksheet. The rest of the classes had fewer complications.

This activity had an impact on the students because they could see a real world application on the school's property. When an elementary school was built near the high school on previously wooded land, the owner of the property erected a sign reading, "Why did you choose to flood my land? I don't want my trails to be flooded and my trees to die!" The new school had been built up, altering the natural flow of water in the area. In response the school district built a drainage ditch to alleviate the problem.

Pesticide Peril

The object of this experiment (Appendix A-II) was to observe the effects of pesticide on nonpest aquatic organisms and look at the impact of agriculture on an ecosystem as in the ecosystem benchmark. The students obtained four test tubes with ten to fifteen milliliters of brine shrimp tank water containing brine shrimp. One test tube was the control and the other three were labeled 50%, 100%, and 150% corresponding to the recommended concentration of pesticide. After recording the activity level of the brine shrimp qualitatively, the students added one milliliter of pesticide solution to the respective test tubes. They recorded the activity level every five minutes for twenty-five minutes.

The pesticide effectively slowed activity when the 50% concentration was added and stopped the activity of the brine shrimp when the 100% and 150% concentration was added. In the higher concentration, the brine shrimp were killed. This had an impact on the students as they actually saw that pesticides can kill organisms that were not targeted and by doing so they effect the entire food web.

Fertilizer Fun

This laboratory experiment (Appendix A-III) was on going for the entire unit and we recorded the results until the day before the post-test. The object was to determine how fertilizers affected an aquatic ecosystem and again show the students the impact that agriculture has on an ecosystem. The students were placed in groups of two and each group had five cups. The students placed between ten and twenty duckweed plants in a plastic cup with about fifty milliliters of pond water. One of the cups was the control, while varying concentrations of fertilizer were put in the other cups. The concentrations were as follows: 50%, 100%, 150%, and 200% of the recommended fertilizer concentration. All other variables were controlled. These cups were kept in the greenhouse during the first semester. Because the heater broke and it was not fixed, the cups were kept in the classroom near the window for light during the second semester. The duckweed plants were fertilized every other day at the appropriate level for twelve days.

Counting and fertilizing the duckweed every day was challenging because during the first semester we were continually interrupted with bomb threats and time out of class. Students in the second semester classes did not have their own sets of duckweed because not enough duckweed plants were delivered. Instead we had two

classroom sets of duckweed per class. Each pair of lab partners was assigned a day to count and fertilize the duckweed. This activity worked well with the exception of one snow day. The duckweed plants in the 50% and the 100% fertilizer concentration increased a lot in number. But the interesting data came when we looked at the 150% and the 200% fertilizer concentration, and there were actually few plants due to the high concentration of fertilizer that actually burned the plants. The plants had received too much nitrogen and phosphorus and were overloaded, causing the plants to die. This stimulated an interesting class discussion.

Urban and Rural Pollution Tests

As a final example of the impact that agricultural and urban development has on an ecosystem, each class performed the tests for air, water, and soil pollution on a specific ecosystem (undisturbed, agricultural, and urban), and then all classes looked at the compiled results the next day for analysis. It would have been optimal to take the classes to each site to perform the tests, but it was not possible to take all of them to every type of site. Samples of air, water and soil, collect by the teacher, were brought to the class instead.

Students were testing the water, soil, and air to determine the levels of different substances and to determine the rate of pollution in each area. The undisturbed ecosystem was found to have very little water, air, or soil pollution, and all of the nutrient levels were adequate. The agricultural ecosystem had little air pollution, but high levels of nitrogen and phosphates were found in the water and soil, leading to a discussion about the substances that make up fertilizers. The urban

ecosystem was deficient in nutrients in the water and soil and had a high rate of air pollution.

The water tests determined levels of nitrates, phosphates, and pH using Hach test kits and a pH meter. Because we were unable to go out to each site we consequently lost readings on temperature and dissolved oxygen for the water pollution test. The soil tests determined levels of phosphates, potassium, nitrogen, and pH, using Rapitest soil test kits purchased at Meijer. The air tests were done with LaMotte test kits. The samples were collected in clean two-liter bottles in which a pump was connected so the air would pass through the collecting liquid, creating a vacuum connected to a water source, filling the bottle with water
The for this apparatus is found in a diagram found in Appendix A-IV. Protocols for the air pollution tests can be found in Appendix A-IV. The soil and water tests were done according to instructions in the kit.

Waste on the Web

This activity looked at by product disposal and it's economic and environmental impact as in the geosphere benchmark. Students explored a website (Appendix A-V) that discussed the amount and contents of waste we produce. They were able to research not only the composition of garbage, but also types of plastics, composting, and new technology for reducing waste. The students completed the worksheet in one block.

Recycle Cycle

The object of this activity (Appendix A-VI) was to show students that plastics are used widely and be recycled into products we may not think about. It was

intended to make them think about how we make plastics and give them alternatives to simply disposing of them. This activity was adapted from Plastics by the Numbers lab found at http//:chem.lapeer.org/ Chem1Docs/ 3D5Plastics Lab.html. The students explored properties of the six specific different types of plastics. Afterward, they were given an unknown plastic to identify.

The properties that the students looked at included the plastic's ability to stretch, bend, float in tap water, float in salt water, float in hot water, and whether or not it was affected by acetone. The acetone test did not work as expected, but the rest of the tests allowed for easy identification of the unknown plastic. By observing these properties, students are able to make the connection as to why recycling is important. Along with that, we discussed where plastic comes from and why it we must make more of an effort to recycle whatever possible.

Paperclip Polymer Production

In this activity (Appendix A-VII), the students used paperclips to construct molecular models of polymers in order to determine some of the physical properties of monomers, polymers, and cross-linked polymers. It was intended to give students a basic idea about polymers and give them some background information for the next lab activity. This activity was modified from SEPUP module: Plastics In Our Lives, "Paper Clip Polymers." Monomers were represented by a single paperclip, a chain of paperclips represented polymers, and chains of paperclips paper clipped represented the cross-linked polymer. Once these structures were built, the paperclips were stirred and poured to simulate the viscosity, which was later discussed in terms of applicable fluids such as water and syrup and their structures.

Trash Bash

Students brought in a number of items that would normally be thrown away but could be recycled. A list of items is found in Appendix A. They were not told how they would be used. Working in groups of two, they constructed as many useful items as they could, using a minimum of 75% of each item. The students were given one week to complete their projects, with one day of in-class time. They were required to give a short oral presentation (Appendix A-VIII) about what they used and what they made. They also wrote a one-page reflection paper describing why using things over again is important, what types of things we do use over again, and how reusing things affects the environment. Most students understood that reusing items produces less waste to reside in landfills, therefore requiring fewer products to be manufactured and fewer natural resources to be used.

Different types of adhesives were necessary including super glue, hot glue, plastic glue, masking tape, rope, twine, and lots of duct tape. Almost everything could be cut with classroom scissors or craft knives. Many interesting projects were completed including clothing, a cat carrier, wreath, and many birdfeeders and watering cans.

The most difficult portion of this project was getting the students to reflect on the reuse of materials. This was done through a reflection paper that was to be written about the importance of reusing materials and how that affects the environment. I was looking for a discussion of the lack of waste sent to landfills, among other things. The papers were graded based on whether they met the requirements of the paper. A score of ten was given to a paper that discussed why it

is important to reuse items and what types of things they reuse. A score of eight or nine left out what types of things they reused. A score of five was given to students who did not discuss reusing items, but instead discussed what they did in their project.

Are they Natural or Fake? Natural and Synthetic Polymers

The laboratory activity introduced students to alternative sources of plastic material by showing them that there are natural alternatives to petroleum-based plastic. The activity was to look at alternative long-range plans for resource use as stated in the geosphere benchmark. Students made a natural polymer, from gelatin and ferric nitrate solution and a synthetic polymer from polyvinyl alcohol and sodium borate and compared the properties to the two polymers (Appendix A-IX). This lab was also adapted from SEPUP module: Plastics In Our Lives, "Paper Clip Polymers." They compared the ability of each polymer to stretch, bounce, and pour and the color, thickness, and temperature during formation. The synthetic polymer was very thick and is commercially sold as Slime©. The natural polymer did not hold together well and consequently was not as interesting to the students. They surmised that even though the synthetic polymer was nonbiodegradable, the strength of the polymer made it worth the time it would spend in the landfill.

The students also explored biodegradable polymers and their properties. They dissolved biodegradable packing peanuts into water and poured them into disposable petri dishes to dry. The next day they compared the properties of the dried samples of synthetic polymer, natural polymer, and the dissolved packing peanuts. The students

saw that the biodegradable polymers had similar characteristics to the dried natural polymer. It was thin and not very durable.

Altering the Course of Resource Use

Continuing on the same idea of alternatives to oil based energy, this web-based activity (Appendix A-X) used the same site as Waste on the Web but this time students researched renewable resources. Biomass, geothermal, tidal, water, and wind sources of energy were discussed in great depth in terms of their availability, how we use them, and their drawbacks. Solar energy was not included in this activity because it is the most readily available renewable resource. The students were to become aware of other alternative sources of energy.

This activity took longer than one eighty-five minute block and finding time to fit it into the schedule was difficult.

Why Recycle?

This activity, adapted from Environmental Science Activities Kit, (Appendix A-XI) showed students how, without recycling, bauxite ore gets used up quickly to make aluminum cans that sit in landfills, again focusing on resource use and disposal. "The Wasters" did not recycle. They turned in four pieces of ore (represented by rocks) for four cans. Each person represented a new year, and after five years they ran out of ore. "The Recyclers" recycled all of their cans and only had to use a little bauxite every year. Every year they recycled four of their cans and they only had to use one piece of ore to receive four cans back. It took this group sixteen years to run out of ore.

The students lined up in their two groups and continued to go through their lines until the bauxite was used up. The "Wasters" were unhappy that they were not all able to participate in the activity, leading to a great discussion about how the people toward the end of the line represented future generations and by continuing our wasteful ways, we are eliminating resources for future generations. By using observations, I was able to determine the level of understanding in the students.

Environmental and Economic Impacts of Air Pollution Sorry Game

The students played Sorry, a children's game that this researcher redesigned, using economic and environmental aspects of air pollution to help move around the board. The rules, game board, and playing cards are found in Appendix A-XIII. Each card allowing the students to move forward required them to do something that reduced air pollution, illustrating the impact of human activities on the atmosphere. The cards requiring the students to move backwards or back to start increased air pollution and listed both the environmental and economic impacts of air pollution. The students played in groups of four and following the game, they completed a post-game assessment (Appendix A-XIV), intended to have them think about the consequences of their actions and give them ideas of things that they could do to reduce air pollution, things such as riding bikes, walking, and getting your car checked for harmful emissions.

