Using Energy as a Unifying Concept in the Marshall Middle School Science Curriculum

by

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ABSTRACT

Energy is increasingly an important topic in the lives of people in the United States and around the world. In education, energy is most often taught as a single unit within physical science and is rarely mentioned in other disciplines. Research shows that environmental education works best when it is infused throughout the curriculum. Energy, as a unifying concept in science, and a major part of EE, should be infused throughout the curriculum as well.

We wanted to know if infusing an entire Science curriculum with energy as a unifying concept would increase students' knowledge of energy. We developed a 25-question test and gave it to 6th and 7th as a pre- and post-test first with our traditional non-energy infused curriculum. During this time, we researched energy activities, lessons and methods to infuse them into our curriculum.

The next year, we gave test again before and after different students had received the new energy-infused curriculum. We found that students receiving the energy-infused curriculum generally scored significantly higher (an average of 12% higher) on the post-test than those who received the traditional curriculum. Both 6th and 7th grade groups improved, though the 6th graders were slightly higher. We feel this supports the idea that using energy as a unifying concept throughout a Science curriculum is an effective way to have students learn and retain more knowledge about energy.

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Chapter 1

INTRODUCTION

Statement of the Problem

The purpose of this project was to design a middle school science curriculum using ENERGY as a unifying concept, and to evaluate its effectiveness in improving students' knowledge of energy.

Importance of the Project

It has been 25 years since the energy crisis of the early 1970s last put energy issues on the front page of magazines and newspapers. Yet, with recent electrical supply issues, unrest in the Middle East, and increases in the price of oil and related products, energy is once again becoming an important topic in the lives of people in the United States and around the world. Because of its importance, the acquisition of knowledge about energy through education also becomes more important. In this project, we propose that energy should take a more central role within science education by becoming a unifying concept throughout a specific curriculum.

Energy is one of the most important concepts in all of science, and it affects our lives in many ways. It can, however, be difficult to teach and to understand. As an example, several different science textbooks can provide one with several different definitions of energy. Indeed, some science textbooks decline to define energy at all. In the average science curriculum, energy is taught as a separate and distinct unit within the physics or physical science class. There is nothing wrong with this approach, however the concept of energy is so pervasive within all science disciplines, it is perhaps best learned in context - in its role within each of the individual science units.

Energy education is also growing in Wisconsin schools. Energy concepts are listed in the Wisconsin State Science Standards as well as in National Science and Environmental Education Standards. The Wisconsin K-12 Energy Education Program, also known as KEEP (1996), seeks to create more emphasis and awareness on the subject of energy in education. Koop (1999) states, "Building energy-literate students is imperative to solving the serious energy-related environmental, social, and political issues we face today and in the future."

In this project, our goal was to infuse the concept of energy into each of our existing middle school science units in a way that meets or exceeds accepted benchmarks and standards for science and environmental education. We also sought to analyze the effectiveness of our methods using a designed testing instrument to assess students' knowledge of energy.

The Subproblems

Subproblem 1: To review previous research that will help us to justify the infusion of energy education throughout the science curriculum.

Subproblem 2: To analyze our current middle school science curriculum regarding energy concepts and the Wisconsin State Standards for Science and Environmental Education, and to develop a plan for infusing appropriate lesson plans on energy into that curriculum.

Subproblem 3: To design an instrument that will effectively measure middle school students' knowledge of energy concepts.

Subproblem 4: To utilize the designed instrument to test a control group of middle school students' energy knowledge before and after a school year with the old science curriculum that is not energy-infused.

Subproblem 5: To implement the new infused energy curriculum

Subproblem 6: To implement the designed instrument to test an experimental group of middle school students' energy knowledge before and after a school year with the new, energy-infused science curriculum.

<u>Subproblem 7:</u> To analyze the results of study.

Hypothesis

Our hypothesis is that if students are instructed in science using a curriculum that is infused with energy lessons, they will attain higher scores on a test of energy knowledge as compared with students who are instructed with a science curriculum that is not energy-infused.

Limitations

The first limitation of this project was that only students attending Marshall Middle School were a part of the study.

The second limitation was that the energy-infused curriculum will only be implemented in the 6-8 grade science curriculum. Although cross-curricular infusion of environmental concepts and issues is one of our long-term goals, it was not a part of this project.

The third limitation was that, although the new curriculum will ultimately be developed for all three grades of the middle school (6th, 7th & 8th), the data we gathered to test the effectiveness of the new curriculum only covered the sixth and seventh grade levels.

The Definition of Terms

control group- The group of experimental subjects that is not subject to changes in the controlled variable.

energy-infused - Curriculum materials based on energy education that are arranged throughout the middle school science curriculum so that energy becomes an integral part of each separate unit.

experimental group- The group of experimental subjects that is subject to changes in the controlled variable.

infusion- The recommended practice of integrating environmental concepts and issues throughout the curriculum so that all learning takes place within the context of the environment (Hayden 1987).

instrument- A test designed to assess specific knowledge as well as attitudes about energy.

Marshall Middle School- Grades 6-8 of Marshall Public Schools, the public educational facility of Marshall, a small, semi-rural town of about 2,000 people in south-central Wisconsin, near the capitol city of Madison, in Dane County.

middle school- Sixth through eighth graders.

renewable energy- Energy sources that can replace themselves through natural processes within four generations.

standards- Guidelines for learning across the K-12 curriculum as published by the Wisconsin Department of Public Instruction.

unifying concept- A major concept with implications across many disciplines that can be used as a foundation for many areas of learning.

Assumptions

The first assumption was that our administration would approve the modifications in our science curriculum.

The second assumption was that we could obtain a testing instrument that could effectively assess student learning over the course of the year for both our old curriculum and the new energy infused one.

The third assumption was that there would be a high degree of similarity between our control and experimental groups of 6^{th} and 7^{th} grade students.

The fourth assumption was that most of the students' learning about energy would be the result of the science curriculum in school, not from outside sources.

The fifth assumption is that we would follow through in the long term, maintaining and improving the energy-based science curriculum, and continuing the experimental testing through at least two more years, even though the results would not be a part of this project.

Chapter 2

A REVIEW OF RELATED LITERATURE

Importance of Energy in the Curriculum

Energy is a topic that is of great importance to human society, yet people may not know much about it. Some of the concepts around energy can be difficult to teach and difficult to understand. For example, many science textbooks will admit that energy is important, but will have a hard time actually defining it, instead describing *what energy does*, or *how energy is used*. Some science textbooks do not define energy at all. Other sources say, "Energy is the ability to do work," but that is a pedestrian definition that does little to explain the vastness and importance of energy as a concept and as a natural phenomenon. In spite of these problems, there are few who would deny that energy is a key concept in science that reaches across all the science disciplines.

In the recent trend towards a standards-based educational system, educational experts at both the state and national levels have acknowledged the importance of Environmental Education in general and energy topics in particular. The *National Science Education Standards* published by the National Academy of Sciences (1995), infuse environmental concepts throughout the standards, while the Wisconsin Department of Public

Instruction (1998) has developed an entirely separate document entitled *Standards in Environmental Education*. These standards contain five major sections of which the largest is section B: Knowledge of Environmental Processes and Systems. In this section there are two main categories of standards. One category "Energy and Ecosystems" contains eleven specific standards relating to energy transfer and use in the environment.

The need for good standards-based learning in environmental topics has been established, and the place within these standards for energy topics is clear. Both national and state sources also place great importance on energy issues throughout the science curriculum. The National Academy of Sciences, for example, in their *National Science Education Standards* (1995), describe a list of "unifying concepts and processes," that establish connections between different science disciplines. These unifying concepts can be seen in Table 2.1:

Table 2.1: The Unifying Concepts and Processes of Science as described by the National Science Education Standards

1. Systems, order, and organization
2. Evidence, models, and explanation
3. Constancy, change, and measurement
4. Evolution and equilibrium
5. Form and function

While the concept of energy is not actually found in this table, the detailed *descriptions* of the unifying concepts are filled with references to energy.

SYSTEMS, ORDER AND ORGANIZATION
*"Thinking and analyzing in terms of systems will help students keep track of mass, **energy**, objects, organisms, and events referred to in the other content standards."*

CONSTANCY, CHANGE, AND MEASUREMENT:
*"Some properties of objects and processes are characterized by constancy, including the speed of light, the charge of an electron, and the total mass plus **energy** in the universe. "*

*"**Energy** can be transferred and matter can be changed. Nevertheless, when measured, the sum of **energy** and matter in systems, and by extension in the universe, remains the same. "*

EVOLUTION AND EQUILIBRIUM
*" Interacting units of matter tend toward equilibrium states in which the **energy** is distributed as randomly and uniformly as possible."*

The National Science Education Standards also put energy at the forefront of their content standards in physical science, as well as giving energy an important role in the teaching and learning of life science, earth and space science, technology and the social aspects of science. Standards relating to energy can be found throughout these different sections.

The Wisconsin Department of Public Instruction (DPI) has also created a document, *Wisconsin's Model Academic Standards for Science* (1998), in which energy concepts are also addressed. For example, standard A.8.8 says that students should be able to, " ...use the themes of evolution, equilibrium, and energy to predict future events or changes in the natural world." Another example is standard D.8.7, which says that students should,

"...use commonly accepted definitions of energy and the idea of energy conservation."

Wisconsin has been a leader in energy education. The Wisconsin K-12 Energy Education Program (KEEP 1996), which was developed specifically because energy should be infused into the curriculum, explains energy this way: "It is the agent of change for all living things and throughout the universe. Every interaction among living and nonliving things is accompanied by the transfer and conversion of energy. " Now there is an explanation of the concept that gets close to the incredible importance of energy education. The KEEP activities guide goes on to say, "Since energy plays an essential role in people's lives, the study of energy and energy issues should be emphasized in education." Energy is so essential, in fact, that it should be infused throughout the science curriculum, and even beyond, into the other disciplines as well.

Hanson (1993) evaluated the effects of a five-year energy-infused curriculum on the knowledge, attitudes, and behaviors of a large group of students who progressed from kindergarten to 6th grade during the course of the research. His results showed "...positive effects of the program over extended time in a variety of school contexts." The program, Energy Source, acknowledged the importance of energy topics in relation to science topics such as biology, physics, chemistry and earth science, as well as the broader school curriculum areas such as social studies, math, and language arts. It is clear from the research that the concept of energy can and should be infused as the central concept in all of science.

Infusing Environmental Topics in the Curriculum

There has been much research showing the effectiveness of infusing Environmental Education into the science curriculum as well as into other disciplines, but there has been little research into the idea of infusing single concepts such as energy into a curriculum. Research from Ramsey, et. al. 1992; Volk 1993; Hayden, 1987, shows that when environmental science and issues investigation is infused throughout the curriculum, increased understanding of the environmental concepts as well as the core knowledge in the discipline can be attained. Engelson and Yockers (1994) state, "... environmental education must be continuous, must pervade all subject areas at all grade levels, and must offer students experiences as concrete as possible..." One of the key problems with infusion, however, is that it requires a large commitment of time and a high level of dedicated cooperation among faculty members. Much of this can be overcome through frequent team-building practices as well as thoughtful in-service training. Ramsey, et. al. (1992) explains that "...environmental knowledge and skills can often be integrated into existing courses without interfering with the content and skills desired by involved faculty members." Two significant methods of infusion explained are 1) The Case Study Approach and 2) The

Issues-Investigation Approach. Both methods work well and are useful in different curricular contexts. Another strategy in infusing a curriculum is the "spiral approach" in which "...concepts, cognitive skills and attitudes may be spiraled vertically through the curriculum, increasing depth and complexity with successive exposures." (Volk, 1993)

Monroe (1986) has published a useful booklet for workshop facilitators to help teachers integrate environmental themes into their teaching. It includes justifications, tips on infusion, activities, and a list of resources for teachers and school administrators to help in content and process infusion. Ultimately, we will use general infusion methods but restrict them to the concept of energy in order to complete our project.

Infusing Energy Education in the Science Curriculum

Despite the amount of information on infusion in general, we found much less research that demonstrates an infused curriculum that uses the concept of energy as its unifying and central them and even less that tests the effectiveness of such a curriculum. The Energy Source program (Hanson, 1993) is a good model to use, although it is aimed at younger students that we will be teaching at the middle school level. Rendl (2000) tested the effectiveness of infusing KEEP activities into a month-long energy unit for seventh graders. That study, however, took place on a much smaller scale than our project will, and the techniques used are not always applicable to our work.

Stein (1998) states, "In order to become responsible, decision-making citizens, students need to become better informed on energy issues, including an understanding of the complexities involved." She goes on to state that, "Educational programs and materials are needed to equip students with the skills needed to understand the complex relationships between energy and economics, politics, and global relations." Her study, which looked at the effectiveness of the Wisconsin Energy Cycle Education Program, introduced energy as a focal point in a science unit.