The students enjoyed the change of pace that came from playing the game and based on the answers received on the post-game assessment, they were able to use the information on the playing deck to learn how to reduce and prevent air pollution. Again I used observation as an additional assessment tool.

What's Happening?

The students spent a block in the library looking up articles related to environmental issues. This activity was taken from Environmental Science Activities Kit. They were required to provide two one-page summaries of two articles and answer questions about how the topics discussed in the articles affected them. Both articles had to be written within this decade and only one could be from an online source, although this source had to be an actual new publication. They also completed a worksheet with follow up questions.

This activity (Appendix A-XV) wrapped up the unit and it was meant to show the students that although there is legislation and large organizations working on environmental issues. It was also meant to inform them that they are an important part of the ecosystem and can do things to protect the environment, too. I received numerous comments from students on their topics, finding interesting and exciting topics they never knew about.

The students felt very rushed to complete the activity, but I had a number of students comment on the types of things they learned form the articles. Since they have been given a choice of whatever environmental, they got to read about what interests them.

Because of the number of bomb threats and time out of the building, the first semester students were unable to do this activity. During the second semester the students spent one day in the library, but there was not enough time for them to obtain the articles and write the summaries. Most students had to do the majority of the

work at home. It was challenging to convince them that a short article would not contain enough for a one-page paper.

MAGAZINE ARTICLES

During second semester I was able to supplement the unit with relevant articles from current publications. When we looked at the effects of pesticides on nonpest species, the students read an article called Transsexual Frogs by Elizabeth Royte published in the February 2003 issue of Discover magazine. The article discussed the consequences of pesticides containing atrazine on the frog population. The article was very interesting for the students to read because the experiment that they had just finished looked at the effects of pesticides on nonpest organisms, which was the focus of the article.

The second article was called A Climate of Despair by Jeffrey Kluger in the April 9, 2001 issue of Time magazine. This piece discussed the Kyoto Protocol (a proposed standard for world wide air pollution control) and the carbon dioxide emission amounts emitted by countries around the world. We read this article after playing air pollution Sorry, which gave the students another perspective on air pollution.

Both articles emphasized to students that environmental issues are not just a concern for liberal, "tree-hugging" environmentalists, but that they affect everyone in the world and we all need to be concerned. I frequently use current event articles in my classroom to enlighten students on new research in the scientific community. Using this approach, I hope to educate the young adults that will make informed decisions for the future of the world.

FIELD TRIPS AND SPEAKERS

Landfill

During the first semester, we took a field trip to a landfill about forty-five miles away. This landfill is where the school's waste is taken, so it was particularly relevant to the students. The manager explained how a landfill is constructed and described the type and amount of waste brought in each day. He discussed the leachate and the gas emitted from the decay. Students were interested in how the leachate was treated and that they burned off the natural gas emitted from the landfill. He also spoke about the career opportunities in the landfill business.

We did not go to the landfill second semester because it was covered with snow. Rather, the landfill manager came to school to talk to the students. The students commented how they enjoyed being able to see how the landfill cells were constructed because he was able to use the board to draw diagrams. Students asked many questions about strange things found in the landfill and how long it would take to fill the landfill.

Recycling

In Montcalm County, there is a company that regularly collects recyclable materials from industry in the area. They have recently expanded to providing community drop-off recycle centers. One of the managers of the company came to class and explained how recycling works, what sorts of things can be recycled, and where to recycle them. In first semester, he was able to talk to first block, but not to third and fourth blocks due to an evacuation because of a bomb threat. He came back the next week for fourth block, but was unable to talk to third block.

Unfortunately he was unable to come during second semester due to his work schedule. This was disappointing to both the students and myself.

ASSESSMENT

Pretest

In order to evaluate the progress of the students, a pretest was given at the beginning of the unit. The pretest (Appendix B) was identical to the post-test given at the end of the unit. The test was composed of five multiple-choice questions and eleven short answer questions that directly addressed the objectives covered in the unit.

Post-test

The posttest was given on day sixteen of the unit. The review on the previous day tied together the ideas of the unit and gave the students an opportunity to see how the topics related to each other. Second semester's test day went very smoothly compared to that of first semester's test day, when we had a bomb threat. The threat came during the middle of their test, so after the evacuation was over they finished the test. Fourth block was given an extra day because we did not meet on their expected test day. They also received the same posttest for the above reasons.

Interviews

Interviews were conducted on a voluntary basis during both first and second semester, about two weeks after the post-test. I interviewed a high, average, and low achieving student in each of the six classes, or a total of eighteen students. The achievement level was determined by past work in this science class. They were conducted before and after school or during lunch. Students were asked eight

questions while this researcher wrote down their verbatim responses. The students had no prior experience with the questions before the interview. The questionnaire for the interview is in Appendix B.

The purpose of the interview was to determine what the students had retained following the test. The questions asked were meant to assess the objectives taught and word them in a different way than was on the pre and post-test.

RESULTS AND DISCUSSION

Nontraditional methods of assessment were used in this unit for various laboratory experiments, activities, and projects. The use of a rubric for the Trash Bash assessed whether they had used the necessary materials, the appropriate adhesives, made something useful, and gave an appropriate presentation. Extra credit was given for creativity. A rubric was also used for the response paper to assess if they had discussed reusing items.

Observation of group interaction was another method of assessment that was used during the Sorry game and Why Recycle? activities. This allowed me to witness the interaction between students as well as determine their knowledge of the content.

During other activities I was able to assess students based on their answers to questions. During the "Pesticide Peril", the objective was to test the effects of pesticide on nonpest species. The questions, "What was the purpose of this experiment? What was it trying to demonstrate?" produced a variety of responses. The rubric is found in Appendix A. Examples of high scoring answers are

> "It was to show the effect of pesticides on organisms not specifically targeted. Our actions have ripples."
>
> "The purpose was to show how drastic the effects of pesticides are and how damaging pesticides can be to nonpest aquatic organisms."
>
> "To show that pesticides don't just kill pests-they kill little things. Little things that don't bug anyone but have an effect on the ecosystem."

Examples of poor scoring answers are

> "To see the results of the pesticide."
>
> "how much pesticide does it take to kill brine shrimp."

"How pesticides work and how they can help."

High scores on this question show that the students understood the connection between species in an ecosystem and that the effect of a poison on one of the species will eventually have an effect on all species in the ecosystem. Poor scores on this question show that the student could not make the connection between small organisms in an ecosystem and their predators, as well as their connection to humans.

Another question on the assessment dealt with analyzing our own pesticide use and what we can do about that. Most students did not feel as though they used any pesticides, but some of the high-quality answers included

> "It makes me realize that when you use pesticides, it just doesn't stop where we want it to stop. It may kill what we want to be dead, but it also affects the things surround (sic) it or what eats that plant that you've just sprayed and if possible, don't use the pesticides on plants because it'll kill more than what you bargained for"
>
> "This makes me think that we should be very cautious when we use pesticides. I think that you should not use pesticides unless it is extremely necessary."
>
> "It shows me how my use of pesticides needs to be carefully monitored. Since I don't use pesticides, this won't change much, but perhaps deter future use."

Poor quality answers included

> "It could kill the brine shrimp. I would use 50%" Student Answer
>
> "How it works. It depends on how fast you want the pests gone. You want them gone fast you use 150%. If you want them gradually to die use 50%" Student Answer
>
> "That pesticides really work and can be useful" Student Answer

Students who answered well comprehended the question and were able to consider the world around them. They analyzed their own use of pesticides, and even if they do not currently perceive themselves to use a lot of pesticides, they mentioned that they would consider other means of pest control, such as biological controls. Students with poor answers only considered the immediate problem and were not able to make the connection between the experiment and the "real world."

During the Recycle Cycle lab, the objective was to determine the different characteristics of plastics and investigate ways of separating plastic types. One of the questions asked during lab assessment was, " Suppose you have been hired to set up a process for separating large quantities of waste plastic that is a mixture of PETE and HDPE. Describe how you might perform this separation." The rubric for these answers is found in Appendix A. Some answers that demonstrated high knowledge include

> "In order to separate these two, you will simply place them in tap water. You will do this because PET sinks in tap, salt, and hot water, and HDPE floats in all so simply remove the floating pieces from the sunken pieces." Student Answer

> "Go by float or nonfloat in tap water because HDPE floats and PETE does not." Student Answer

These students were able to produce logical ideas to separate the types of plastics. Answers that demonstrated poor knowledge included

> "separate big things from little things" Student Answer

> "thinner plastic" Student Answer

These poor answers clearly demonstrate that the students did not understand the concept of the laboratory experiment. They were able to comprehend what the

question was asking for but were unable to explain how plastics could be tested and separated.

After making their Trash Bash projects and presenting them, it was required that the student write a reflection paper explaining the importance of using items over again, discussing the things that they use over again, and how they use them. Some students did not read the instructions thoroughly and used the reflection paper to explain what they did in their projects and what they made. These students did not receive points on their paper because they did not follow the instructions. The rubric is found in Appendix A. There are examples of good (students A through F) and poor reflection papers (students G through I) included in the Appendix C.

The assessment for the air pollution game, Sorry, included a number of questions that were designed to make the students think about the negative effects of air pollution and to realize things that they can do to reduce air pollution. One of the questions asked, "Explain the reasoning for the 10 card. Why does buying a fuel efficient car let you move forward 10 spaces or back 1 space?" Some of the high quality answers included

> "because you are helping to reduce air pollution quite a bit, but you are still polluting." Student Answer
>
> "you don't use as much gas but it needs more resources to make the car" Student Answer
>
> "It is helpful but expensive. Even though it is fuel efficient it still gives off pollution." Student Answer

Lower quality answers included

> "Because it doesn't pollute the air" Student Answer
>
> "So we won't waste the gas" Student Answer

"Because if you buy a car like that you might move forward or backward" Student Answer

The answer for this question was intended to make students think about a fuel-efficient car in terms of conserving petroleum, with the keyword being conservation not preservation. We are still using petroleum, so even though the cars get better gas mileage, they are still contributing to air pollution.

The post-test covered the benchmarks as presented in the Implementation section of this paper and was sixteen questions long. One of the questions was not included in the analysis because we did not study the relevant material to my satisfaction and an alternative question was substituted during the second semester test. There were five multiple-choice questions and eleven short answer questions. On both the pretest and the posttest there was a wide variety of correct responses dependent on the question.

Table 1 represents the percentage of correct answers for each of the multiple-choice questions on both the pre and the posttest, as well as the increase in average score. The results are characterized in Figure 1 and Figure 2.

Table 1 Combined Percentage from all class for the Multiple Choice Questions n=127

Number of Question	Percent Correct on Pretest	Percent Correct on Posttest	Increase of Average Score
1	58.2	85.7	27.5
2	72.1	95.8	23.7
3	64.8	86.5	21.7
4	89.3	76.5	-12.8
5	39.3	73.9	34.6

Table 2 Combined Average Score from all Classes for the Short Answer Questions n=127

Number of Question	Average Percent on Pretest	Average Percent on Posttest	Increase of Average Percent
6	33.0	82.5	49.5
7	deleted question	deleted question	deleted question
8	8.5	67.4	58.9
9	25.8	62.5	36.8
10	20.0	82.3	62.3
11	28.7	65.8	37.3
12	12.0	51.5	45.5
13	39.1	86.0	46.9
14	45.3	84.4	39.1
15	78.5	99.2	20.7
16	4.6	45.5	40.9

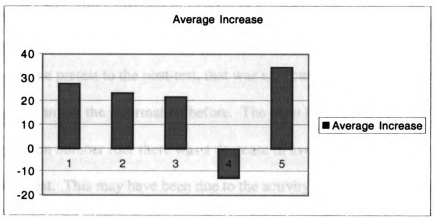


Figure 1 Average Increase in Percentage from all class for the Multiple Choice Questions

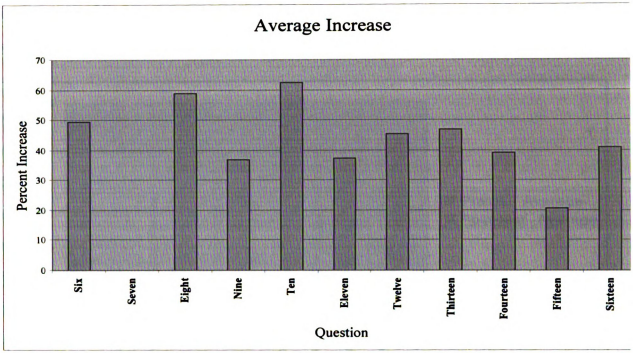


Figure 2 Average Increase in Percent in Short Answer score for all classes

Although most questions saw a significant increase in the average percent from the pretest to the post-test, that was expected because the students had not been taught any of the information before. The most interesting outcome was that for question number four there was a decrease in average score, comparing the pre to post-test. This may have been due to the activity, Effects of Construction on Water Flow. The activity focused only on the effects of building on water flow of an area not on the other impacts of urban development. Because of this, students may have forgotten that urban development affects more than just the water flow, but also the air and land that surrounds the site.

In addition, Figure 3 compares the average pretest score for each short answer question to the average posttest score for each short answer question. There was a great increase in average score in question eight, which asked the students to fill in a table dealing with the six different types of plastics. The question that showed the

least amount of improvement was question fifteen, which asked the students do state four things that they or society could do to reduce pollution.

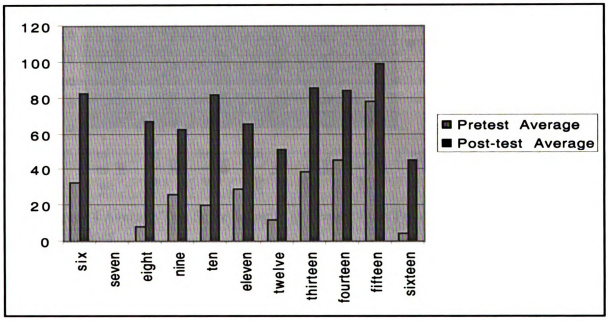


Figure 3 Average Pre and Posttest Scores for Short Answer questions for all classes

The analysis of the effectiveness of this unit was based primarily on pre and posttest scores. Since most of the students had not taken this class previously, and the objectives were not addressed in the prerequisite course, the pretest scores were expectantly low at an average of twenty five percent. The scores went up to an average of sixty-eight percent at the end of the unit.

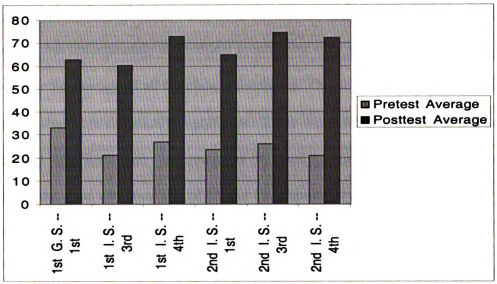


Figure 4 Average Test Score Increase in Percent from Pre and Post-tests based on Classes

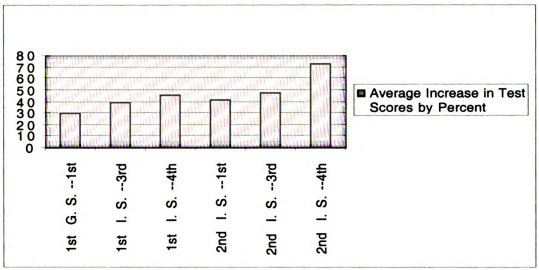


Figure 5 Average increase in test scores according to classes

In addition to looking at the IIS course's performance during the pollution unit, I wanted to look at the improvement with a group of students who had successfully completed the IIS and, thus had discussed the pollution unit without any of the activities. The class of juniors and seniors who had already had the IIS course and were enrolled in Global Science, a course that is geared toward environmental

science, had pretest scores that averaged thirty-three percent, higher than the total class average, but unfortunately the posttest scores were only sixty five percent, approximately the average of all the classes combined. Of the six classes tested, four had increases that were statistically significant. There were two that did not prove to be statistically significant with t-test results of between 0.1 and 0.2. This may be due to the size of the class with numbers of 13 and 12, respectively. The class with the most significant result was the last IIS class of second semester with a 0.01 t-test value. I feel that the reason this class had the greatest increase in score (Figure 4) was that it was the last class of the day during second semester, and I had fine-tuned my lesson plans. This is based on the comparison of scores with the other classes. The IIS class with the least increase in average test score was my first class of the day during first semester. The ability to fine tune lesson plans was an advantage to second semester students. This is evident when observing Figure 5.

The overall low and high scores in the pretest were six and seventy-one, respectively. On the posttest the low and high scores were eighteen and one hundred, respectively. The scores were out of one hundred points. The students in all classes with the low scores on the pretest in all classes were labeled learning disabled by the special education department. These students have a hard time processing information. After completing the unit, five of the six low scoring students improved a great deal. The other student improved, but only by five points. This may have been due to poor attendance on the student's part. Five of the six students who scored well on the pretest all have high cumulative grade point averages, ranging from 3.0 to 4.0. The sixth student does not and only scored a few points higher on the post-test.

The majority of students who scored higher on the pretest tended to also have the highest scores on the post-test.

The average posttest score on question number fifteen was most impressive. The short answer question involved students listing four possible solutions to pollution problems in general. There are a variety of possible correct answers and this gave students an opportunity to think of many potential answers.

Question number sixteen had a low average percentage of correctness both on the pretest and the post-test. The information for this question was never specifically laid out in the unit, but it was discussed throughout, especially during the beginning of the unit when we talked about ecosystems and the effect of urban and agricultural development. Because this was not specifically defined for the students, apparently they did not understand the concept and consequently did not score well on the question.

After the unit was completed, I interviewed students from different ability levels about the objectives covered in this unit. All students interviewed could identify ways in which pollution could be reduced; with over fifty percent saying that they could do the same things that society could do to reduce pollution. Most of the students focused on air pollution, possibly because they connected the reduction of pollution with the Sorry game. On the other hand, less than twenty-five percent of the students interviewed were able to define biodiversity. The ability to answer the question correctly was gauged on a scale of 5-3-1. Complete answers received a five, and incomplete answers received a one. A three was given to a partially correct

answer. There were six students in each category, based on their posttest scores and then the ratings were averaged.

Table 3 Average rating for interview questions of high, average, and low achieving students.

Question	Average for High Achieving Students	Average for Average Achieving Students	Average for Low Achieving Students
1	4	3.6	3.3
2	5	3.6	2.3
3	4	3.3	3.3
4	4.3	2.3	1.3
5	4.3	4	4.3
6	5	3.3	3.3
7	4	3.3	2.6

The pattern of high, average, and low students was just as expected. The high achieving students steadily scored the highest of the three categories and, with only a couple of exceptions; the low achieving students scored the lowest (Figure 6).

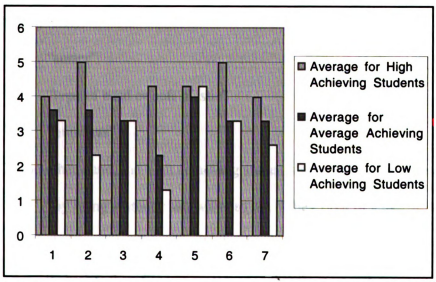


Figure 6: Comparison of the average score of interview questions with high, average, and low students.

The question "What are some consequences to altering the landscape of an area and changing its water flow?" generated good answers like

"land subsides, sinkholes, and flood or drought in certain areas."

"area could dry out or flood, erosion where they put houses could wear away buildings."

"flooding and destruction of habitat."

These students understood that there are many consequences to building in a location without putting any thought into it. Some of the lower scoring answers to this question were

"habitat, other people's land, erosion."

"bad soil, destroy habitat."

"flooding."

Some of the words given as answers were along the right path, but the students were no able to verbalize a complete answer and expand on their thoughts. When asked to explain how recyclable plastics are sorted, these same students again answered incompletely.

"sorter"

"type of hard or soft plastic"

"numbers"

On the other hand, the high achieving students gave more complete answers, such as

"by using water or salt water to see if they float or sink"

"by the code given to tell what kind of plastic they are"

"whether they float on water, ones that float go one way, ones that sink go another"

These students were able to expand their answers. The process of determining types of plastics by floating or sinking came from the "Recycle Cycle" activity where they

tested each type of plastic in tap water, hot water, and salt water to see if they would float or sink.

Overall, I was pleased with the outcome of the interviews. Over eighty percent of all of the questions asked were answered at a rating of three or five. This leads to the conclusion that most students have a good grasp of the material even if the test scores did not reflect that.

CONCLUSION

Teaching the pollution unit was challenging because I taught it differently than any other unit I had ever taught. I tried to take a totally different approach by letting the students discover science for themselves. This led to a lot more preparation on my part, but after looking at the data, the average post-test scores in the IIS course were much higher than the pretest scores from the Global Science course. These students had already been taught the objectives that this unit was meant to cover, without the hands on activities. Some of the students had taken the IIIS course the previous year; others had taken it two years prior. Not all of the students had the same instructor for the course. By comparing their pretest scores with the IIS post test scores, I can draw a conclusion about the effectiveness of the unit.