Since energy is important for all facets of life on Earth, it can be used as a unifying concept throughout an entire science curriculum. When environmental topics like energy are infused into regular curriculum, students can become more knowledgeable regarding the content being taught as well as issues relating to those topics. Beginning with an increase in core content knowledge can lead to a change in students' attitudes and behaviors. These changes can help students become environmentally responsible citizens.

Chapter 3

PROJECT METHODOLOGY

Subproblem One

The first subproblem was to evaluate previous research to help justify using energy as a unifying concept in the Marshall Middle School science curriculum.

In the summer of 2001, a thorough search was begun of literature in environmental education and science textbooks for information to support the use of energy as a unifying concept in the science curriculum. We felt that if someone had set up a model for energy as a unifying concept, or even any general topic as a unifying concept, we would have a model to work from. We wanted to know if people had looked at energy as a unifying concept in science topics and for science courses that lasted a year, several years, or throughout an entire K-12 sequence of classes. We also were interested in how people who have infused these topics accomplished their goal.

Subproblem Two

The second subproblem was to analyze our current science curriculum regarding energy concepts and the Wisconsin State Standards for Science and Environmental Education, and to develop a plan for infusing appropriate lesson plans on energy into the science curriculum.

In summer of 2001, we evaluated the old (ca 1987) K-12 science curriculums to determine the degree of infusion and the status of energy concepts currently being taught in Marshall Middle School. We also updated the new science curriculum maps and checked them for the level of energy infusion.

During the 2001 – 2002 school year, we compared both curriculums to state standards on Science and Environmental Education. We determined where each of the specific energy concepts belongs in an infused science curriculum.

In the summer of 2002, we conducted a thorough search of recent literature in environmental education as well as science textbooks for information on methods of infusing environmental topics into the general science curriculum.

In August of 2002, we began to implement the new lessons into our curriculum. Throughout the course of the project, but especially during the summer and fall of 2002, we searched for and acquired educational resources on energy, especially activity guides, textbooks, websites, and specific lesson plans. We evaluated the lessons and activities to determine which ones would be the most effective for middle school students. Some lessons were used as they were, while others required us to adapt them for our own purposes. Some lessons we created on our own.

We relied heavily on the *KEEP Guide* (1996) for activities, lessons, and information. This comprehensive guide is geared towards teachers who want to infuse energy topics into their curriculum. It was up to us to create the connections with current content that make infusion such a valuable instructional method.

We also used several other activity guides to supplement the KEEP guide. One of these is called *Exploring Energy with Toys* (Taylor, 1998), and has a unique angle on teaching energy, as the title suggests. This book is one of a wonderful series of "Toys" books on science teaching. Many of the activities in these books are especially successful with middle school students because they are fun. From our experience, students having fun while learning are more likely to flow into "peak" experiences in which they will have long-term, deep understanding of the material or situation.

In their publication titled *Energy, Economics and the Environment* (1994), the Indiana State Department of Education has provided a fantastic resource filled with dozens of lesson plans and activities organized into four sections: (1) basic economic concepts; (2) trees and forests; (3) water resources; and (4) energy resources. This resource will prove to be especially valuable because of its emphasis on interdisciplinary activities, economics, and issues investigation.

Subproblem Three

The third subproblem was to design an instrument that will effectively measure students' knowledge of energy concepts.

One of the important first steps we took in our study was to design a testing instrument that would effectively and fairly assess students' knowledge of basic concepts regarding energy. This testing instrument needed to be completed and ready to use very early in our project, even before the curriculum work started, because we began our testing with a control group of students in the fall of 2001. Once the testing instrument was designed and used, of course, we realized it could not be changed, so the analysis of the instrument was crucial to our success.

Subproblem Four

The fourth subproblem was to utilize the designed instrument to test a control group of middle school students' energy knowledge before and after a school year with the old science curriculum (not energy-

infused).

The ultimate design of our study needed careful consideration. According to *Leedy's Practical Research* (1989), we may have employed a "true" experimental design if we divided a class of students in half, with half receiving energy infusion and the other half as a control receiving the normal curriculum. Both groups could be tested concurrently, and problems with prior knowledge could have been avoided. Because of timing and curricular constraints, we were obliged to create a quasi-experimental design in which our control groups were instructed without energy infusion and tested in the first year of the study. The experimental groups then received energy-infused instruction and were tested in the second year of the study. A flow chart of the experimental design can be found in Appendix A. The results could carry more meaning if we could establish a certain degree of similarity between our testing groups.

At the beginning of the 2001-2002 school year, the designed testing instrument was used as a pre-test in late September with the sixth grade class and seventh grade classes. The identical testing instrument was also utilized as a post-test with the same groups of students at the end of the school year as a measure of the increase in their knowledge of energy using a non-energy-infused curriculum. Since this group of students did not receive energy-infused instruction, they are considered to be the control group.

Subproblem Five

The fifth subproblem was to implement the new science curriculum, using energy as the unifying concept.

Using lesson plans and activities found in our research, we implemented the new energy-infused science curriculum. To do this, we took our original curriculum and added appropriate activities and subject matter to augment every unit. We then taught the same progression of topics, but discussions included relationships to energy, and new labs and activities were performed at appropriate times during the units.

Our main guide for the implementation process was the article by Bencze and Hodson (1999) that undertakes to show how a new curriculum (especially one with environmental themes being infused) can be effectively implemented with as little resistance as possible. Hungerford and Volk (1991) also offer several suggestions for successful implementation of new Environmental Education (EE) curricula.

Subproblem Six

The sixth subproblem was to use the designed instrument to test an experimental group of middle school students' energy knowledge before and after a school year with the new, energy-infused science

curriculum.

At the beginning of the 2002 – 2003 school year, we used the designed testing instrument as a pre-test with the incoming sixth grade class. Since this group of students was to receive energy-infused instruction, they were considered to be the experimental group.

At the end of the 2002 – 2003 school year, we utilized the identical testing instrument as a post-test with the same group of students at the end of the school year to measure the increase in their knowledge of energy using an energy-infused curriculum.

<u>Subproblem Seven</u>

The seventh subproblem was to analyze the results of study.

In May of 2003, we compiled the results from our study in order to analyze the significance and validity of the data. We compared the energy test scores from two different groups at the sixth grade level and two different groups at the seventh grade level. At each grade level, we scored a pre-test and a post-test on a control group that did not receive energy-infused instruction. At each grade level, we also gave a pre-test and a post-test on an experimental group that received instruction that was infused with energy concepts. We did not test or analyze students at the eighth grade level because the physical science curriculum at that grade level already concentrates heavily on energy, with many energy-related units and activities. The sixth grade curriculum is called General Science and surveys the major science disciplines, with a focus on earth science. The seventh grade curriculum is almost entirely life science. Infusing energy into these two curriculums was more of a challenge, but also offered the possibility of richer results.

In our testing, we attempted to control as many environmental and procedural variables as possible. We did not change the testing instrument at all from the very first day of the research until the end. The answer sheets were identical for every student. The time of year was very similar for each group: sometime during the first week of school for the pre-test and sometime during the last three weeks of school for the post-test. The location was the same for both groups. Identical testing instructions were given to each group, and each group was given unlimited time to finish the test. Nearly all students finished in about ten minutes.

In our data analysis, we discarded the scores of any student who did not take both the pre-test and post-test in any given year. Then we recorded both raw scores and percentages for all remaining test subjects. We calculated mean, median, range and average deviation for all test groups. One of the most important tests we did was to calculate the degree of randomness between our testing groups. The project results would carry much more significance if the control groups were statistically similar to the experimental groups. We also created various graphs showing the test scores of students who had the traditional curriculum compared with students who had the energy infused curriculum.

Chapter 4

PROJECT RESULTS

Subproblem One

The first subproblem was to evaluate previous research to help justify using energy as a central concept in the science curriculum.

On a very basic level, the main justification for using energy as a unifying concept in science comes from the daily news. Energy is so central to our lives and such a part of the daily information stream, it is difficult to deny its importance. The four major branches of science – earth science, life science, physics and chemistry – each rely on the concept of energy to make sense.

We found that science textbooks treat the subject of energy quite differently. Some define it specifically, others define it vaguely, and others decline to define energy at all. Most of the textbooks we looked at acknowledged the importance of energy as one of the most important topics in all of science. We found, however, that some life science and earth science textbooks at the middle school level barely mentioned energy at all. We concluded that these branches of science offer the richest possibilities for infusing energy into the curriculum.

The KEEP guide states, "[Energy] is the agent of change for all living things and throughout the universe. Every interaction among living and nonliving things is accompanied by the transfer and conversion of energy." (1996) This statement as well as the fact that KEEP was created to help infuse energy into the state standards reinforces our conclusion that energy should be infused throughout the science curriculum.

Subproblem Two

The second subproblem was to analyze our current science curriculum regarding energy concepts and the Wisconsin State Standards for Science and Environmental Education and to develop a plan for infusing appropriate lesson plans on energy into that curriculum.

Although a K-12 science curriculum written for Marshall Public Schools in 1990 was supposed to be infused with environmental topics and issues, it actually was not. The primary grades (K-5) contained isolated environmental units, but in the middle-school and high-school curriculums, only Life Science and Biology courses contain any environmental topics, and those are typically limited to units on ecology. This curriculum appears to have been implemented on a very limited basis or, in some grade-levels, may not have been implemented at all.

The updated middle-school science curriculum maps (Appendix B), which were completed in 2001 as part of a two-year district wide curriculum-mapping project, were not infused with environmental education topics. No special status was given to energy as a major unifying concept. Instead, energy was treated as a traditional single unit within the sixth grade general science curriculum and the physical science curriculum in the eighth grade. No mention at all was made of energy topics within the earth science curriculum (grade six) or the life science curriculum (grade seven). This process showed us that there is much work to do in terms of meeting the standards and infusing EE issues, and especially energy topics within our science curriculum.

We utilized a document produced by the Missouri State Department of Education (1999) which relates teaching goals to the standards, offering suggestions for actual placement of environmental topics within a curriculum, as well as connecting the standards to statewide assessments.

We conferred on several occasions to evaluate our existing curriculum and discuss where energy activities and information could be infused into our existing course of instruction. We found that currently there was no emphasis on energy in our curriculum: it was covered as a topic in the context of our ecology unit.

In studying the Wisconsin State Standards, we found that we could address energy in a variety of concepts while addressing several state standards. Energy is specifically addressed in EE standard B.8.1-11 Energy and Ecosystems, and Science standards A.8.8 and D.8.8-10. There also are several other standards in which energy is not specifically stated but is an integral part in the proper teaching of that subject.

Our work on infusing energy into our curriculum resulted in a plan that had several steps. First, we searched for energy activities and demonstrations for each unit that we were teaching using the internet as well as the resources listed in Chapter 2. Second, once we found the activities, we analyzed them for their applicability to the topic, how interesting and exciting the activity would be for the students, and how the activity might be assessed. (Appendix C) Third, we planned the best time to introduce the activities. Last, we actually performed the activity and assessed its usefulness in presenting the energy concepts. Specific activities were also correlated to Wisconsin State Science and EE Standards (Appendix D).

Subproblem Three

The third subproblem was to design an instrument that would effectively measure students' knowledge of energy concepts.

In summer of 2001, we evaluated several potential resources containing questions on energy knowledge and issues-related attitudes. We compiled the most effective questions from these resources into an easy-to-use test appropriate for middle school students. (Appendix E)

The resource we used to design our test was the Baseline Study from KEEP (1999), designed as "An Evaluation of Teacher Practices and Student and Parent Learning." Their baseline study is a comprehensive, recent, statewide look at energy teaching and learning throughout Wisconsin and includes several excellent chapters discussing the results of the study as well as copies of the test they used. We researched other potential sources for a testing instrument, but we settled on the KEEP Baseline Study as the best one (Hagler Bailly, 1999). We adapted their intermediate-level test for our own use by deleting certain questions, adding a couple and changing the wording on others.

From the Baseline Study, we used the *Energy Education Survey for Wisconsin Students*, the intermediate (4^{th} - 6^{th} grade) version, for our assessment instrument. We felt that this tool, even though it was designed for a slightly younger age group, contained the right type of questions to adequately assess the energy knowledge of our students. We only eliminated one question, number 23. We felt that this question did not reflect energy knowledge, and substituted a question of our own design on photosynthesis.

Subproblem Four

The fourth subproblem was to utilize the designed instrument to test a control group of middle-school students' energy knowledge before

and after a school year with the old science curriculum (not energy-infused).

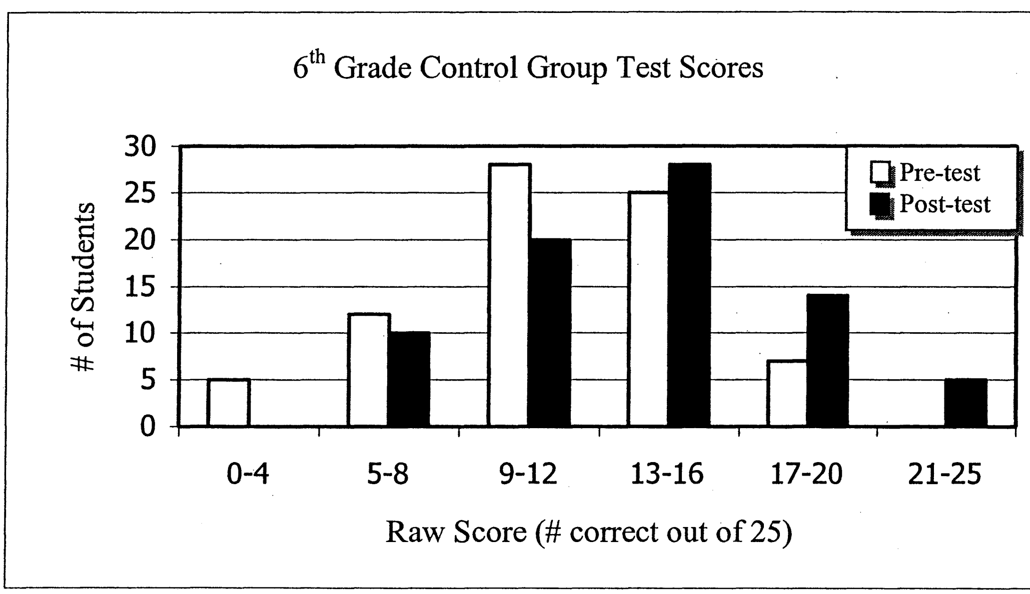
During the first week of the 2001-2002 school year, we pre-tested nearly the entire sixth grade at Marshall Middle School using our designed testing instrument. This was our first test; procedures we followed were used on all subsequent tests. After a year spent learning our standard science curriculum, the students were tested again using the identical instrument and procedures. The raw data is included in this project (Appendix F). We then eliminated students who missed either of the tests, which yielded the results seen in Table 4.1.

Table 4.1 – Results of sixth grade control group testing in 2001-2002 school year

6th Grade Control Group (not energy-infused)			
	Pre-test	Post-test	Change
Number of Students (n)	77	77	--
Mean (25 questions)	11.64	13.55	+ 1.91
Median	12	14	--
Minimum	2	5	-6
Maximum	20	23	13
Standard Deviation	4.10	4.31	3.40

In the sixth grade control group, with the normal science curriculum, students improved their knowledge of energy concepts on an average by nearly two points during the year. Fifteen of the 77 test subjects (19%) had test scores that declined in the post-test, which may indicate a certain degree of guesswork involved. The greatest decline in test scores was six points, while the greatest improvement was thirteen points. The standard deviation was over four points from the mean for both the pre-test and the post-test. A histogram of the average scores can be seen in Figure 4.1.

Figure 4.1 – Histogram chart of sixth grade control group testing (not energy-infused)



This chart provides a clear indication of both the normal "bell curve" of score distributions as well as the slight increase in scores between the pre-test in white and the post-test in black.

At the same time, using the same testing instrument, we also tested the seventh grade class for their knowledge of energy concepts. This control group received instruction following our normal, non energy-infused life-science curriculum. The results of these tests can be seen in Table 4.2.

Table 4.2 – Results of seventh grade control group testing in 2001-2002

7th Grade Control Group (not energy-infused)	Pre-test	Post-test	Change
Number of Students (n)	77	77	--
Mean (25 questions)	12.87	13.77	+ 0.90
Median	12.5	14	--
Minimum	8	2	-9
Maximum	24	23	+7
Standard Deviation	4.16	4.02	3.11

Surprisingly, the seventh grade control group had an identical number of test subjects as in the sixth grade group. The number of test subjects appears to be coincidental, and has no real bearing on the outcome of our study. This control group started the year by scoring more than a point higher on average than the sixth-graders did on the pre-test. Their average improvement on energy knowledge over the course of the year was only 0.9 points, less than half as much as the sixth-grade group. This result was somewhat expected because they did not receive energy-infused instruction and the normal curriculum is mainly life science, with very little emphasis on energy. Also, the seventh graders received an energy unit as part of the normal, non-energy infused curriculum in sixth grade. A large group, 24 of the 77 test subjects, had test scores that declined in the post-test (see raw data in Appendix F), once again indicating a significant possibility of guesswork involved. The greatest decline in test scores was nine points, while the greatest improvement was only seven points. Like the other control group, the standard deviation was just over four points from the mean for both the pre-test and the post-test.

Figure 4.2 – Histogram chart of seventh-grade control group testing (not energy-infused)

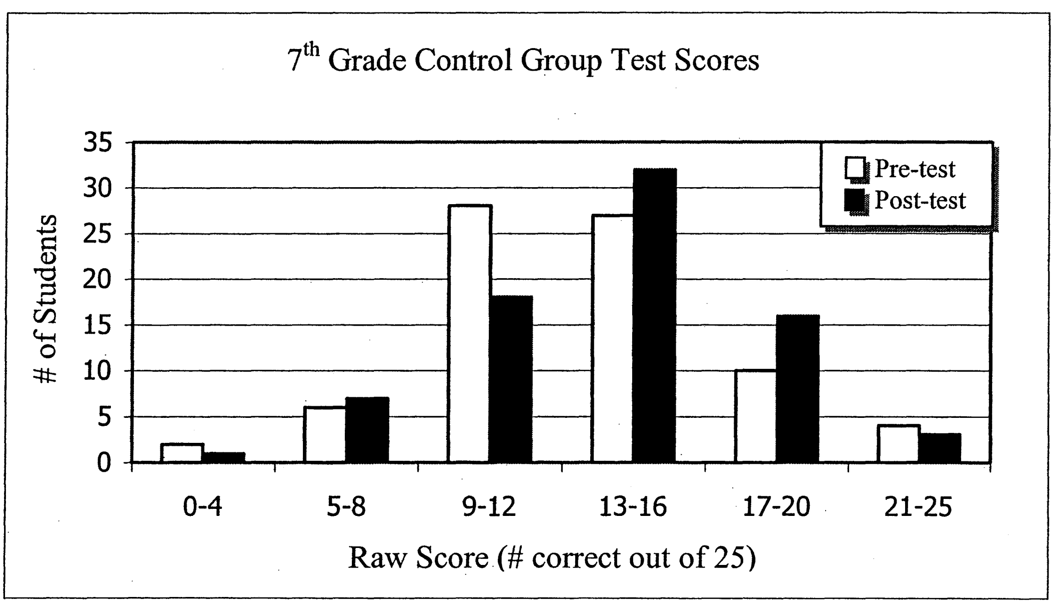


Figure 4.2 provides a clear indication of both the normal "bell curve" of score distributions as well as the mean increase in scores between the pre-

test in white and the post-test in black.

Subproblem Five

The fifth subproblem was to implement the new science curriculum using energy as the unifying concept.

Implementing energy activities was a time-intensive task, requiring research for activities, analysis of the activities, and assessment of those activities where actual performance could be measured. The activities and plans that were used for infusion can be found in Appendix C.

The seventh-grade curriculum, a life science curriculum, started with a six-week unit on insects. During this time, we included several new discussions, activities, and videos. We discussed honeybees and traced the energy flow starting at the sun and continued through the bees' production of honey and the use of it as an energy source. We dissected grasshoppers and traced the path of food from mouth to anus and discussed why grasshoppers need to eat. We also watched the video Winnie the Pooh and the Honey Tree and discussed energy flow from honey to other organisms and the resulting storage as fat if unused.

The next unit in the school year explored trees. Besides our usual topics, we also handed out apples and discussed why animals eat them, where the energy comes from, and where it goes. We also discussed wood as a fuel source and where the energy for that comes from.

Following trees, we conducted a unit on ecology. Energy is a central concept in any discussion on ecology, so it was natural to add extra activities. Energy was covered in discussions of food webs and energy flow. We also lead activities called "How Many Bears Can Live in This Forest" and "Eagle Population" which both modeled population changes in ecosystems as different parameters were changed. These included changing food conditions as well as surrounding habitat. Students then analyzed what happened to the populations as the amounts of energy changed.

After ecology, we moved on to cells. During this unit, we discussed the function of mitochondria as the powerhouse of the cell. We also modeled an activity where the cell made a protein (Kool-Aide) by going through the appropriate cell organelles. To accomplish this, though, each organelle required energy to perform its function. This showed students how even sub-cellular processes need energy to function.

The sixth grade science curriculum is a general science curriculum. In our first unit on natural resources, we talked about energy in the context of mining and recycling. We discussed the efficiency of recycling resources as opposed to mining them in their raw state.

We also developed a unit specifically on energy. This unit was focused on all aspects of energy and included many activities and discussions: energy as a natural resource, forms and types of energy, renewable energy resources, energy efficiency in the home and in your life, and the future of energy.

Next we discussed light energy. We talked about the physics behind light and reviewed solar energy and how it can be transformed into usable energy.

Most of the rest of the year was spent covering earth science topics. We included in our discussions activities related to geothermal energy. We modeled the layers of the earth and talked about characteristics of each. We tried to infuse energy into each topic of discussion even though we may not have had a specific activity to go along with it.

Throughout the year in both the sixth and seventh-grade curriculums, energy was infused in all topics. Some topics received more infusion than others based on the activities we found, information obtained, or time allowed for coverage. Energy has become a unifying concept for the sixth and seventh grade curriculum.

Subproblem Six

The sixth subproblem was to use the designed instrument to test an experimental group of middle-school students' energy knowledge before and after a school year with the new, energy-infused science curriculum.

During the first week of the 2002-2003 school year, we tested almost the entire sixth grade at Marshall Middle School using our designed testing instrument. Because these students received a newly designed, energy-infused science curriculum, they were considered the experimental group. We followed the same testing procedures as the previous year. After a year spent learning in the new science curriculum, the students were tested again using the identical instrument and procedures. We then eliminated students who missed either of the tests and came up with the following results seen in Table 4.3.

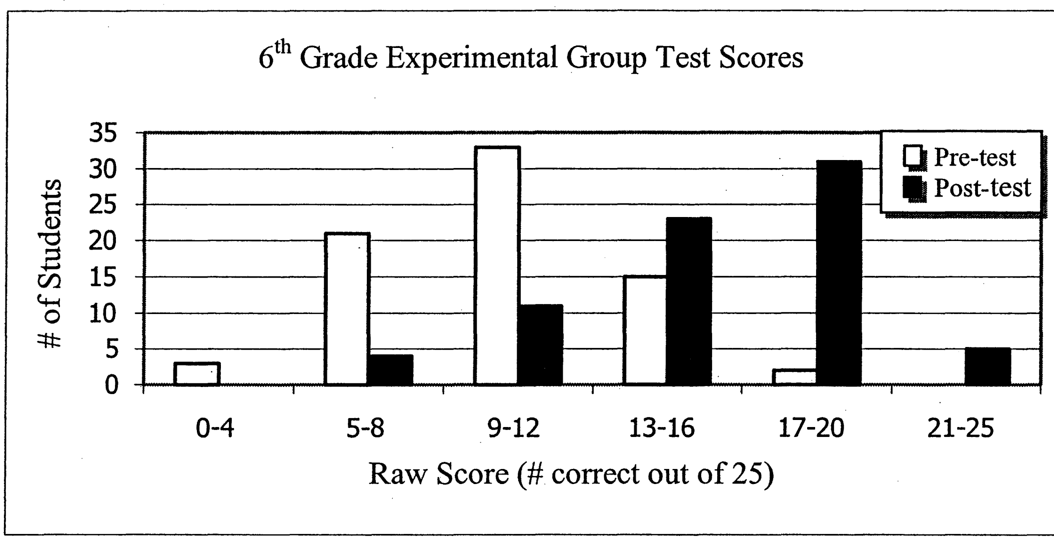
Table 4.3 – Results of sixth grade experimental group testing in 2002-2003 school year

6th Grade Experimental Group (energy-infused)	Pre-test	Post-test	Change
Number of students (n)	74	74	--
Mean (25 questions)	10.24	15.82	+5.58
Median	10	16	--
Minimum	3	7	-3
Maximum	20	25	+20
Standard Deviation	3.25	3.84	4.28

There were noticeable improvements in energy knowledge over the year with the sixth grade experimental group. Their average improvement, after using an energy-infused curriculum, was from 10.24 points on the pre-test to 15.82 points on the post-test, nearly six points better out of a possible

25! There were only four students whose scores declined on the post-test, and three of those only went down by one point.