By comparing the average posttest scores to those of other units, I suspect that the activities in this unit were more effective than the activities in others. The Effect of Construction on Water Flow was a good activity in terms of illustrating the objective of determining the effect of urban development on an ecosystem. I do think that the emphasis on water flow in this activity affected the students' post-test answer to question number five. In the future, an alteration to the activity allowing for the inclusion of other aspects of urban development, such as air pollution and addition of chemicals, will help students to remember that there is more to urban development damage than water flow.

The Pesticide Peril and Fertilizer Fun laboratory experiments went very well. Based on the student's answers, they were able to grasp the concept of the lab, which was to look the effect of agriculture on an ecosystem. Although the next time I teach this unit, I will test them more thoroughly on the objectives and emphasize biodiversity.

The Trash Bash was a great activity to make them think about reusing things at home. The downfall of this activity came when the students had to write a response paper about things that they reused. Apparently the students did not understand the assignment and summarized what they did instead of answering the question. This will need further instruction in the future.

After taking a field trip to the landfill and having the landfill manager come and speak to the class, I think that I would rather have him come and speak to the class. Because in the class he had a board to use to describe the structure of a landfill, the students were able to understand what he was talking about. Also, they seemed more interested in what he was telling them. The students had better questions and wanted to know more about landfill operations. There was the same type of results with the recycle center manager. The students were interested because he was able to use the board to illustrate what he was talking about.

Although I tried to move away from lecturing, there was some vocabulary and other ideas that needed more lecture time in front of the class. For example, sustainability of resources was the objective of looking at alternative sources of energy and the importance of recycling. This was lost in the excitement of the lab activities. Another term that needed more time was biodiversity. This was the

objective of Fertilizer Fun and Pesticide Peril by showing the relationship between organisms in an ecosystem, and between humans and the environment. I would not add a lot of lecture, but enough to reiterate the objectives of the activities.

One activity I will not do again is the "Why Recycle?" activity. This focused on bauxite ore and aluminum cans, which was not a focal point of this unit. Because we spend more time on plastics, and we already had done the Recycle Cycle lab with plastics, the aluminum can activity was not necessary.

After completing the "What's Happening?" activity with second semester students, I wished that first semester's classes had had the opportunity to do it. I let the students choose whatever articles they would like to read on an environmental topic. The students commented to me while they were doing the activity that they had found some very interesting things that they didn't know before. The next time that this unit is presented, I will be sure to get enough library time for them to look up the articles, as it was one of the most beneficial activities that we did.

The web searches gave the students a lot of information that they would have otherwise had to obtain through lecture. It also gave them the opportunity for guided research. I like the website that they used because it provided a lot of valuable information, but I plan to expand the activity to other, more current websites.

Overall, I feel that the students learned a great deal about environmental science and they were excited about learning it. The coherency of the unit was not as smooth as I would have liked, but by adding a review period at the end of the unit, I was able to tie the ideas and objectives together for the students. I felt the objectives were sufficiently covered (Table 4).

Table 4: Objective and the Activity used to Demonstrate it

Objective	Activity
Explain the effects of agriculture and urban development on selected ecosystems	Effect of Construction of Water Flow Pesticide Peril Fertilizer Fun Testing Urban, Agricultural, and Undisturbed Ecosystems Transsexual Frogs Article
Evaluate alternative long-range plans for resource use and by-product disposal in terms of environmental and economic impact	Waste on the Web Trash Bash Recycle Cycle Paperclip Polymer Production Are the Natural or Fake? Altering the Course of Resource Use Why Recycle?
Explain the impact of human activities on the environment and explain ways that individuals and society can reduce pollution	Sorry A Climate of Despair Article

By analyzing the objectives that the unit was intended to illustrate, I think that the ecosystem development and the resource use objectives were adequately met. In the future I will plan to develop more activities that help to illustrate ways that society and individuals can reduce air pollution. This seemed to be the weakest portion of the unit.

Also, in the future I will try to make smoother transitions between topics. After the unit was over, the students still commented how they do things at home now, like recycling, that they never did before. Because the goal of this unit was for students to be able to take what they learned and use it in their everyday lives, having students use what they have learned is the ultimate reward.

APPENDICES

APPENDIX A

I.
Effect of Construction on Water Flow

Objective: To observe the flow of water in a natural habitat and the effect construction has on the water flow.

Materials: Landform pan with screen (for half the class)
Shallow aluminum pan
Diatomaceous Earth
Play sand
Lego's
Rain mechanism (plastic cup with holes in the bottom and a ring stand)

Procedure:

1. Along the bottom of the landform pan, sprinkle diatomaceous earth. Wet it.
2. Use sand to cover the screens. Wet it.
3. Using more sand, create a variety of landforms in your pan, including hills, valleys, and canyons.
4. Raise the landform pan by placing it on a book. Slightly raise the intact end of the landform pan. Place the shallow pan at the screen end of the landform pan.
5. Put the rain mechanism at the intact end of the landform mechanism.
6. Observe the water flow on an undisturbed landform. Draw and describe.
7. Using Lego's, create 5 building structures of different shapes and sizes. Place them in random spots in the landform pan and observe how the water flow changes. Draw and describe.
8. Try 3 different positions of buildings and draw and describe their effect on water flow.
9. If necessary recreate original landform with sand.
10. Now place the 5 Lego buildings in locations that you think will least disrupt the water flow. Observe the water flow. Draw and describe.

Name_____

Effect of Construction on Water Flow

Draw and describe the flow of water on the undisturbed landform.

Draw and describe the four different building positions and their effect on water flow.

1. 2.

3. 4.

Based on your knowledge, draw your landform and place the buildings where you think their effect on water flow will be the least.

Was your hypothesis correct? How much effect did the buildings have? Draw and describe.

Why is it important for contractors to keep in mind the natural flow of water when developing a building site?

Name some consequences to altering water flow.

II.
Pesticide Peril

Objective: observe the effects of pesticide on nonpest aquatic organisms.

Materials: 75 mL of brine shrimp tank water with brine shrimp

4 large test tubes
pesticide solutions (powdered pesticide made at 50%, 100%, 150%, and 200% concentrations)
pipettes or 1 mL eyedroppers

Procedure:

1. Put 10-15 mL of brine shrimp tank water in each of four test tubes.
2. Label the test tubes: control, 50%, 100%, 150%
3. Record the activity of the brine shrimp on the data table.
4. Place 1 mL of 50% pesticide solution in the beaker labeled 50%.
5. Repeat for the 100% and 150% solution.
6. Record the activity of the brine shrimp every five minutes for a total of twenty-five minutes.
7. Dispose of brine shrimp in designated container.

CONTROL

	Activity very, moderate, little, none	**Location** top/bottom of beaker	**Other Observations**
0 minutes			
5 minutes			
10 minutes			
15 minutes			
20 minutes			
25 minutes			

50%

	Activity very, moderate, little, none	**Location** top/bottom of beaker	**Other Observations**
0 minutes			
5 minutes			
10 minutes			
15 minutes			
20 minutes			
25 minutes			

100%

	Activity very, moderate, little, none	**Location** top/bottom of beaker	**Other Observations**
0 minutes			
5 minutes			
10 minutes			
15 minutes			
20 minutes			
25 minutes			

150%

	Activity very, moderate, little, none	**Location** top/bottom of beaker	**Other Observations**
0 minutes			
5 minutes			
10 minutes			
15 minutes			
20 minutes			
25 minutes			

Name_____

Pesticide Peril

1. How did the concentration of pesticide affect the brine shrimp?

2. Which concentration had the most drastic effect? Explain.

3. How did time affect the shrimp?

4. What was the purpose of this experiment? What was it trying to demonstrate?

5. Why is this not an accurate demonstration for an aquatic ecosystem?

6. What does this experiment make you realize about the use of pesticides? How does this make you think about changing your pesticide use?

III.
Fertilizer Fun

Objective: observe growth in an aquatic species due to the addition of fertilizer.

Materials: 5 plastic cups or other appropriate containers per lab group
duckweed
fertilizer solutions
pond water
5 mL pipette
light source
tray or box that will hold cups

Procedure:

1. Label cups: control, 50%, 100%, 150%, and 200%.
2. Fill each beaker with 50 mL of pond water.
3. Count out 10-20 duckweed for each container
4. Add 5 mL of 50% fertilizer solution to the beaker labeled 50%.
5. Repeat steps 4 and 5 for 100%, 150%, and 200%.
6. Label all cups with your group's name and put in the tray. Place the tray under the light source.
7. Count duckweed daily and record in data table. Add fertilizer every other day.

Data Table 1: Amount of duckweed per day

Days	**1**	2	**3**	4	**5**	6	**7**	8	**9**	10	**11**	12
control												
50%												
100%												
150%												
200%												

***bold represents days to fertilize**

Questions:

1. What happened to the beakers that had fertilizer solution added to them?

2. Was there any difference in the number of duckweed in the 50% solutions versus the 150% solution? Explain.

3. Which beaker had the largest increase in growth?

4. Why was there a control beaker? What happened to it?

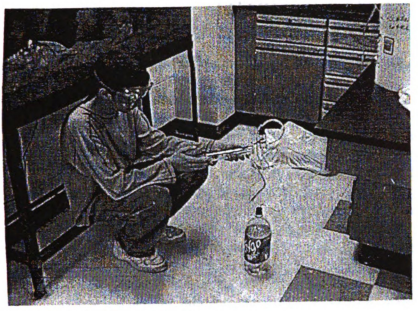
IV.

CARBON MONOXIDE AND SULFUR DIOXIDE SAMPLE PROTOCOL

1. Follow procedure for each individual test.
2. Collect 2-liter bottles of air. (5 will be needed for the carbon monoxide test, and 5 will be needed for the sulfur dioxide test)
3. Place a sample bottle in a tray to catch the excess water.
4. Put a bucket full of water at a level that the bottom of the bucket is equal to the top of the sample bottle.
5. Depress the plunger of the air pump to the "0" position.
6. Pour the designated amount of absorbing solution into the glass tube and put the stopper assembly into the impinging tube.
7. Connect the flexible tubing from the short tube to the outlet of the air pump.
8. Connect the flexible tubing from the long tube onto the sample bucket. Note: do this part very quickly to prevent the escape of sample air.
9. Place the remaining tube into the bucket of water, making sure the end of the tube is at the bottom of the bucket.
10. Begin pumping. The sample bottle ought to start filling up with water.

Note: Be careful in pumping not to collapse the bucket. Allow the bucket to fill and the water to slow before pumping any more.