Figure 4.3 – Histogram chart of sixth grade experimental group testing (energy-infused)



This chart clearly shows a significant increase in test scores achieved by this experimental group *after receiving energy-infused instruction*. The post-test bars are clearly higher on the right side of the histogram. The distribution of scores is shifted substantially towards higher scores on the right of the post-test.

The seventh grade also was tested during the 2002-2003 school year. We followed testing procedures similar to tests the previous year. Students were pre-tested in September, and after a year spent learning with the new, energy-infused science curriculum, the students were tested again using the identical instrument and procedures. The raw data is included in the Appendix F. We then eliminated students who missed either of the tests, and the results appear below in Table 4.4.

Table 4.4 – Results of seventh grade experimental group testing in 2002-2003 school

7th Grade Experimental Group (energy-infused)			
	Pre-test	Post-test	Change
Number of Students (n)	77	77	--
Mean (25 questions)	13.30	15.52	2.22
Median	13	16	--
Minimum	5	3	-7
Maximum	19	23	+8
Standard Deviation	3.74	4.37	2.85

The seventh grade experimental group also showed substantial improvement in energy knowledge after receiving energy-infused instruction. Their average improvement, after using an energy-infused curriculum, was from 13.30 points on the pre-test, to 15.52 points on the post-test, more than two points better out of a possible 25. There were ten students whose scores declined on the post-test, with one student declining by ten points. The largest improvement in scores was eight points.

Figure 4.4 – Histogram of seventh grade experimental group testing during 2002-2003 school

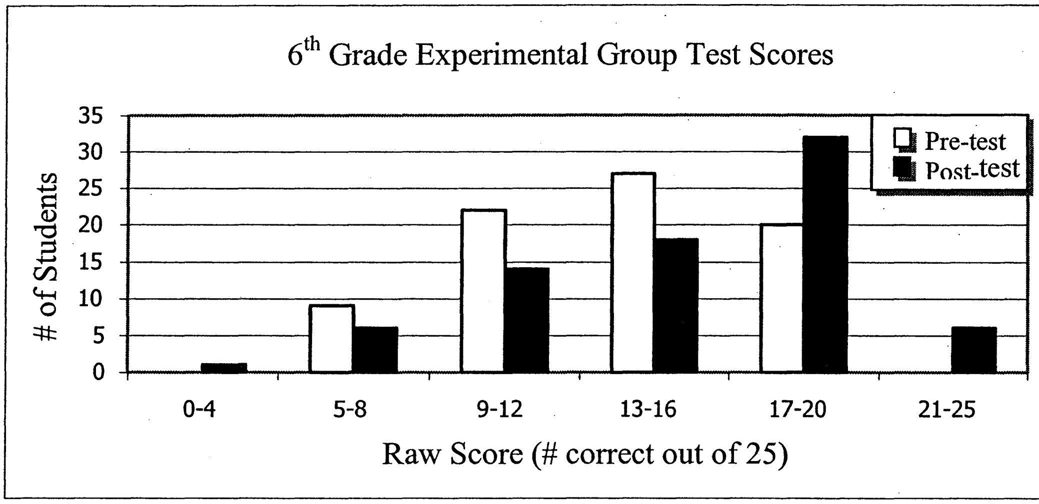


Figure 4.4 is interesting in that it shows a fairly normal distribution of scores for the pre-test, but the post-test scores are skewed to the right, with a very large number of students scoring in the 17-20 range out of 25 possible, indicating the possibility of significant improvements in energy knowledge after receiving energy-infused instruction during the 2002-2003 school year.

Subproblem Seven

The seventh subproblem was to analyze the results of study.

In order to help ascertain the significance of our results, we needed to determine that the control groups were similar to, yet independent from, the experimental groups. We did this using a t-test for independent samples on the results of their pre-test. The procedure we followed is included in this project (Appendix G). The sixth grade t-test results, t = 2.32, show that, according to their results on the pre-test, the control group and experimental groups are statistically similar to each other within a 95% certainty. For the seventh grade, the t-test result was t = 0.665, which also shows similarity of the two groups with a 95% probability.

To analyze the data further, we calculated the average increase in scores for both the control group and the experimental group at both grade levels. The results of this direct comparison at the sixth grade level are seen in Table 4.5 below.

Table 4.5 – Comparison of average change from pre-test to post test among sixth grade students

TESTING GROUP	CHANGE IN SCORE
Not Energy-Infused (6th grade Control Group, n=77)	+ 1.91
Energy Infused (6th grade Experimental Group, n=74)	+ 5.58

The experimental group, made up of students who received the new, energy-infused curriculum, increased their scores nearly three times more, on average, than the control group, made up of students who received the normal "general science" sixth grade curriculum.

Figure 4.5: Sixth Grade comparison average change in scores from pre-test to post-test

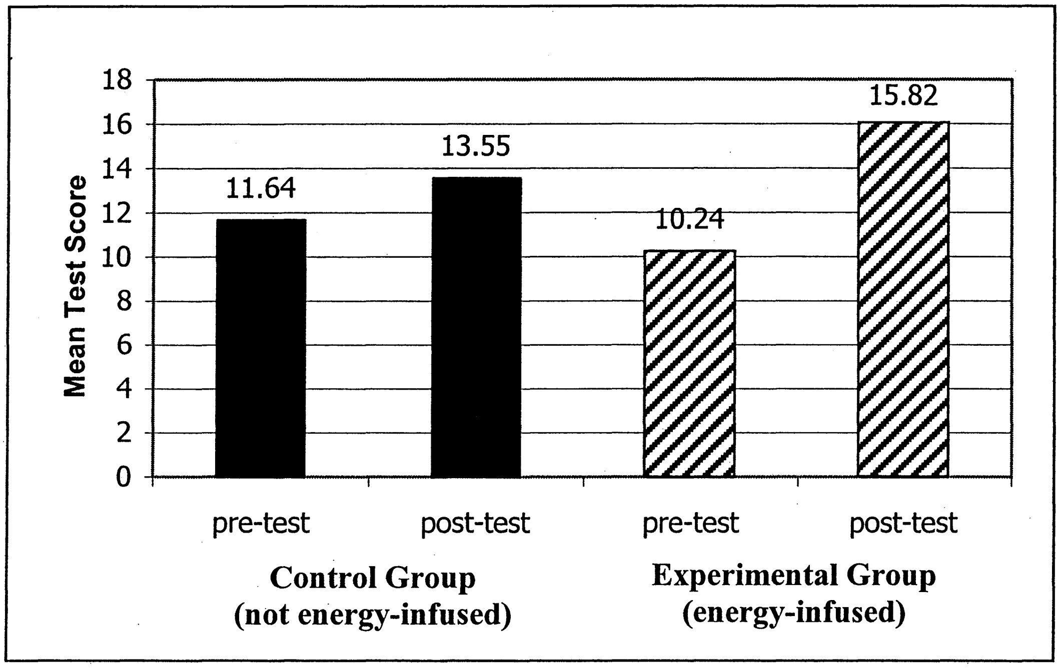


Figure 4.5 shows graphically the substantial difference in test scores between the control group and the experimental group of sixth grade students. Those students who received energy-infused instruction improved their scores much more than those who did not receive energy-infused instruction.

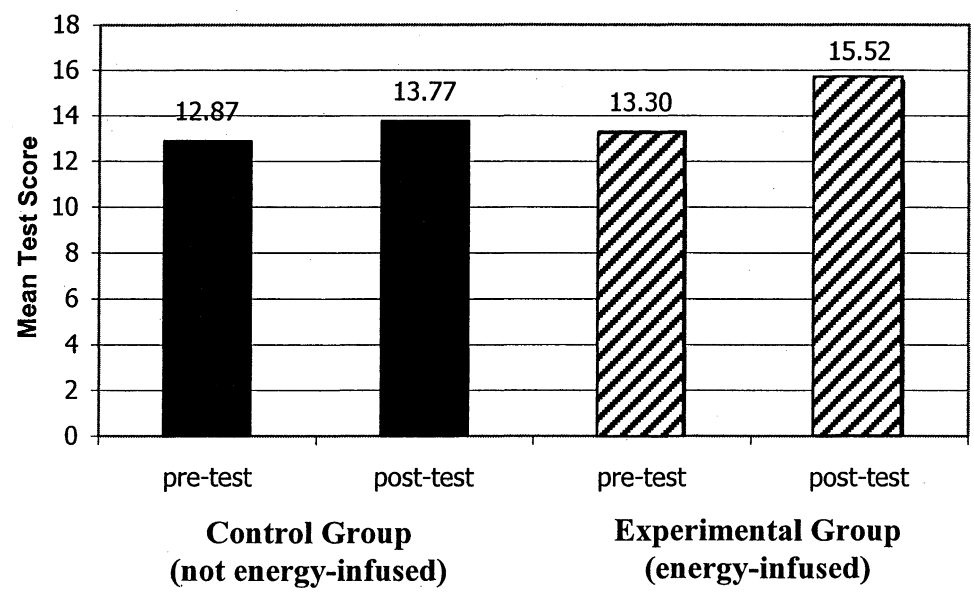
We also did a comparison of improvement in energy test scores on the two seventh grade groups, both control and experimental. See Table 4.6.

Table 4.6 – Comparison of average change from pre-test to post-test among seventh grade students

TESTING GROUP	CHANGE IN SCORE
Not Energy-Infused (7th grade control group, n=77)	+ 0.90
Energy-Infused (7th grade experimental group, n = 77)	+ 2.22

The improvement in energy knowledge is not as substantial with the seventh grade Life Science curriculum as it was in sixth grade General/Earth Science curriculum. The control group only improved 0.9 points out of 25. The experimental group, even with energy-infused instruction for an entire school year, only improved by an average of 2.2 points out of 25 possible. A histogram of the data is shown in Figure 4.6

Figure 4.6: Seventh Grade comparison of average change in scores from pre-test to post-test



The pre-test means for both groups are extremely close together, while on the post-test, the experimental group improved substantially more than the control group.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

Infusing Energy in a Curriculum

As mentioned in the literature review, studies have shown that an energy-infused curriculum can have a positive effect on students' attitudes, knowledge, and behaviors. (Hanson, 1993) Energy is a topic that is central to everyone's life, whether it is food as energy or where we get our electricity and heat. In order to establish long-term feasibility and sustainability, students need to be knowledgeable as well as have positive attitudes towards energy issues. The best way to develop knowledgeable students is to make energy a concept that they understand and can see how it fits into their lives as they fit into the ecosystem on Earth. If students can see how energy is a central part of all systems in which they interact, they will be able to make better decisions regarding management and sustainability.

Research from Ramsey, Hungerford, Volk 1992; Volk 1993; Hayden, 1987, as well as others, shows that when environmental science and issues investigation is infused throughout the curriculum, increased understanding of the environmental concepts, as well as the core knowledge in the discipline can be attained. The state standards from the Wisconsin Department of Public Instruction require the teaching of energy concepts as well. This shows the need for energy infusion in any science curriculum as well as other subject areas.

When more than one staff member is involved, an open-minded team approach is needed in order for complete and successful infusion. All team members need to be committed to the approach if students are to benefit. It is important to point out, though, that this does not mean all staff members need to throw out their existing curriculum and start over. Energy infusion is an effective method when it is simply added to existing curriculum materials. The KEEP guide is an excellent resource for finding energy activities that can be added into varied topics and subjects.

Another thing we found when analyzing our current sixth and seventh grade curriculum was that it was not infused with energy concepts at all. There were energy concepts in the existing plan, but no emphasis was made regarding the universality of energy in all things, nor was any effort made to discuss how energy was tied in to all things. We expanded the sixth-grade energy lesson as well as infused all topics with discussions and activities related to energy. This not only reinforced what students learned from previous lessons, but also tied things together where before there may not have been a connection between them. This cross-topic teaching would seem to be effective in long-term retention of energy topics.

Flaws in the Testing Instrument

Our testing instrument, adapted from the KEEP Baseline Study (Hagler Bailly 1999), was one that was put together and already screened for biases. It was normed and made to be an accurate assessment of energy knowledge. We decided to use this instrument since we did not have the necessary time to create a test. We also felt the fourth to sixth-grade level of the Hagler energy test would be most appropriate since it measured the energy concepts we wanted without using advanced vocabulary that might not have been covered. Even though the test was designed for a slightly younger age group (fourth through sixth-graders) than what we were testing (sixth through eighth-graders), when we reviewed the questions, we felt they were difficult enough to create an accurate measure of students' energy knowledge.

A potential drawback to our testing instrument was that it only contained 25 questions, and it did not address attitudes or behavior regarding energy. There also might be some question raised if energy knowledge can truly be assessed with a test of this sort.

Another major flaw is that the fifth choice for each question was "Don't Know," which, if used, always counted as an incorrect answer. If we were able to do the project over again, we would want to remove that choice from the list of possible answers on each question. It is certain that the use of that choice introduced error and irregularities into our data.

Additionally, our techniques for assessing the effectiveness of our project were limited. It is important to remember that alternative and authentic methods of assessment can be just as valid as formal tests and can enrich the data in powerful ways. Something as simple as a five-question survey on energy attitudes and opinions could easily have been included as part of our testing instrument, however, the quantification, scoring, and analysis of the results of the study would have been more difficult and time-consuming. Authentic assessment techniques such as portfolios, projects, performances, etc. may have played a valuable role in evaluating the effectiveness of our project. We were not prepared to deal with the complexities of such a study, and those things remain to be part of a future study.

Flaws in the Experimental Design

There were some obvious flaws in the design of our project. In an ideal world, we would have employed a "true" experimental design by dividing each grade level in two, randomly, with half of the students receiving energy infusion and the other half (the control) receiving the normal curriculum. With both groups being tested concurrently, problems with similarity between the groups and prior knowledge could have been avoided.

Because of timing and curricular constraints, we were obliged to create a quasi-experimental design, in which our control groups were instructed without energy infusion and tested in the first year of the study. The experimental groups then received energy-infused instruction and were tested in the second year of the study. One of the obvious problems with this design is that some of the students actually ended up taking the test four times! They took it twice as a sixth grade control group and a year later they took it twice as a seventh grade experimental group. Another major issue was that the testing and instructions were not carried out concurrently between the control and experimental groups, introducing unwanted variables in the students, the instructors and outside events. The results of this design, while still being meaningful, could not possibly convey any significance in the strict, statistical sense.

Designing and Implementing an Infused Curriculum

Implementation is a continuous process that needs to be done throughout the year if the entire curriculum is going to be infused. As new activities, lessons, and other relevant energy issues are found they need to be implemented in places that do not disrupt the flow of the material. They should naturally follow what was previously taught and lead into whatever comes next. This also can be a time consuming process, but for effective implementation, infusion cannot be done at the last minute. Discussions and references can be spontaneous, but actual activities need to be placed appropriately.

Again, if multiple staff is involved, care needs to be taken that activities need to be uniform between staff members. If a previous class runs over its time or is missed, the energy-related materials need to be covered if maximum benefit from the infusion is to take place. Preference differences in subject matter need to be discussed and agreed upon by staff if results are to be taken in a pre-test/post-test fashion.

In general, if we were to do this again, we would probably need to start the process much earlier, and put much more care and thought into the actual planning of the lessons and where they belong in the curriculum. Although we researched quite a lot, developed several new, effective lessons on energy, and infused them into the curriculum, we nonetheless felt that we could have done much better in this area.

Implications of the Data

It was interesting to see the change in knowledge from the beginning to the end of the year. We had a reasonably large number of test subjects in each group. Some students' scores went down in the post-test, probably due to a certain degree of random guessing, possibly because of flaws in the testing instrument that are mentioned in a previous section.

Intrarater differences (differences in the same test given at different times by the same instructor) and interrater differences (differences in the same test given by different instructors) also could be important variables that were not addressed. One instructor may not give tests in the same way as another. One testing environment may be different from another. In order to get accurate data, every effort must be taken to normalize as many variables as possible. For example, the seventh-grade class in our study had two different teachers. Half of the students had one teacher while the other half had the other. Differences in teaching style may have an effect on students' knowledge and retention versus the actual curriculum content. When multiple teachers are involved, the consistency of curriculum between teachers must also be maintained. The results would be most meaningful if all teachers involved taught exactly the same topics and lessons. Addressing these issues would help make a more homogenous population for testing.

Looking at the data that was collected and the limited amount of statistical analysis performed, it seems a reasonable conclusion to say that that there is a meaningful increase in energy knowledge when energy is infused into the curriculum. A study that could be done to really test the effectiveness of infusion would be to take the exact same set of energy lessons out of the infused curriculum, create a single, month-long unit from them, and test that curriculum directly against the infused curriculum with pre-test / post-test and a true, experimental design.

Conclusions

The main goal of this project was to see whether infusing a science curriculum with energy concepts had an effect on students' energy knowledge as measured by a pre-test / post-test type of experiment. Our findings appear to show that when energy is made the central or unifying theme of a science curriculum, students who are taught using that curriculum do acquire more knowledge of energy concepts than students who are taught without an emphasis on energy concepts throughout the discipline.

Although the design flaws mentioned earlier preclude the possibility of drawing major scientific conclusions from our data, we believe that the results of the project and the work we have done, warrant the retention of this infused curriculum within the sixth and seventh grades of the Marshall School District. With some work, the ideas could be extended into the eighth grade curriculum, which is taught by one of the authors (Collins). With positive feedback from students, parents, and other staff, it is possible that the infusion of energy concepts throughout the curriculum could be undertaken in other classes and grade levels as well. We see special possibilities for this at the elementary level. That, however, is a major project that would involve a serious commitment from the school district. Such a change implies major amounts of curriculum work from many different people on many levels.

Specific Conclusions & Recommendations

1. **Energy is important enough to justify being a unifying concept throughout a science curriculum.**

2. **As a unifying concept, energy ought to be infused throughout the curriculum.**

3. **Our study, though flawed, shows meaningful improvement in energy knowledge after energy-infused instruction.**

4. **"Don't Know" should have been removed as a choice of answers on our testing instrument.**

5. **For more significant data, a "true" experimental design should have been used, with all instruction and testing running concurrently.**

6. **The new, energy-infused curriculum should be maintained in the Marshall School District.**

In summation, we started this project with the idea that the subject of energy is of enough importance to the lives of people and the future well-being of our country and planet to warrant the establishment of energy as one of the unifying themes of science in school districts throughout Wisconsin and elsewhere. At the end of the project we still maintain that belief.

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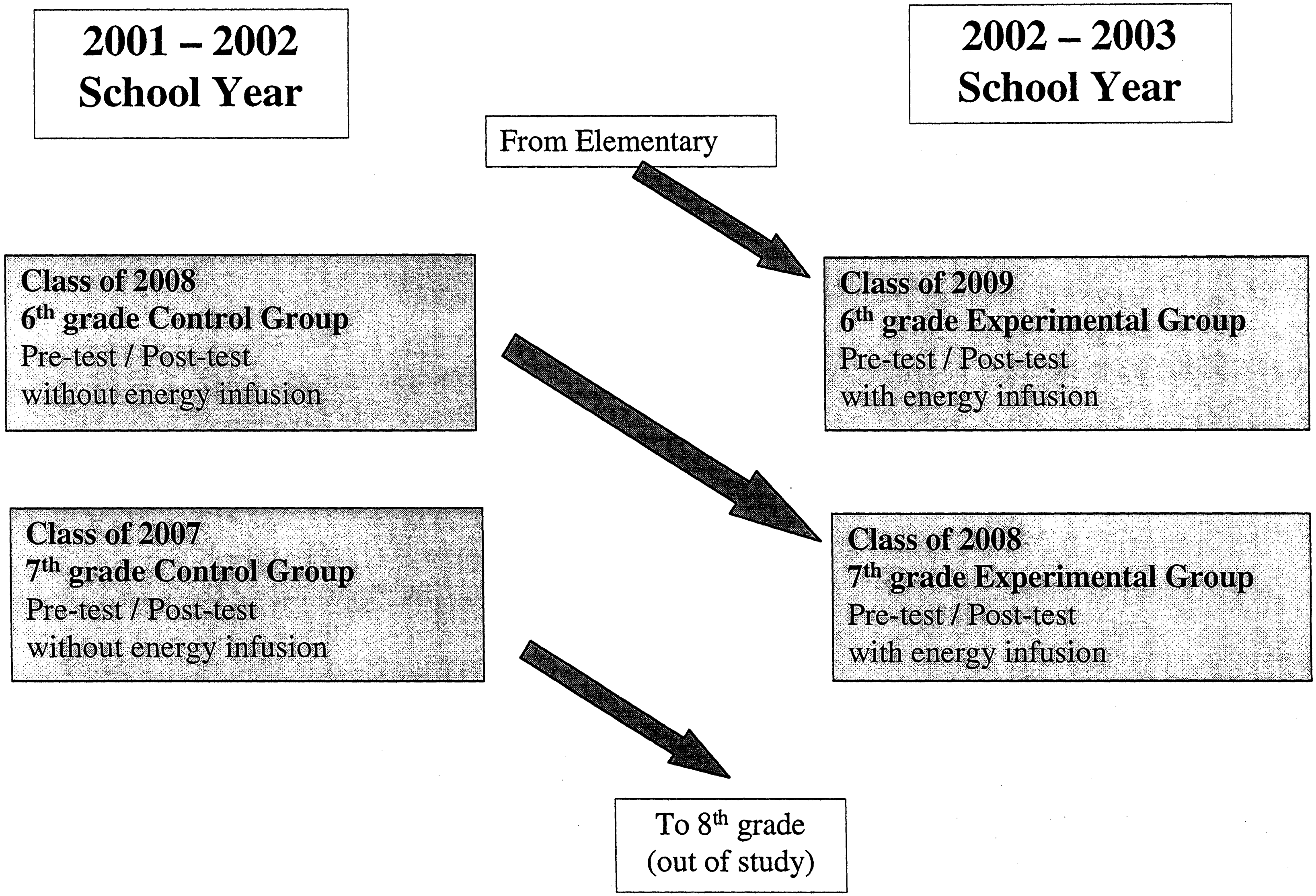
Appendix A

Flow Chart of Experimental Design

Methodology - Experimental Design



Appendix B

Curriculum Maps for Science
Marshall Middle School

MARSHALL PUBLIC SCHOOLS
CURRICULUM MAP TEMPLATE

Subject Level: GENERAL SCIENCE

Grade Level: 6TH

MONTH	CONTENT	SKILLS	ASSESSMENTS	STANDARDS
September	ENVIRONMENT Natural Resources Resource Pollution Resource Conservation	• Observing • Measuring • Controlling variables • Collecting data • Inferring	• Teacher observation • Class discussion • Written work • Labs • Quizzes and tests • Daily journals	**Science**: A.8.6, E.8.6, A.8.8, F.8.9, B.8.1, F.8.10, B.8.4, G.8.1, B.8.5, G.8.3, B.8.6, H.8.1, C.8.2, C.8.6, C.8.8 **EE**: A.8.1, B.8.3, B.8.5, B.8.6, B.8.10, C.8.2, D.8.1, D.8.3, D.8.5, D.8.7
October/ November	ENERGY Nature of Energy Transformation of Energy Electricity Production Alternative Energy	• Observing • Measuring • Controlling variables • Collecting data • Inferring	• Teacher observation • Class discussion • Written work • Labs • Quizzes and tests • Daily journals	**Science**: A.8.6, E.8.4, A.8.8, E.8.6, B.8.1, G.8.1, B.8.2, G.8.3, B.8.6, H.8.1, D.8.5, H.8.2, D.8.6, D.8.7, D.8.8, D.8.9 **EE**: A.8.1, A.8.2, A.8.4, B.8.5, B.8.10
December	LIGHT ENERGY Nature of Light Behavior of Light Vision an Color	• Observing • Measuring • Controlling variables • Collecting data • Inferring	• Teacher observation • Class discussion • Written work • Labs • Quizzes and tests • Daily journals	**Science**: A.8.6, A.8.8, B.8.1, D.8.8, D.8.9 **EE**:

MARSHALL PUBLIC SCHOOLS
CURRICULUM MAP TEMPLATE

Subject Level: GENERAL SCIENCE

Grade Level: 6TH

MONTH	CONTENT	SKILLS	ASSESSMENTS	STANDARDS	
January	LANDFORMS Forces of Change Water Shaping Landforms Glaciers Shape Landforms	• Observing • Measuring • Controlling variables • Collecting data • Inferring	• Teacher observation • Class discussion • Written work • Labs • Quizzes and tests • Daily journals	**Science** A.8.6 A.8.8 E.8.1 E.8.3 E.8.4	**EE** A.8.1 B.8.2
February/ March	CHANGES IN THE EARTH Evidence of Change Plate Tectonics Changing Earth's Surface	• Observing • Measuring • Controlling variables • Collecting data • Inferring	• Teacher observation • Class discussion • Written work • Labs • Quizzes and tests • Daily journals	**Science** A.8.6 E.8.5 A.8.8 G.8.1 B.8.1 H.8.1 B.8.2 H.8.2 C.8.2 C.8.6 C.8.8 E.8.1 E.8.2	**EE** A.8.1 A.8.2 A.8.3 A.8.4 A.8.5 A.8.6 B.8.5 C.8.2 C.8.3
April	ROCKS AND MINERALS What are Rocks & Minerals Traits of Rocks & Minerals How do Rocks & Minerals Form	• Observing • Measuring • Controlling variables • Collecting data • Inferring	• Teacher observation • Class discussion • Written work • Labs • Quizzes and tests • Daily journals	**Science** A.8.6 A.8.8 B.8.1 D.8.8 D.8.9 E.8.1 E.8.2	**EE**