11. When the bucket is filled with water, switch only the sample bottle, leaving all the rest in place. The water from the sample bottle may then be returned to the bucket.
12. Repeat for 5 sample bottles.
13. Follow procedure for each individual test.



Air Sampling Apparatus

Pollution Testing Protocol

AIR

Carbon Monoxide:

1. Pour the carbon monoxide absorbing solution into a clean test tube (0822) to the 10 mL line.
2. Insert the tube into the carbon monoxide comparator (7783). Match the reagent color to a color standard.
3. Use the chart to convert the index number to concentration. Record the reagent blank as ppm carbon monoxide.
4. Pour the carbon monoxide absorbing solution from the test tube into the impinging tube to the 10 mL line.
5. Connect the impinging apparatus to the intake of the air sampling pump making sure that the long tube is immersed in the absorbing solution.
6. At the end of the sampling period, pour the contents of the impinging tube into a clean test tube. The presence of carbon monoxide is indicated by a yellow color in the absorbing solution.
7. Insert the tube into the carbon monoxide comparator (7783). Match the reagent color to a color standard.
8. Use the chart to convert the index number to concentration. Record the test result as ppm carbon monoxide.
9. Subtract the reagent blank result from the test result to determine the carbon monoxide concentration.

Sulfur Dioxide:

1. Add 10 mL of sulfur dioxide absorbing solution to the impinging tube. Connect the impinging tube to the air-sampling pump. Make sure the long tube is immersed in the absorbing solution.
2. At the end of the sampling period, fill the small test tube (0230) to the line with the absorbing solution from the impinging tube. Add one level measure of sulfur dioxide reagent #1 (7693) with the 0.25g spoon. Cap the test tube and shake vigorously to dissolve the powder.
3. Use a 1 mL pipet (0354) to add 1 mL sodium hydroxide 1.0N to the small test tube. Cap and invert several times to mix.
4. Use the other 1 mL pipet to add 2 mL of sulfur dioxide indicator to the large test tube (0204).
5. Pour the contents of the small test tube into the large test tube. Immediately cap and invert 6 times, holding the cap firmly in place.
6. Wait 15 minutes. Place test tube in the sulfur dioxide comparator. Match sample color to color standard. Record index number.

Pollution Testing Protocol
Calibration Charts

Carbon Monoxide:

	Comparator Index Number							
Volume (liters)	1	2	3	4	5	6	7	8
10	33	67	100	133	166	200	233	267
20	25	50	75	100	125	150	175	200
30	20	40	60	80	100	120	140	160
40	17	34	51	68	83	100	117	134
60	12.5	25	37.5	60	72.5	85	97.5	110

Sulfur Dioxide:

Volume (liters)	1	2	3	4	5	6	7	8
10	0.00	0.19	0.29	0.38	0.48	0.57	0.67	0.76
30	0.00	0.06	0.10	0.13	0.16	0.19	0.22	0.25
60	0.00	0.03	0.05	0.06	0.08	0.10	0.11	0.13
90	0.00	0.02	0.03	0.04	0.05	0.06	0.07	0.08

V.
Waste on the Web

Use http://www.soton.ac.uk/~engenvir/index.html to find the following:

1. What are the typical contents of a household trashcan?

2. How is trash turned into fuel?

3. What type of paper makes up 80% of the paper thrown away?

4. The plastic from packaging makes up what percent of the plastic thrown away?

5. Name the two types of plastics and explain the differences between them.

6. What is the "high-tech" way of sorting plastics? Explain.

7. Define composting.

8. What are the two stages of composting?

9. What is anaerobic digestion? Why is it important?

10. How does a composting plant work?

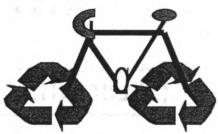
11. Explain why recycling aluminum cans is important.

12. What are two ways to reduce waste?

13. Give two example of things made from thermoset plastics.

14. What kind of things are needed for composting?

VI.



Recycle Cycle

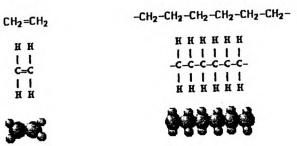
Background

Plastics are everywhere in our daily lives: in the furniture we sit on, carpets we walk on, utensils we eat with and clothes we wear. Plastics are made from long chains of polymers. Polymer comes from the Greek polys (many) and meros (parts). Basically, all polymers are giant molecules made up of repeating units, called monomers. The units may be identical or not. Chemists have their own language for designating different monomers. A single polymer is often made up of thousands of monomers linked together like the cars of a train.

MONOMER **POLYMER**

Example: An ethylene molecule (C2H4) is made from two carbon atoms and four hydrogen atoms. The resin polyethylene is formed by linking many monomers of ethylene molecules to form the polymer.

MONOMER **POLYMER**



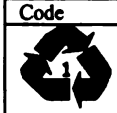
Not all polymers are manufactured. Natural polymers are found in foods such as proteins, starched, and carbohydrates. DNA and RNA proteins in our bodies are natural polymers. Polymer molecules give structure, function, and protection to all living things. Likewise, synthetic polymers are used to create manufactured products with these attributes.

Some plastic polymers are very hard and rigid (bowling balls, football helmets), while others are soft and flexible (foam mattresses). Some polymers are resistant to heat (adhesives used on the space shuttle), while other can be readily melted (milk jugs). Some polymers can be molded into useful objects over and over, while others may resist being reformed.

Chemists can produce plastic polymers to meet specific needs by controlling the various factors that contribute to the polymer properties. These factors include the size of the polymer, the structure of the polymer (is it linear or does it have branches) and whether or not additives, such as pigments, are present. The same resin can have different properties if one version of it "foamed" by adding gases.

When plastics are recycled, their properties can be manipulated chemically to create a new plastic object that may differ functionally from the original object. An example would be recycling 2-liter PET soda bottles into fiberfill insulation for winter jackets.

Table 1: Major Plastic Resins and Their Uses

Code	Resin Name	Original Product Uses	Recycled Products
	Polyethylene Terephthalate (PET)	Plastic soft drink bottles, mouthwash bottles, peanut butter container	Soap bottles, strapping, fiberfill for winter coats, surfboards, soft drink bottles, fuzz on tennis balls, egg cartons, carpets, skis, boats, film
	High Density Polyethylene (HDPE)	Milk, water, and juice containers, grocery bags, toys, liquid detergent bottles	Flower pots, drain pipes, signs, sodium seats, trash cans, recycling bins, traffic barrier cones, golf bag liners
	Polyvinyl Chloride (PVC)	Clear food packaging	Floor mats, pipes, hoses, mud flaps
	Low Density Polyethylene (LDPE)	Bread bags, frozen food bags, Tupperware tops, grocery bags	Garbage bag liners, grocery bags, multipurpose bags
	Polypropylene (PP)	Ketchup bottles, yogurt containers, margarine tubs	Manhole steps, paint buckets, videocassette storage cases, fast food trays, lawn mower wheels., ice scrapers
	Polystyrene (PS)	Video cassette cases, compact disc jackets, coffee cups, mat trays, plastic cups and silverware	License plate holders, golf course and septic tank drainage systems, desktop accessories, hanging file, videocassette

Procedure

1. Read Table 1. Major plastic resins and their uses. This resin chart describes six common resins and the variety of uses each has. The uses depend on the properties of each resin listed (e.g. lightweight, flexible, incredibly hard, rigid, durable). The code numbers are used by recyclers to identify different resins.
2. Collect a sample of each type of plastic from the front lab counter.
3. Test each sample according to Table 2. Properties of plastic resins
    a. What is the number and short name of the sample?
    b. Is it clear?
    c. What is the color of the sample?
    d. Does it bend or break?
    e. Does it stretch?
    f. Does it float in tap water?
    g. Does it float in salt water? (2 g/100 ml)
    h. Does it float in hot water?
    i. Does it deform in hot water?
4. When you have completed Table 2, test each sample with acetone (nail polish remover) on a cotton ball and record your results in Table 2, continued.
5. Compete Table 3 and finish the questions.
6. Once you have finished the table, obtain an unknown plastic sample and perform the same tests. Determine which type of plastic it is.

Clean-up

Wash each sample and put it back in the correct bin. Throw away acetone soaked cotton ball. All solutions may be dumped down the drain. Clean all lab equipment and put away. Hold on to your lab for discussion.

Data Sheet

Table 2. Properties of Plastic Resins

Symbol	Short Name (PET, PP)	Is it clear?	What is the color?	Does it bend or break?	Does it stretch?	Does it float in tap water?	Does it float in salt water?	Does it float in hot water?	Does it deform in hot water?

Table 2. Properties of plastic resins, continued

Symbol	Short Name	Is it affected by acetone?	Product it came from?	Product it can be recycled into?

Unknown substance: _____

Is it clear?	What is the color?	Does it bend or break?	Does it stretch?	Does it float in tap water?	Does it float in salt water?	Does it float in hot water?	Does it deform in hot water?	Is it affected by acetone?

Questions:

1. What type of substance is the unknown? (5 pts)
2. What plastics deformed in hot water? (1 pt)
3. Which plastics stretched? (1 pt)
4. What kind of material is made into lawn mower wheels? What is its symbol? (2 pts)
5. Name three things that milk containers can be made into. (3 pts)
6. Suppose you have been hired to set up a process for separating large quantities of waste plastic that is a mixture of PETE and HDPE. Describe how you might perform this separation. (15 pts)

VII.

P^3

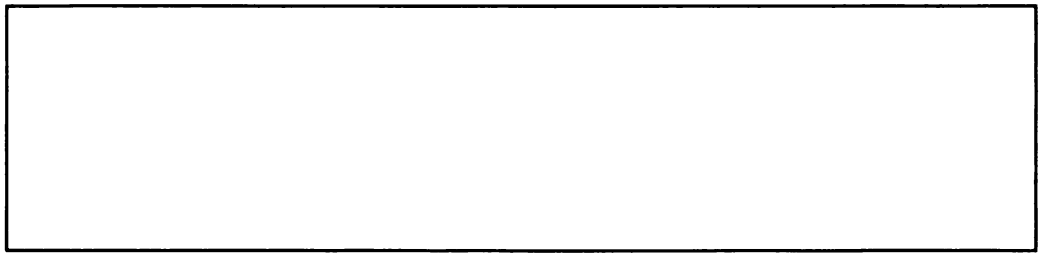
(Paperclip Polymer Production)

Objective: To construct molecular models of polymer molecular models of polymer molecules that will help explain some of the physical properties.