MARSHALL PUBLIC SCHOOLS
CURRICULUM MAP TEMPLATE

Subject Level: GENERAL SCIENCE

Grade Level: 6TH

MONTH	CONTENT	SKILLS	ASSESSMENTS	STANDARDS	
May/ June	SPACE The Universe The Sun and Other Stars Stars Change With Age The Solar System	• Observing • Measuring • Controlling variables • Collecting data • Inferring	• Teacher observation • Class discussion • Written work • Labs • Quizzes and tests • Daily journals	**Science** A.8.6 A.8.8 B.8.1 B.8.2 C.8.2 C.8.6 C.8.7 C.8.8 E.8.7 E.8.8 G.8.1	**EE**

MARSHALL PUBLIC SCHOOLS
CURRICULUM MAP TEMPLATE

Subject Level: LIFE SCIENCE

Grade Level: 7TH

MONTH	CONTENT	SKILLS	ASSESSMENTS	STANDARDS: Science	STANDARDS: EE
September	INSECTS	• Create a collection of up to 40 insects • Build and learn to use different tools for capturing insects • Hunt for insects in a variety of habitats • Research and write on a particular insect topic	• Quality of Collection (rubric) • Written Test: multiple choice, matching, short answer, etc.. • Quality of Research Paper (rubric) • Lab assessment on insect I. D. • Lab quiz on dissection • Portfolio	A.8.8 B.8.4 B.8.6 C.8.2 C.8.6 C.8.8 G.8.1 H.8.1	A.8.1 A.8.2 B.8.2 B.8.8
	CLASSIFICATION TAXONOMY	• Dissect of a grasshopper • Identify anatomy & life-cycle stages • Classify according to the 5 kingdoms of life • Classify according to binomial system			
October	TREES	• Identify & describe 12 - 15 important tree species of WI • Continue classification & binomial system • Press leaves and construct a leaf collection • Design and construct a poster on trees	• Practical Lab Quiz on Tree ID • Written puzzles & worksheets • Quality of tree poster (rubric) • Portfolio	A.8.8 C.8.2 C.8.6 C.8.8 H.8.1 F.8.1 F.8.2	A.8.1 B.8.2
	PLANT KINGDOM	• Cultivate Wisconsin Fast Plants • Maintain a daily Plant Journal • Define plants & explain their importance • Briefly describe basic plant classification, including vascular/non-vascular, moncot/dicot gymnosperm/angiosperm, etc. • Collect and grow mosses in bottle caps • Explain Photosynthesis & Respiration • Design experiment on plant tropisms • ID basic parts & functions of vasular plants • ID basic parts & function of flowers • Use stereomicroscope to observe flower structure	• Written worksheets & Test • Quality of Plant Journal (rubric) • Lab activity grades • Quality of Lab work (observation) • Portfolio		

MARSHALL PUBLIC SCHOOLS
CURRICULUM MAP TEMPLATE

Subject Level: LIFE SCIENCE

Grade Level: 7TH

MONTH	CONTENT	SKILLS	ASSESSMENTS	STANDARDS
November	ECOLOGY	• Explain the relationship between organisms and their environment. Define "species." • Define population, community, niche, and ecosystem. Explain "web of life." • Evaluate population densities using math formulas and graphing • Describe "biodiversity" and variation • Team Project - create an "Eco-Column" • Experiment - WFP: Population explosion • Individual Project - Ecosystem Study • Biography - Rachel Carson / Aldo Leopold	• Written assignments and Quiz • Problem-solving • Quality of Ecosystem Study (rubric) • Lab write-ups • Portfolio	**Science** — **EE** A.8.1 F.8.9 — A.8.1 A.8.3 F.8.10 — A.8.2 A.8.4 G.8.3 — A.8.3 A.8.6 H.8.1 — B.8.2 A.8.8 H.8.2 — B.8.3 B.8.1 — B.8.5 C.8.3 B.8.5 — B.8.6 C.8.4 B.8.6 — B.8.7 D.8.1 E.8.4 — B.8.8 D.8.2 F.8.7 — B.8.10 D.8.4 F.8.8 — C.8.2 D.8.6
December	EVOLUTION	• Genetic background - species, genes, traits • Define Evolution • Define natural selection, artificial selection, variation, diversity, adaptation, mutation, etc. • Project: Construct a poster of geologic timeline and major evolutionary events • Observe fossils in lab • Describe limitations of fossil record • Explain "fossil" fuels & carboniferous era • Experiments - "Bird Buffet" and "Camouflage" • Biography: Charles Darwin	• Written assignments and Quiz • Lab write-ups (accuracy) • Quality of poster project(rubric) • Portfolio	A.8.6 — B.8.2 A.8.8 — B.8.3 B.8.1 B.8.2 B.8.6 C.8.2 C.8.6 C.8.8 F.8.2 H.8.1
January	GENETICS	• Cell Background - DNA, chromosomes, genes • Master specific vocabulary of genetics • Solve practical problems with Punnett suqares • Project on Mendelian Genetics): REEBOPS • Plant Breeding: The Purebred Cross (WFP) • Experiment on Probability: "Bean Counters" • Meiosis and Mitosis • Genetic Code - DNA structure & replication • Biography: Gregor Mendel • Biography: Watson & Crick / Rosalind Franklin	• Punnett Square problems • Written puzzles & worksheets • Written Test • Lab write-ups • Portfolio	A.8.6 — B.8.3 B.8.1 B.8.2 B.8.6 C.8.2 C.8.6 C.8.8 F.8.4 F.8.5 G.8.1

MARSHALL PUBLIC SCHOOLS
CURRICULUM MAP TEMPLATE

Subject Level: LIFE SCIENCE

Grade Level: 7TH

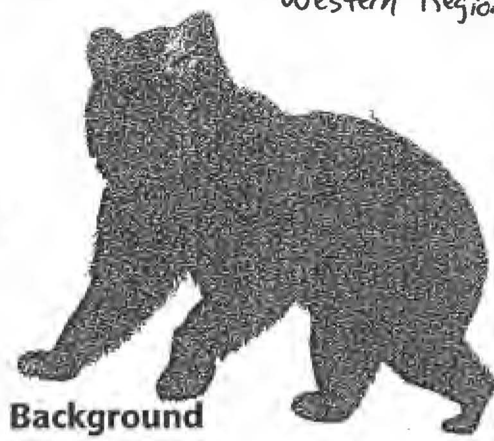
MONTH	CONTENT	SKILLS	ASSESSMENTS	STANDARDS: Science	STANDARDS: EE
February	CELLS	• Explain cell theory & cell structures • Single-celled v. multicelled organisms • Describe cell functions & structures • Master use of compound microscope • Observe prepared slides of cells • Make wet-mount slides of plant cells • Describe cell specialization and growth • Cancer as cell growth gone unchecked • Differences between plant & animal cells • Design and construct a cell model	• Written worksheets and test • Vocabulary practice • Quality of Cell Model (rubric) • Laboratory practical quiz	A.8.6 A.8.8 B.8.1 B.8.2 E.8.5 F.8.1	
March / April	MICROBIOLOGY	• The Edge of Life: VIRUSES • Kingdom Monera: The BACTERIA • Describe structure & methods of microbes • How microbes are harmful and beneficial • Update AIDS readings • Learn and practice sterile technique • Identify types of bacteria with microscope • Experiment: Culturing microbes in lab • Experiment: Cholera epidemic	• Written worksheets and test • Lab write-ups • Practical Lab techniques • Germ Journal • Portfolio	A.8.6 A.8.8 B.8.1 B.8.2 C.8.2 F.8.1 G.8.1 H.8.1 H.8.3	A.8.1 A.8.2 A.8.3 A.8.4 A.8.5 A.8.6 C.8.2 C.8.3
April / May	ANIMAL KINGDOM	• Classification and diversity of animal kingdom • Characteristics & habitats of the cold-blooded vertebrates - fish, reptiles & amphibians • DISSECT - worm, frog & owl pellet • Characteristics & habitatsof the warm-blooded vertebrates - birds & mammals • CATS & DOGS - research and write report on a particular breed of dog or species of wild cat	• Written worksheet & test • Lab techniques • Quality of research report • Portfolio	A.8.8 F.8.1 F.8.2 G.8.1	B.8.8
	HUMANS	• Major body systems	• Written worksheets & test		

Appendix C

Energy Activities

Western Regional (199

How Many Bears Can Live in This Forest?



Objectives

Students will: 1) define a limiting factor; and 2) describe how limiting factors affect animal populations.

Method

Students become "bears" to look for one or more components of habitat during this physically involved activity.

Materials

Five colors of construction paper (a couple of sheets each of red, yellow, green, blue and orange) or an equal amount of light poster board or colored tokens; one black felt pen; envelopes (one per student); pencils; one blindfold; five sheets green construction paper (for extension)

Grade Level: [illegible]

Subject Areas: Science, Environmental Education, Mathematics

Duration: one 20- to 45-minute session or longer

Group Size: 10 to 25

Setting: outdoors

Conceptual Framework Topic Reference: [illegible]

Key Terms: limiting factor, habitat, shelter, cover

Appendices: Simulations, Ecosystem

Background

Black bears are the focus of this activity that illustrates the importance of suitable habitat for wildlife. The activity demonstrates the consequences for a population of bears if one or more habitat components is relatively scarce. When any element or factor in a habitat is inappropriate or exceeds the tolerance range for an animal or population, it directly affects the well-being of the animal(s) and may result in death or population reduction. This factor "limits" the animal or population. Limiting factors may include habitat components such as food, water, shelter and appropriate space, as well as life history parameters such as disease, predation and climatic conditions. Limiting factors also may be related to human activity such as development, pollution and hunting. Populations tend to increase in size until limited by one or more of these factors.

Black bear habitat limits black bear populations, especially through the influences of shelter, food supply and the social tolerances or territoriality of the animal. Shelter or cover is a prime factor. Black bears need cover—for feeding, hiding, bedding, traveling, raising cubs and denning. With limits of space, adult bears will kill young bears or run them out of the area. These young bears must keep moving around either until they die or until they find an area vacated by the death of an adult.

When food supplies are reduced by factors such as climatic fluctuations, competition becomes more intense. Some adult bears might temporarily move to seldom-used areas of their home range, sometimes many miles away. They must live on what food is available in the area. These individuals may become thin and in poor

continued

Number of Cards to Make

Paper Color	Label	Represents	Number of Students in Group						
			10-15	16-20	21-25	26-30	31-35	36-40	41-45
Orange	N-20	Nuts, 20 lbs.	2	3	3	4	5	6	7
Orange	N-10	Nuts, 10 lbs.	8	13	17	21	25	29	33
Blue	B-20	Berries, 20 lbs.	2	3	3	4	5	6	7
Blue	B-10	Berries, 10 lbs.	8	13	17	21	25	29	33
Yellow	I-12	Insects, 12 lbs.	2	3	3	4	5	6	7
Yellow	I-6	Insects, 6 lbs.	8	13	17	21	25	29	33
Red	M-8	Meat, 8 lbs	2	3	3	4	5	6	7
Red	M-4	Meat, 4 lbs.	8	13	17	21	25	29	33
Green	P-20	Plants, 20 lbs.	2	3	3	4	5	6	7
Green	P-10	Plants, 10 lbs.	8	13	17	21	25	29	33

condition for winter hibernation or, in the case of young bears, be forced from the area by more aggressive adults.

All possible conditions are not covered by the design of the activity. However, by this simple illustration it is possible for students quickly to grasp the essential nature of the concept of "limiting factors"—habitat components affecting the survival of an animal or restricting the numbers or range of an animal population.

Procedure

1. Make a set of 2" x 2" cards from the colored construction paper. Use the chart on this page to determine how many cards of each color to make and what to write on each one.

As shown in the chart, the color of the card determines the type of food it represents:

orange—nuts (acorns, pecans, walnuts, hickory nuts)

blue—berries and fruit (blackberries, elderberries, raspberries, wild cherries)

yellow—insects (grub worms, larvae, ants, termites)

red—meat (mice, rodents, peccaries, beaver, muskrats, young deer)

green—plants (leaves, grasses, herbs)

The number on each card represents the number of pounds of food. For example, a card with the label M-4 represents four pounds of meat.

2. The following estimates of total pounds of food needed for one bear in 10 days are used for this activity:

nuts	20 pounds	(25%)
berries and fruit	20 pounds	(25%)
insects	12 pounds	(15%)
meat	8 pounds	(10%)
plants	20 pounds	(25%)
	80 pounds	(100%)

NOTE: These figures represent the food of a typical black bear in Arizona. The components of an actual bear's diet will vary between areas, seasons and years. For example, a bear in the state of Alaska would likely eat more meat (fish) and fewer nuts than a bear in Arizona. One similarity among black bears everywhere is that the majority of their diet is normally made up of vegetative material.

If the table is followed when making the food cards, there should be less than 80 pounds of food per student, so that there is not actually enough food in the area for all the "bears" to survive.

3. It is also possible to include "water" as a habitat component by making additional squares from light blue paper. To calculate how many water cards to make, multiply the number of students by 1.25 (round to the nearest whole number). For example, for a group of 20 students, make 20 x 1.25 = 25 water cards. Divide the water squares into five equal piles (or roughly equal) and mark each group with the one of following letters: R, L, ST, SP and M. These letters represent all the places where a bear could find water: rivers, lakes, streams, springs and marshes.
4. In a fairly large open area (e.g., 50′ x 50′), scatter the colored pieces of paper.
5. Do not tell the students what the colors, initials and numbers on the pieces of paper represent. Tell them only that the pieces of paper represent various kinds of bear food. Since bears are omnivores, they like a wide assortment of food and the students should gather different colored squares to represent a variety of food.
6. Have each student write their name on an envelope. This will represent the student's "den site" and should be left on the ground (perhaps anchored with a rock) at the starting line on the perimeter of the field area.
7. Have the students line up on the starting line, leaving their envelopes between their feet on the ground. Give them the following instructions: "You are now black bears. All bears are not alike, just as you and I are not exactly alike. Among you is a young male bear who has not yet found his own territory. Last week he met up with a larger male bear in the big bear's territory and before he could get away, he was hurt. He has a broken leg. (Assign one student as the injured bear. He must hunt by hopping on one leg.) Another bear is a young female who investigated a porcupine too closely and was blinded by the quills. (Assign one student as the blind bear. He or she must hunt blindfolded.) The third special bear is a mother bear with two fairly small cubs. She must gather twice as much food as the other bears. (Assign one student as the mother bear.)
8. Students must walk into the "forest." Bears do not run down their food; they gather it. When students find a colored square, they should pick it up (one at a time) and return it to their "den" before picking up another colored-square. (Bears would not actually return to their den to eat; they would eat food as they find it.)
9. When all the colored squares have been picked up, the food gathering is over. Have students pick up their den envelopes containing the food they gathered and return to class.
10. Explain what the colors and numbers represent. Each color is a kind of food and the numbers represent pounds of food eaten. Ask each student to add up the total number of pounds of food they gathered—whether it is nuts, meat, insects, berries or plant material. Have each student write the total weight on the outside of their envelope.
11. Using a chalkboard, list "blind," "injured" and "mother." Ask the blind bear how much food she aquired. Write the amount after the word "blind." Ask the injured bear and the mother bear how much they aquired and record the information. Ask each of the other students to tell how much food they found; record each response on the chalkboard. Tell the students each bear needs 80 pounds to survive. Which bears survived? Is there enough to feed all the bears? How many pounds did the blind bear collect? Will she survive? What about the mother bear? Did she get twice the amount needed to survive? What will happen to her cubs? Will she feed her cubs first or herself? Why? What would happen to her if she fed the cubs? What if she ate first? If the cubs die, can she have more cubs in the future, and perhaps richer, years? (The mother bear will eat first and the cubs will get whatever, if any, is left.

continued

The mother must survive; she is the hope for a continued bear population. She can have more cubs in her life; only one needs to survive in order for the population to remain static.)

12. If the water squares are included, each student should have picked up at least one square representing a water source or they do not survive. Water can be a limiting factor and is an essential component of habitat.

13. Ask each student to record how many pounds of each of the five categories of food they gathered. Ask each student next to convert these numbers into percentages of the total poundage of food each gathered. Provide the students with the background information about black bears so that they can compare their percentages with what are typical percentages eaten by black bears in Arizona. Ask students to guess how healthy their bears would be. How do the bears' requirements for a diet seem to compare with the needs of humans for a balanced and nutritious diet?

14. Ask the students to arrive at a class total for all the pounds of food they gathered as bears. Divide the total by the 80 pounds needed by an individual bear (approximately) in order to survive in a ten-day period. How many bears could the habitat support? Why then did only ____ bears survive when your class did this activity? Is that realistic? What percentage of the bears survived? What percentage would have survived had the food been evenly divided? In each case, what percentage would not survive?

15. Ask the students to determine the amount of food tokens that must be added in order to support all of the bears in this activity. If sufficient food were available for all of the bears would the population likely increase the following year? Have the students support their answers. Other than food, what factors, natural or human-related, might also limit the growth of the bear population? How would each of these factors affect the bear population? Could the bear population increase indefinitely if unlimited food were available? Why or why not?

16. Based on their discussion, ask the students to try to define the term limiting factor. Have them suggest examples of limiting factors, cultural and natural, that would be likely to actually influence the survival of other animals and their populations.

Extensions

1. Cut paper or poster board into 2" x 2" squares. Make five squares per student. For example, with a class of 30 students, you would make 150 squares. Divide all the squares into five equal piles and mark the cards in each pile with one of these letters: B, T, D, H and F. These represent B = bedding sites, T = travel ways, D = dens, H = hiding cover and F = feeding sites. For purposes of this activity, these are defined as follows:

Bedding Sites: Black bears are usually active in early morning and late evening, and bedded most of the rest of the day and night. Bedding sites are usually in areas of dense vegetation, steep topography and/or large trees where the bears feel secure.

Travel Ways: Bears require corridors of cover (made up of thick vegetation and/or steep topography) to enable them to travel between areas of food, water and shelter within their home range.

Dens: Black bears use dens as shelter for hibernation from November to April in each year. Bears have been found denning in hollow logs, caves, holes dug into hillsides, under buildings on top of the ground and even in culvert pipes. Bears often prepare and may use more than one den, and may change dens during the winter because of disturbance or if the den leaks. Bears seldom re-use dens from one year to the next.

Hiding Cover: Black bears evolved as animals that escape danger from predators and other bears by hiding in thick cover.

Feeding Sites: Bears often will use areas with less cover than hiding areas or bedding sites for feeding. Feeding sites are, however, often found close to thick hiding cover to allow the bear to quickly escape danger if necessary.

NOTE: This information is based on actual research data from a study in Arizona. These components of shelter may vary slightly in different parts of North America.

2. In a fairly large open area (e.g., 50′ x 50′), scatter the colored pieces of paper.
3. Have the students line up along one side of the area. Tell them that they are to become "bears" for the purposes of this activity. Review the concept of habitat—that a bear would need shelter, food, water and space in a suitable arrangement in order to survive. Do not tell the students what the letters on the squares of paper represent. Tell them only that they represent one element or component of bear habitat.
4. Direct the students to move as individual "bears" into the area. Each bear must pick up as many of the components of habitat as possible. Some competitive activity is acceptable as long as it is under control. Bears are territorial. Remember that if bears fight, which they seldom do, they can become injured and unable to successfully meet their needs for survival.
5. When the students have picked up all of the squares of paper in the area, have them return to the classroom or be seated in any comfortable area. Ask the students to separate their squares of paper into piles according to the letter on each. Using a chalkboard or large pad for a visual reference, ask the students to predict what the letters on the green cards represent—giving them the clue that each is an element of cover or shelter for a black bear. What kinds of shelter would a bear need? What do these initials represent? Record how many bears aquired at least one of each kind of shelter. How many got only four kinds? Three? Two? How many got only one kind of shelter? For the purposes of this activity, only those bears with at least one of each kind of necessary shelter can survive through one year.
6. Shelter is a very important part of a bear's habitat. A bear needs shelter in which to search for food and water. Bears also need shelter for traveling through their home range, and shelter for bedding, hiding and denning. Ask students why a den is important. (The bear could live from April through October but would not have a secure place to hibernate and might not survive the winter.) Ask the students what would happen if a bear did not have travel ways? (Without travel ways, home ranges become fragmented and bears are not able to reach needed food, water or other shelter. Without suitable habitat, bears move into marginal habitats and get into trouble with people.)
7. In this activity, how many bears survived? What was a limiting factor for this population of bears? (Shelter.) What other things possibly could become limiting factors? (Water and space or territory are two examples.) Could food be a limiting factor for bears? (Yes, however bears are omnivores and can utilize many sources of food.)
8. Ask the students to summarize what they have learned about the importance of suitable habitat for bears' survival. How are the bears' habitat needs similar to and different from the needs of other animals?

Evaluation

1. Define limiting factor.
   a. Describe some of the factors that may limit the survival of an animal.
   b. What might be the consequences to the individual animal and to its population if one of these limiting factors were no longer limiting?

Name Modern Biology (1990) Date

INVESTIGATION

How Does the Environment Affect an Eagle Population?

5–1 LAB

With unlimited resources and ideal environmental conditions, a population would continue to increase in size. This rarely happens, however, because resources are limited and environmental conditions are not ideal. The carrying capacity of an ecosystem is the maximum number of organisms that an area can support. In nature, many populations remain below the carrying capacity because of a combination of both nonliving (abiotic) and living (biotic) factors. These factors include climate, habitat, available food, water supply, pollution, disease, and interactions between species, including predation, parasitism, and competition. The interactions between a population and the many components of an ecosystem are very complex. In this Investigation, you will make a simplified model of the effects of some abiotic and biotic environmental factors on a bald eagle population.

OBJECTIVES

- Make a model to show how abiotic and biotic factors affect a bald eagle population.
- Hypothesize how biotic factors affect a bald eagle population.

MATERIALS

- index card
- uncooked rice grains dyed red with food coloring (75)
- 20 cm × 20 cm pieces of paper (2)
- uncooked white rice grains (150)
- metric ruler
- scissors
- graph paper
- colored pencils (6 colors)

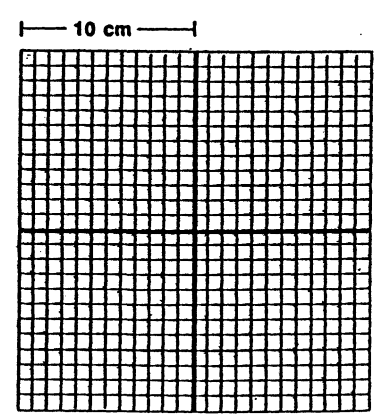
PROCEDURE

Part A.

Eagles mate for life. Only one pair of eagles occupies, defends, and hunts a well-defined territory.

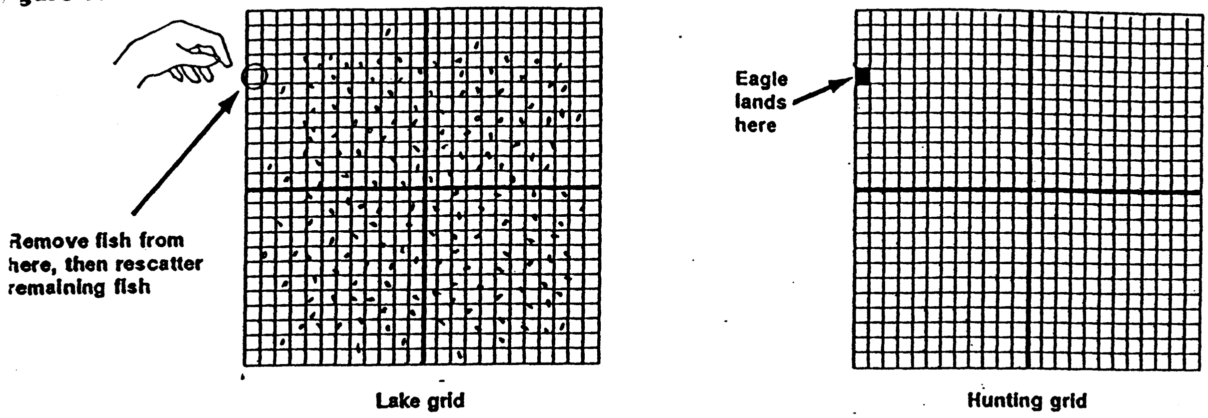
1. Mark off the edges of the two sheets of paper in centimeters. On each sheet, draw a grid of 400 1-cm squares as shown in Figure 1. The grid represents a 4-km² lake (10 cm = 1 km) where the eagles hunt for fish. This will be their only source of food.
2. Cut two 1-cm squares from the index card. Label one of the squares M for male and the other F for female.
3. Lay the two grids near each other on a flat surface. Scatter 150 grains of white rice over one of the grids. Each grain represents a large fish in the lake. Eagles eat only the large fish.

Figure 1.



Eagles' lake (4 km²)

gure 2.