Materials:
96 paper clips
6 colored paper clips
4 clear plastic cups
1 250 mL beaker
stirring rod

Background Information
A polymer is a chemical substance whose molecules are made by linking many smaller molecules together. The prefix *poly-* means "many"; the root word *-mer* means "part." These smaller molecules are called monomers. The prefix *mono-* means "one." The process of linking monomers together is called *polymerization.* Typical polymer molecules consist of 1000 to 10,000 monomer molecules. Polymers can be synthetic or natural. In this activity, a single paperclip will represent a monomer, and a chain of paperclips will represent a polymer.

Procedure:
Forming polymers
1. In the first plastic cup, put twenty-four paper clips unattached.
2. In the second plastic cup, put four six-paperclip chains.
3. In the third plastic cup, put one twenty-four paperclip chain.
4. In the fourth plastic cup, put the cross-linked paperclip chain. Make four six-paperclip chains and place them in four lines parallel to each other. Use two colored paperclips to make connections between the first and second chain. This is called cross-linking. Repeat using two colored clips between the second and third and the third and fourth chains. Draw a picture of your cross-linked polymer.



Determining the Properties of Polymers

1. Test the "pourablity" of each plastic cup by pouring the paperclips between the beaker and the cup
   - Cup 1: Normal
   - Cup 2-4: Leave one clip hanging outside.
2. Record the data on Data Table 1.
3. Test the "stirability" of each cup with your stirring rod and record on the data table.

Data Table 1: Comparing model monomers and polymers

	"Pourability"	"Stirability"
Monomer		
Many short polymers		
Long polymer		
Cross-linked polymer		

Questions:

1. If you remove the long polymer chain from the cup and pull on one end.
   a. How does this affect the other molecules in the chain?

b. Would you expect polymer molecules that are connected in long chains to have different physical properties than single monomer?

2. The scientific term that describes how easily a liquid flows is called *viscosity*. Highly viscous liquids are gooey, while liquids of low viscosity are runny or thin. How does the viscosity of the monomer compare to the viscosity of the polymer?

3. Write a sentence to describe what happens to the properties of a chemical substance as more and more molecules of that substance are polymerized, forming increasingly longer chain molecules. Hint: Ethylene is a colorless gas, polyethylene is...

4. How is viscosity affected by cross-linking?

VIII.
Science 10 Project

Bring in 3 of the following items that you would normally throw away:

- 1 detergent bottle
- 1 milk jug
- 1 plastic ring from 6 pack of plastic bottles or cans
- 2 aluminum cans
- 2 plastic bottles
- 1 cardboard box
- 2 newspapers
- 1 egg carton
- 2 styrofoam tray (from meat or produce)
- 3 plastic shopping bags

Trash Bash

For this project, you will have one partner. Using **all** the items that you and your partner have brought in, you will construct one or more useful items. You must use a minimum 75% each individual item in your construction. You may use adhesives of any sort, but you may not melt down any items. You will have 20 minutes today to brainstorm ideas and tonight to think about your project. Tomorrow you will be given the entire block to work on your construction. Then you will have the remainder of the week to finish you project outside of class. I will be available before and after school for you to work on your project, or you may take it home. Extra credit points may be earned for creativity.

As you create your useful items, think about why it is beneficial to use items more than once. You need to write a one-page reflection paper describing why it is important, what types of things you use over, how you use them, and how reusing things effects the environment. You will also be presenting your item to the class. You will tell us what you used, what you made and how it is useful. Demonstrations are optional, but encouraged.

Rubric

__ Used all necessary items (18 pts)

__ Used appropriate adhesives (6 pts)

__ Extra items were recyclable (8 pts)

__ Item is useful (10 pts)

__ Presentation: What you used (2 pts)

__ Presentation: What you made (3pts)

__ Presentation: How it is useful (3 pts)

IX.

Are they Natural or Fake?

(Natural and Synthetic Polymers)

Objective: Observe the similarities between synthetic and natural polymers.

Materials:
Part 1
(per lab group)

- plastic spoon
- paper towels
- 1 graduated cylinder
- 1 50 mL beaker
- 10 mL of gelatin solution
- 10 mL of 4% polyvinyl alcohol solution
- 4 mL of 4% sodium borate solution
- food coloring
- ferric nitrate solution

Procedure:

1. Place 10 mL of polyvinyl alcohol in the 50 mL beaker and 2.5 mL of sodium borate in the graduated cylinder. List their properties in Data Table 1.
2. Add one drop of food coloring to the polyvinyl alcohol (the larger volume).
3. While stirring with a plastic spoon, add the contents of the graduated cylinder-the sodium borate-to the polyvinyl alcohol.
4. Observe what happens and record any changes on Data Table 2.
5. Remove the polymer from the cup to a paper towel. (Note: Avoid getting your polymer on the table, the floor, or your clothes)
6. Record what happens when you pull it slowly, pull it quickly, flatten it, and bounce it on Data Table 3.
7. Clean the spoon, beaker and graduated cylinder thoroughly.
8. Obtain 10 mL of gelatin solution from the front lab counter in the 50 mL beaker. List its properties in Data Table 1
9. Examine the ferric nitrate solution. List its properties in Data Table 1.
10. Stirring constantly, add 5 drops of ferric nitrate solution to the gelatin solution. Observe what happens and record any changes on Data Table 2.
11. Place your polymer on a paper towel.
12. Record what happens when you pull it slowly, pull it quickly, flatten it, and bounce it on Data Table 3.
13. Clean the spoon, beaker and graduated cylinder thoroughly.

Data Table 1: Comparing polymer properties

Properties of Reactants		Properties of Products
Polyvinyl Alcohol	Sodium borate	New polymer
Gelatin Solution	Ferric nitrate	New polymer

Data Table 2: Comparing formation of new polymers

	Temperature	Thickness	Other Observations
Polyvinyl alcohol and sodium borate			
Gelatin solution and ferric nitrate			

Data Table 3: Properties of new polymers

	Pull slowly	Pull quickly	Flatten	Bounce	Is it sticky?
Polyvinyl alcohol and sodium borate					
Gelatin solution and ferric nitrate					

Materials:	biodegradable packing peanuts
Part 2	1-400 mL beaker
(per lab	tap water
group)	hot plate
	disposable petri dish
	stirring rod

Procedure:

1. Add 20 packing peanuts to 50 mL of water
2. Place on hot plate.
3. Continue to stir until completely dissolved and absorbed into water.
   Note: add more water or packing peanuts as necessary.
4. When completely dissolved and absorbed pour into petri dish.
5. Label dish and let sit until tomorrow.

Questions:

1. What is the difference between a synthetic and a natural polymer?

2. What properties were similar between the natural and synthetic polymer?

3. Which properties were different between the natural synthetic polymer?

4. What properties do the melted packing peanuts have that are similar to the other polymers?

5. What is a benefit to biodegradable packing peanuts?

6. Can you think of any other products where biodegradable polymers would be beneficial? Give some examples.

X.

Altering the Course of Resource Use

Web Search

Use the following website: www.soton.ac.uk/~engenvir/index.html

For hydroelectricity, wind, tidal, geothermal, and biomass, answer these questions:

- What is the history of this type of energy?
- How do we get energy from this source?
- What is the potential for use?
- What are the risks? What are the benefits? What are disadvantages?
- What does the future look like for this type of energy?
- Two other facts about this type of energy

XI.

Why Recycle? Background Information

One of the basic laws of the universe is the law of the conservation of matter. Basically, the law says that matter cannot be created or destroyed, it can only change. The result of this law is that, aside from a few meteors that have survived the trip through the earth's atmosphere and some cosmic dust, for the foreseeable future, all of the material that we will ever have on Earth is already here. Also, except for a few very costly rockets and spacecraft, all of the matter of Earth will stay here. Our problem is how to wisely use the resources that we have. In some cases nonuse (preservation or saving for the future) is the best use at this time!

In our industrial society, we have been accustomed to using an object once, throwing it away, and buying or making another when we need it. We have become a "throw-away society". We have been able to do this because our environment has been rich in resources, both material and energy. In our country, we have been able to expand our resource base to include countries that are thousands of miles away by obtaining materials from them.

As we continue to use up our resources, it becomes more difficult and more costly to obtain new raw materials. As we use up the resources of other countries, and as they use their own resources, less of their resources are available to us. What we are allowed to by becomes more expensive.

Recycling is the process of recovering materials from a used object and using that material as raw material for making other objects. Glass from bottles can be crushed, melted, and made into new glass. Paper, oil, and rags can be recycled. Iron, copper, aluminum, and other metals can be recycled.

Aluminum is made from an ore called bauxite. Most of the bauxite or new aluminum used in the United States has been imported. Mining, refining, and shipping the bauxite or the aluminum all cause damage to the land, air pollution, water pollution, and use a lot of energy. By reusing aluminum we reduce all of these harmful effects.

How important is recycling aluminum?

- Making aluminum from recycled cans uses 90-95 percent less energy than making it from raw materials and reduces related air pollution by 95 percent.
- Our nation's consumers and industries throw away enough aluminum every three months to rebuild our entire commercial air fleet.
- Between 50 and 60 percent of the aluminum cans used in America are recycled. That means that about 40 to 50 percent are still thrown away.
- Recycling a 12-ounce aluminum can save the energy equivalent of 6 ounces of gasoline.
- Recycling reduces litter and slows the filling of landfills.

For all these reasons, recycling is a wise choice. Why, then, don't more people recycle? The major reason is convenience. While many communities have effective recycling programs, including buy-back programs and curbside recycling, many don't. Only when the citizens insist on effective programs will recycling be easily available to all. Also, it is important to purchase recycled products or the recycling cycle is not complete and does no good.

There are a number of ways to slow down this spiral of materials use. Recycling is one way. We can reduce our use of materials, purchase fewer unnecessary things, make less packaging, and do not use material wealth as a measure of our importance or happiness. We can decide not to buy every new product that is offered in the marketplace. We can refuse to buy things that are packaged in wasteful ways. For instance, buying larger containers and transferring to smaller ones can reduce the number of containers. Some call this "precycling".

We can also reuse many things that we now throw away. We can give toys, clothes, and other things that we no longer want to others who can still use them. We can reuse bags, jars, and other containers. We can use worn-out clothes for rags rather than using so many paper towels. Our potential for reusing things is limited only by our imagination.

Recycling is treating symptoms (litter, shortages of materials and energy) rather than treating the illness (wasteful habits, over consumption, and careless attitudes). Recycling is better than discarding. Better still, though is reusing containers or refusing to by them in the first place unless they are reusable.

Why Recycle?

The class will be divided into two teams. Each team will receive 20 rocks. These represent bauxite ore, from which aluminum is made. Once you have "spent" a piece of ore, you cannot recover it. One piece of ore is "worth" one aluminum can.

Each round represents a certain amount of time, for our purposes, we will say one year. Before playing the game, predict how many rounds it will take until both teams have run out of ore. Record your prediction.

A: _____ B:_____

Each team should have a data recorder.

Team:_____ **Team:**_____

round	bauxite spent	bauxite left		round	bauxite spent	bauxite left
1				1		
2				2		
3				3		
4				4		
5				5		
6				6		
7				7		
8				8		
9				9		
10				10		
11				11		
12				12		
13				13		
14				14		
15				15		
16				16		
17				17		
18				18		

Why Recycle?

1. Explain the effect of recycling on the length of time that a resource will last.

_____

_____

_____

2. Explain why the recycling team doesn't get as many cans back as it turns in for recycling. _____

_____

_____

3. What are some ways that recycling aluminum cans helps protect the environment?

_____

_____

_____

4. What can you do to support and promote recycling? _____

_____

5. Refusing to buy wasteful products saves energy and materials. What can you do to support the idea of refusing to buy wasteful products? _____

_____

_____

6. How many years did the bauxite last for "The Wasters"? _____

   How many years did it last for "The Recyclers"? _____

7. What other materials can be recycled and what kind of resources to they preserve?

_____

_____

_____

XII.
Sorry Rules

- Maximum of four players
- Player draw for first to go. Must draw from the top of a shuffled pile of cards. Player with lowest number goes first.
- Must draw all cards from the top of the pile. When there are no more cards, the last player to draw shuffles and replaces the cards.
- Players go in a clockwise manner
- A 1, 2, or SORRY gets you out of home. A 1 or a 2 to get out of home only moves you to the first spot OR 1 or 2 spaces forward.
- A 4 moves you back 4 spaces.
- A 7 moves you forward 7 spaces or you may split the move between two pawns.
- A 10 moves forward 10 spaces or back 1 space
- An 11 moves forward 11 spaces or you can switch with any other player's pawn on the board.
- A 12 move you forward 12 spaces.
- SORRY moves you from home to any other player's spot on the board.
- There are sliding areas on the board. You may only slide at the end of your turn if you land exactly on the triangle space. You may not slide on your own color.
- In order to get a pawn into Home, you must land exactly in home.
- If you cannot move a pawn, you forfeit your turn.
- The first player with all four pawns in Home wins.

Sorry Cards

4

Move back
4 spaces

Lose $4 billion in crop yields due to acid rain

4

4

Move back
4 spaces

Forests lose 50% of trees

4

1

Move forward 1

space or move 1
pawn from home

Walk to school

1

1

Move forward 1

space or move 1
pawn from home

Walk to work

1

7

Move 7 spaces
forward or split
it 2 ways

Have your car checked for emissions

7

7

Move 7 spaces
forward or split
it 2 ways

Have your car checked for emissions

7

8

Move forward
8 spaces
Carpool

8

8

Move forward
8 spaces
Get a CO detector

8

12

Move forward
12 spaces
Choose not to smoke

12

12

Move forward
12 spaces
Heat your home with solar energy

12

SORRY

Move a pawn from
home to someone
else's spot
Parasitic infestation catastrophic damage due to global warming

SORRY

SORRY

Move a pawn from
home to someone
else's spot
Lose 10% of crop yield due to acid rain

SORRY

2

Move forward 2
space or move 1
pawn from home
Ride your bike to school

2

2

Move forward 2
space or move 1
pawn from home
Ride your bike to work

2

11

Move forward 11
spaces or switch
with another pawn
Plant trees in your yard

11

11

Move forward 11
spaces or switch
with another pawn
Buy recycled plastic

11

10

Move forward
10 spaces or move back
one space
Buy a fuel efficient car

10

10

Move forward
10 spaces or move back
one space
Buy a fuel efficient car

10

1

Move forward 1 space or move 1 pawn from home

Walk to the store

1

1

Move forward 1 space or move 1 pawn from home

Walk to a friend's

1

2

Move forward 2 space or move 1 pawn from home

Ride your bike to the library

2

2

Move forward 2 space or move 1 pawn from home

Ride your bike to the store

2

4

Move back 4 spaces

Plants sensitive to acid rain die

4

4

Move back 4 spaces

Ozone level 0.2 ppm, above EPA standards

4

8

Move forward
8 spaces
Carpool

8

8

Move forward
8 spaces
Get a CO detector

8

10

Move forward 10
spaces or move
back 1 space
Buy a fuel
efficient car

10

7

Move forward 7
spaces or split
between 2 pawns
Have car
checked for emissions

7

SORRY

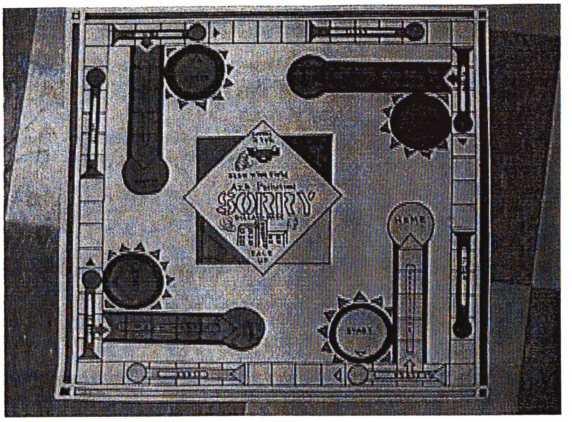
Move a pawn from
home to someone
else's spot
pH range for hatching eggs of water organisms are affected by acid rain

SORRY

SORRY

Move a pawn from
home to someone
else's spot
Marble statues and structures are destroyed by acid rain

SORRY



Example of Sorry Board

XIII.
Economic and Environmental Impacts

1. Name three ways that air pollution can be reduced.

2. Explain the reasoning for the 10 card. Why does buying a fuel-efficient car let you move forward 10 spaces or back 1 space?

3. Name three things that are caused by air pollution.

4. What kinds of things help you to move around the board?

5. What are 5 things that you learned from this game?

XIV.

What's Happening?: Background Information

Taken from: Michael Roa; Environmental Science Kit

The 1970s were called the "Environmental Decade". Many people were very concerned about environmental issues ranging from air pollution to overpopulation. The concern of the people resulted in legislation intended to address the multitude of environmental problems facing us. Some of the legislation included:

- The National Environmental Policy Act
- The Clean Air Act
- The Endangered Species Act
- The Safe Drinking and Water Act
- The Toxic Substances Control Act

States established various environmental agencies and offices. The federal government established the Environmental Protection Agency and Department of Energy. The Atomic Energy Commission was organized into the Nuclear Regulation Commission and the Energy Research and Development Administration within the Department of Energy.

In the 1980s, many people, both in and out of government, turned their attention away from environmental issues. Some thought that the measures taken in the 1970s had taken care of the problems. Some became involved in other issues. Others became frustrated because the solutions were not simple or the results immediate. Still others became disenchanted when they found that some measures taken to protect the environment resulted in problems of their own, such as increased cost, less convenience, and even the loss of some jobs.

Now we find that the environmental problems of the 1920s are still unsolved. In fact, many problems, such as overpopulation, are even greater than before. As we have learned, there are few easy solutions to problems. Every issue has more than one side. We cannot, however, ignore the problems or leave them to the "experts". It is imperative that everyone of us learns about what is happening in our environment now. Why? Because we are directly affected by our environment. The air we breathe, the water we drink, the food we eat, and the energy we use are all affected by environmental influences. We, in turn, affect our environment, sometimes in harmful ways and sometimes in helpful ways. Only by becoming informed of environmental issues can we make wise choices in our daily lives.

By becoming more informed, most of us also become more concerned about environmental issues. When we become more concerned, many of us want to become involved in working toward improving our environment. As we work toward a better environment, we become even more informed. Thus, learning about environmental issues gives us the exciting opportunity and ability to work toward solutions.

What's Happening?: Questions

1. Are general news publications unbiased in their reporting? Should they be? Why or why not? _____

_____

_____

2. Are environmental organizational publications unbiased in their reporting? Should they be? Why or why not? _____

_____

_____

3. Did the articles about environmental problems suggest solutions? Should they? Why or why not? _____

_____

_____

4. Even "experts" frequently disagree. If opposite sides of an environmental issue both seem to have good arguments and believable "experts" supporting them, how would you decide on which side to believe?

_____

_____

_____

5. Do the general new publications seem to go into depth, or do they just do superficial coverage of environmental issues? If they only do superficial coverage, what can you do to find out more? _____

_____

_____

6. What is your response to the attitude "What I don't know won't hurt me" when it comes to environmental issues? _____

_____

_____

_____

_____

_____

7. What does "Think globally, act locally" mean to you? _____

_____

_____

What's Happening?: Article Cover Sheet

Name_____ **Date**_____

article title:_____ topic_____
Attach this cover sheet to a copy of the article.

Publication_____ _____ _____
name date page

Source: ☐ home ☐ school library ☐ other _____

Summary of the article: Minimum of one page

My opinions and reaction to the article:

_____

_____

_____

_____

_____

_____

How this affects me; what I can do:

_____

_____

_____

_____

_____

APPENDIX B

Name_____
Date_____

Pretest

__D__ 1. We live in a _____ ecosystem.
a. coniferous forest
b. desert
c. savannah
d. deciduous forest

__C__ 2. Which is not a renewable resource?
a. solar
b. wind
c. coal
d. water

__B__ 3. Type one recyclable plastic is from
a. detergent bottles
b. soda bottles
c. tupperware
d. glue bottles

__D__ 4. Construction destroys the natural _____ of an area.
a. water flow
b. atmosphere
c. land forms
d. all of these

__A__ 5. Runoff from agricultural land increases the amount of _____ in a stream.
a. nitrogen
b. sulfur
c. sand
d. oxygen

6. Why is it important for contractors to keep in mind the natural flow of water when developing a building site? Name some consequences to altering water flow. (10 pts)

2 pts--drought and flood
2 pts--habitats for organisms
3 pts--mudslides, sinkholes, land subsides
1 pt--increase water pollution
2 pts--building drainage ditches

7. Name the 5 different types of air pollutants and give an example of a source of each. (10 pts)

deleted question

8. Given the table of the six types of recyclable plastics, put the symbol in the appropriate box, name one product it comes from, and one product it is made into. (24 pts)

Code	Resin Name	Uses	Recycled Products
	Polypropylene (PP)		Manhole steps, paint buckets, videocassette storage cases, fast food trays, lawn mower wheels., ice scrapers
	High Density Polyethylene (HDPE)		Flower pots, drain pipes, signs, stadium seats, trash cans, recycling bins, traffic barrier cones, golf bag liners
	Polyethylene Terephthalate (PET)		Soap bottles, strapping, fiberfill for winter coats, surfboards, soft drink bottles, fuzz on tennis balls, egg cartons, carpets, skis, boats, film
	Polyvinyl Chloride (PVC)		Floor mats, pipes, hoses, mud flaps
	Polystyrene (PS)		License plate holders, golf course and septic tank drainage systems, desktop accessories, hanging file, videocassette
	Low Density Polyethylene (LDPE)		Garbage bag liners, grocery bags, multipurpose bags

9. Discuss the "life cycle" of plastic. Trace the path of a piece of plastic from its origin to termination. Explain the difference at its time of disposal, recording the path it would take to the landfill **and** to the recycling plant. (15 pts)

Name 1 pt
Petroleum 2 pts
Type of plastic 1 pt
Type of material used in 2 pts
Disposal in landfill as nonbiodegradable 2 pts
What happens to it 2 pts
What happens at the recycling center 2 pts
Products recycled into 2 pts
Symbol of plastic 1 pt

10. What is the effect of fertilizer on a stream ecosystem? Give three reasons for the effect. (5 pts)
Lower biodiverisity 1 pt
Increase nitrogen, phosphorus, and potassium, 1 pt
Leads to increased growth of plants and animals 1 pt
Organisms die and decomposers use up available oxygen 1 pt
Causes fish kills 1 pt

11. Name three environmental and three economic damages due to air pollution. (6 pts)

Answers will vary

12. Define the following: (5 pts)

- land subsides **movement of land due to water loss**
- acid rain **precipitation with a pH of less than 5.4**
- sinkholes **areas where ground water has been depleted and the land sinks**
- sustainability **ability to maintain a stable resource use**
- nonrenewable resources **substances that cannot be regenerated in this lifetime**

13. Pick one of the following alternative energy sources: wind, water, geothermal, tidal, or biomass. Explain what it is, how energy is obtained from the source, how it is used, and the risk/benefit analysis of using that type of energy. (5 pts)

Answers will vary

14. Explain the pros and cons of creating biodegradable plastics. (4 pts)

Pro:	**Cons:**
does not last forever	**expensive to produce**
can grow more plant material	**may biodegrade too quickly**
doesn't use nonrenewable resources	**require more land for farming**
less air pollution	**not readily accepted by public**

15. Give 4 examples of ways that individuals and society can reduce pollution. (4 pts)

Answers will vary

16. What is biodiversity? Why is it important? What are 2 things contributing to its loss? (5 pts)

2pts--Definition
1 pt--Importance
2 pts--Contributions to its loss

Interview Questions

1. What are some consequences to altering the landscape of an area and changing its water flow.

2. How are recyclable plastics separated?

3. Name an alternative source of energy and tell me how we use it.

4. What is biodiversity?

5. a. How can society reduce pollution?

b. How can you reduce pollution?

6. Name some damages due to air pollution.

7. What was your favorite activity in the pollution unit? Why?

8. Name five things that you learned during the unit from most important to least important.

APPENDIX C

Trash Bash Reflection Paper

Student A (sic)

I believe it is beneficial to use item that you can over, but recyclable items I believe should be recycled. My family recycles most of our products, but there is one I wish our community did, which they don't, is paper. I go through so much of it doing homework assignments even though we use the scraps for notes I see it as very wasteful.

In my family we reuse cool whip containers for leftover foods and we just refill our hand soap dispensers. We also use the reusable bowl covers instead of saran wrap. All those cut down on the waste we create. Besides the containers we recycle we al so have a compost for our biodegradable materials.

Our community really needs to get active in recycling because is the best thing for the planet. By looking at all the statistics I have watched my self and what I throw away. The recycling of products makes the environment so much nicer and cleaner for us in the present and for future generations to come. Recycling is becoming more and more necessary because of the increase in products made and how wasteful and messy we have become. It really surprised me about how much just my family throws away and how just recycling an aluminum can saves so many resources.

I can't believe how simple recycling is and yet so many people just take the lazy way out.

Trash Bash Reflection Paper

Student B (sic)

I think one of the main reasons why it's important to recycle or reuse things is because we only have so much land in this earth. The land we use for landfills can't be used again for any type of building, so we'll have to destroy other land, animal's habitats, in order to house our ever-growing population. Another good reason we should recycle or reuse products is because it takes a lot of energy to make new products. It takes less energy to create products out of recycled material, and no energy at all if you reuse a product.

We also do a lot of reusing items at my house. For example, did you know that ketchup from Gordon Food Service, in Grand Rapids sells really cheap when you buy it in bulk? One problem, it comes in a huge can. It's kinda two for one, you get cheaper and you don't throw away another plastic container with each new bottle of ketchup you buy. Also, you know what makes a great substitute for all those cute little Tupperware containers everyone just has to have? Margarine tubs! They come in all different sizes, and they really work pretty well to keep you leftovers in. Besides, at the same time, you're saving all those margarine tubs from going to the landfill.

Trash Bash Reflection Paper

Student C (sic)

Recycling is very important. It helps to save the planet. when you recycle you are giving resources back. This is a very important issue because the nonrenewable resources we take for granted and use every day, will not last much longer. If people do not reuse or recycle we will have to use other resources that are possible harder to get and/or more expensive. Also, our planet will just be one giant landfill, which can have very harmful effects.

I do have to admit that I do not reuse or recycle as much as I should or could. We recycle aluminum cans and plastic bottles, but that's about it. I do sometimes try to reuse things, though, as much as I can. I usually try to make something crafty out of something that would get thrown away. I make decorations for my room a lot.

Reusing things has a big impact on the environment. It is very good for it. Just throwing things away lead to giant landfills and pollution. Landfills and pollution lead to destroyed land and habitats, health problems, and more. It is a big chain so if one small thing is affected, somewhere down the line, so is everything else.

Trash Bash Reflection Paper

Student D (sic)

Reusing trash is a vital aspect of keeping things clean. No everybody recycles, but the people who do recycle or reuse stuff make a lot of difference. Reusing things can be fun, and it can also save you money, time, and saves natural materials.

There are many things you can reuse. My family reuses milk jugs, egg cartons, glass jars, canning jars, newspapers, and fabrics. We use milk jugs for watering plants and insulating plants outside during spring to protect them from frost. We reuse egg cartons by keeping our own chicken's eggs in them. We use the glass jars for canning and storage of foods, and we reuse canning jars. We use newspapers for mulch, and we use fabric to make new things.

Reusing things cuts down on the use of natural resources, and it also cuts down on pollution and the disturbances of the natural environment.

For our projects, we made a terrareum out of a milk jug, a plant out of a milk jug, a paint holder out of a detergent bottle and two pop cans, and a plant starter out of half an egg carton.

Trash Bash Reflection Paper

Student E (sic)

There are many reasons why using items more than once is beneficial. The most important reason is because, even though we think we do, we don't have an unlimited supply of everything. We are going to eventually run out. What will we do then?

We can pretty much reuse anything (Besides our leftover food and such). For example take an aluminum can. It can be recycled to make more cans. We can do more than recycle. We can take an old shoebox and make a planter. You can make lots of things out of your so-called "garbage" if you just put your mind to it.

By reusing our "garbage" we can reduce the amount (of) stuff piling up in our landfills. This reduces the amount of carbon dioxides and other harmful gasses released from the garbage.

Trash Bash Reflection Paper

Student F (sic)

The older I get the more I find recycling emphasized on a daily basis. in a world where non-renewable resources are being used constantly and new renewable energy sources are being researched and searched for desperately, recycling remains key. The fact of the matter is that by simply recycling you save countless amounts of energy that could be used toward something else. Factories wouldn't have to reproduce the product and dig it up, adding more pollution to our world's air.

Some of the main things that can be recycled are papers, plastic and aluminum bottles, and glass. These are things that people throw away everyday, not even taking a second thought at how much would be saved if they just recycled. Plastics can be recycled to make many useful tools, tires, orange highway cones, plastic cutlery and dishes, and so much more.

By reusing things, the environment is saved form being attacked by the producers, trying to gain access to more substances to make the product. The more natural resources that are touched to make a product, the more the ecosystem is affected. By hauling in the tools to find the material local animals are driven form their homes and forced to retreat to another nearby ecosystem. The end result is that the ecosystem lacks a key link for its survival.

in conclusion, recycling is necessary to save the world from dying of pollution and to save our ozone layer which protects human beings and all life on earth.

Trash Bash Reflection Paper

Student G (sic)

Sunreflector- I made this because I thought it would work just as good as a real one, and all you need is a box lid and about three or four empty pop bottles. Pillow-There is a pillow made of a egg carton, and newspapers. It is a relaxing thing to keep your head comfy. Doll bed-We made this for little kids who like to play with dolls, it would save a lot money and all you need is a box, egg carton, and newspaper. Bug holder-we made this for plastic bags, but you put them in a old detergent container and they will smell nice. Bird feeder-Everyone has one. Why not make one for practically nothing!! All you need is a pop bottle and egg cartons. Mobile-for a baby's room, all you need is a milk carton, string, and can pieces.

Trash Bash Reflection Paper

Student H (sic)

In our project, we used plastic bags, paper bags, detergent bottles, pop bottles and a box. First we made shirts. The shirts were made from the plastic bags which all we did was cut the bottoms of the bags and decorated them. These shirts could be used when and if it was raining and you had a tank top on, you could put it over the tank top so it wouldn't get wet. Our next item that we made was a skirt (rather nice actually), out of a paper bag and a little bit of a plastic bag. You could use it for a sunny day over a bathing suit or anything. Then we made a sock and some shoes. The sock was waterproof and went quite far up your ankle so if you were in mud or a little creek then you wouldn't even get wet, then the shoes you could also use in mud Oh and we made earings (sic) out of the ring on a pop bottle. If these things weren't recycled, then many more animals would be dead, like fish suffercating (sic) in a plastic bag, but it is better to recycle than wast more things and pollute our water, air, ozone etc. even more than we have.

Trash Bash Reflection Paper

Student I (sic)

I had used 1 laundry detergent bottle, 6 plastic, 4 plastic pop bottle, 1 cereal box and 1 milk jug, a bank. We made a folder, bird house, flower pot, watering can, a bank. The folder can be used in many different ways. The bird house can be used by the birds so they can be protected by the weather. Flower pot can be used several times for many kinds of flowers. The watering can also be used several times for watering different things. The band can be used to put loose money in or just extra money.

We should recycle a lot of things. We actually need to recycle because we have a lot of trash in our world.

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WORKS CITED

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