4. The other grid is the hunting grid. Hold the M (male eagle) square about 30 cm over the hunting grid and drop the M square onto the grid.
5. Note which grid square is most completely covered by the M square. Remove all of the rice from the corresponding square on the lake grid. Do the same thing with the F square. This process represents the eagles catching fish.
6. Each adult eagle hunts twice a day. Rescatter the remaining rice and repeat steps 4 and 5. Total the number of fish caught by each eagle on Day 1 and record the data for Day 1 in Table 1.
7. Repeat steps 4 to 6 nine times and complete Table 1. This observation is taking place in the fall when the fish population does not increase.
8. An eagle will share the fish it catches with its mate, but it will feed itself first. If an eagle does not eat a total of nine fish in any three-day period, it grows too weak to hunt and dies. Be sure to examine the data for each three-day period as you continue. If one eagle dies, continue hunting with only one eagle for the remaining days.
9. Graph the daily total number of fish from Table 1, using a colored pencil. Record the days on the horizontal axis and the number of fish on the vertical axis. Answer questions 1 and 2 in the Analysis section.
10. Make a **hypothesis** to describe what might happen if two ospreys (other birds of prey) also hunted in the lake, each averaging a take of three fish per day. Write your hypothesis in the space provided.
11. Return all the white rice to the lake grid. Repeat steps 4 to 8, but randomly remove an additional six fish per day that the ospreys catch. Record the data in Table 2.
12. Graph the daily total number of fish from Table 2, using a different colored pencil. Answer question 3 in the Analysis section.

Part B.

1. Rescatter all the rice as before.
2. Other factors in the ecosystem affect the fish population and, thus, the eagle population. Choose Factor D and any three other factors listed below. Follow directions for each factor. Record your data in Tables 3, 4, 5, and 6, labeling them properly. Be sure to rescatter the remaining rice before each hunting trip and scatter all the rice when you begin a new factor.
3. Graph the data from Table 3 through 6. Use a different colored pencil for each table.

Factors That Might Affect an Ecosystem

A. A drought occurs that causes the water level of the lake to fall. This causes one quarter of the fish to die. Remove 38 fish from the lake. Repeat steps 4 to 6 from Part A ten times. Answer Analysis question 4.

B. It is spring. The fish in the lake are spawning. Double the number of fish (rice grains). Repeat steps 4 to 6 from Part A ten times. Answer Analysis question 5.

C. It is winter. The lake is frozen and the eagles cannot hunt fish. Answer Analysis question 6.

D. Insecticides are sprayed on land near the eagles' territory. Some insects that have ingested the insecticide are eaten by small fish in the lake. The small fish are, in turn, eaten by large fish. When eagles eat fish contaminated with insecticide, they lay eggs that do not hatch. Remove half of the fish (75 of the white rice

Name ______________________________ Date __________

grains) and replace them with fish contaminated with insecticide (75 red rice grains). Repeat steps 4 to 6 from Part A ten times. Answer Analysis questions 7 and 8.

E. Phosphate pollution causes the algae in the lake to grow out of control. The algal growth reduces the amount of dissolved oxygen in the lake water and causes three quarters of the fish to die. Remove 112 fish. Repeat steps 4 to 6 from Part A. Answer Analysis question 9.

F. The eagles have two offspring. The adults have to catch two additional fish a day. Repeat steps 4 to 6 of Part A. Answer Analysis question 10.

HYPOTHESIS

____

____

DATA AND OBSERVATIONS

Table 1.

Day	1	2	3	4	5	6	7	8	9	10
No. of fish										

Table 2.

Day	1	2	3	4	5	6	7	8	9	10
No. of fish										

Table 3.

Day	1	2	3	4	5	6	7	8	9	10
No. of fish										

Table 4.

Day	1	2	3	4	5	6	7	8	9	10
No. of fish										

Table 5.

Day	1	2	3	4	5	6	7	8	9	10
No. of fish										

Table 6.

Day	1	2	3	4	5	6	7	8	9	10
No. of fish										

ANALYSIS

1. How might eagle predation affect the fish population over time? ______________________________

____

.Vhat effect, if any, might a small scale decrease in the fish population have on the eagle population?

___

Ospreys and eagles compete for food. What effect, if any, might the competition have on the eagle population? ___

___

Explain how a climate change might or might not indirectly affect the eagle population. ___

___

What effect, if any, does an increase in the fish population have on the eagle population? ___

___

How can a seasonal change affect the eagle population? ___

___

What effect, if any, does the insecticide have on the fish population? ___

on the eagle population? ___

. Can a pollutant, such as an insecticide, affect one population in an ecosystem and not another? ___

. Explain how pollution can indirectly affect the eagle population. ___

___

!. How does an increase in the eagle population affect the fish population? How is this situation similar to the competition from ospreys? ___

___

:HECKING YOUR HYPOTHESIS

/as your hypothesis supported by your data? Why or why not? ___

___

'URTHER INVESTIGATIONS

1. Perform an experiment to test the effect of competition among bean plants. Germinate about 25 bean seeds. Select and plant one seedling in a pot three quarters full of soil. This serves as a control. Plant about 18 seedlings in another pot of the same size and filled with the same amount of soil. Measure the growth of the seedlings.
2. Design and carry out an experiment to test the effect of overcrowding in a yeast population. Since yeast reproduces by budding, a population increases rapidly. Observe changes in the number of yeast cells in the population by making a wet-mount slide and counting the number of cells in the field of view. How do light and temperature affect a yeast population?

Collins

About Honeybees

- Bees do not create honey; they are actually improving upon a plant product, nectar. The honey we eat is nectar that bees have repeatedly regurgitated and dehydrated.
- The average American consumes a little over one pound of honey a year.
- In the course of her lifetime, a worker bee will produce 1/12th of a teaspoon of honey.
- To make one pound of honey, workers in a hive fly 55,000 miles and tap two million flowers.
- In a single collecting trip, a worker will visit between 50 and 100 flowers. She will return to the hive carrying over half her weight in pollen and nectar.
- A productive hive can make and store up to two pounds of honey a day. Thirty-five pounds of honey provides enough energy for a small colony to survive the winter.
- Theoretically, the energy in one ounce of honey would provide one bee with enough energy to fly around the world.
- Although Utah enjoys the title "The Beehive State," the top honey-producing states include California, Florida, and South Dakota. In 1998, the United States made over 89,000 metric tons of honey. China, the world's top honey-producer, created more than 140,000 metric tons of honey in 1997.
- While foraging for nectar and pollen, bees inadvertently transfer pollen from the male to the female components of flowers. Each year, bees pollinate 95 crops worth an estimated $10 billion in the U.S. alone. All told, insect pollinators contribute to one-third of the world's diet.

- Most researchers believe the honeybee originated in Africa. The first European colonists introduced *Apis mellifera,* the common honeybee, to the Americas. Native Americans referred to the bees as "White Man's Fly." Today honeybees can be found all over the world.

- Bees are not fast fliers; while their wings beat over 11,000 cycles per minute, their flight speed averages only 15 miles per hour. In comparison, a true fly in the genus *Forcipomyia* beats its wings over 62,000 cycles per minute. The Australian dragonfly *Austrophlebia costalis* has been clocked flying at a speed of 36 mph.

- Honeybees gather nectar from flowers, add an enzyme to invert the complex sugars to simple sugars, evaporate the excess water, and seal the honey in wax bottles, the honeycomb. It takes approximately 10 pounds of nectar to make one pound of honey. To gather this nectar, the bees had to visit an average of two million flowers and traveled about 55,000 miles, over twice the distance around the world. Each worker will fly about 500 miles during its lifetime of six weeks before it simply wears out and dies. The honeybees depend on the honey as food for energy and store up excess so that the colony can survive long winters when no flowers are blooming.

- In gathering the nectar, the honeybees also supply pollination to the flowers by transferring sticky pollen from the stamens of one flower to the pistil of another, thus completing the symbiotic relationship between bees and flowers. The bees supply pollination service in return for the nectar since the flowers cannot achieve pollination by wind due to other characteristics of the plant. In other cases, the flower does not supply nectar but has abundant pollen and the bees actually gather pollen as a protein source while simultaneously supplying pollination. Over ninety agricultural crops in the United States benefit from pollination by honeybees with a total value of over 20 billion dollars per year.

Mittermaier (2000)

Every Tree For Itself

What do trees need so they can grow? Some of their needs are the same as those of people and other animals. For example, trees need plenty of water. They also need plenty of nutrients, which they get from food. But trees and people don't get food in the same way. Plants make their own food by using energy from the sun.

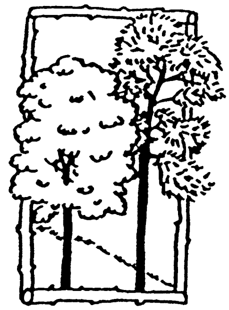
If trees don't get enough water, nutrients, or sunlight, they may grow slowly or die. Growth rings show this graphically. In general, wide rings indicate good conditions for growth (plenty of nutrients, water, and sunshine), while narrow rings often indicate less favorable conditions for growth (drought, insect damage, lack of nutrients, or competition).

Getting Ready

1. Cut two 3" x 3" (7.6 cm x 7.6 cm) squares out of blue, yellow, and green construction paper for each student. To save time, you could use colored poker chips or milk caps. These work much better than paper if you're doing the activity outdoors on a breezy day.

Doing the Activity

1. Pass out cross-sections from several trunks or branches (tree cookies), and have your students examine the growth rings. (If you don't have an actual cross-section, draw a big one on the chalkboard.) Explain that the number of rings indicates a tree's age.
2. Give a large piece of paper (at least 8.5" x 11" or 22 cm x 28 cm) or a white paper plate to each student.
3. Tell students to imagine that they are trees. Have them draw a cross-section of themselves, representing their age in growth rings. (You might laminate these drawings for durability.)
4. Have students stand about three feet (91 cm) apart on their cross-sections.
5. Equally distribute the colored squares (or poker chips) on the floor around the students so the squares are about one to two feet (30 - 61cm) apart.
6. Tell students that they'll be playing a game called "Every Tree for Itself." The object of the game is for the "trees" to gather as many squares as they can. Explain that each colored square represents a tree requirement. Blue represents water, yellow represents sunlight, and green represents a nutrient



Method

Students become trees competing for water, sunlight, and nutrients.

Key Concepts

The earth's atmosphere, water, soil, climate, and geology vary from region to region, thus creating a wide diversity of biological communities.

Organisms are interdependent; they all depend on nonliving components of the Earth.

Altering the environment affects all life forms—including humans—and the interrelationships that link them.

Objectives

- simulate how trees compete for their essential needs
- describe how varying amounts of light, water, and nutrients affect a tree's growth

Subjects & WI Academic Standards

Science:
A.4, C.4, F.4
A.8, C.8, F.8

Math:
A.4, B.4
A.8, B.8

Standards cont.

English/Language Arts:
B.4, C.4
B.8, C.8

Environmental Education:
A.4, B.4
A.8, B.8

Materials

- 8.5" X 11" pieces of paper or paper plates
- pieces of blue, yellow, and green paper or 3 colors of poker chips or milk caps
- markers or crayons
- tree trunk or branch cross-sections showing annual growth rings (optional)

Preparation Time

15 minutes

Activity Time

1 50-minute class period

Setting

classroom or outdoors

such as nitrogen, oxygen, or carbon dioxide. Make appropriate adjustments if you use poker chips.

7. Give a signal to start the first round. Have student trees reach with their roots and branches (arms and legs) to gather their requirements. Tell students that one foot (their tap root) must remain planted on their cross-section at all times. They are not allowed to slide their cross-section along the floor or step off it; they will be disqualified for doing so.

8. Allow student trees to gather these requirements for one 30-second round. (They can either collect all types of requirements at once or one type of requirement each round.) Have students use a notebook to record how many of each color requirement they gathered. Use the following questions to discuss the results of the first round:

   ✤ How many requirements did each tree get?

   ✤ Do any trees lack a particular requirement?

   ✤ What might happen to a real tree that lacked one of its requirements? (It might grow slowly or eventually die. Point out to the students, though, that different species of trees have different requirements.)

   ✤ Is there such a thing as too much water, sunlight, or nutrients? (Yes, every species has optimum levels beyond which the tree becomes stressed.)

9. Have students stand on their cross-sections in groups of three to five. Gather the colored squares and spread them around the room again. Play another round and have student trees record their results.

10. Compare the results of this round with those of the first. In most cases, students will notice that each tree gathered fewer requirements. Ask if they can reach any conclusions about trees that grow close to each other. (Such trees compete for requirements. Often they don't grow as well as trees that are more widely separated from one another.) Ask if any trees "died" because they couldn't get a particular requirement. (You can allow trees to fall down or look tired and droopy if they haven't received their vital requirements.)

11. Ask students how foresters might use their knowledge of competition in caring for a stand of trees. (Foresters plant trees a certain distance apart so the trees will be able to get enough nutrients. The distance varies depending on the species of the tree. Foresters also thin young stands of trees).

12. Try several more rounds, comparing the results each time. Here are suggestions for additional rounds:

    - Have all of the students stand closer together.
    - Put students closer together, but have only half of the class participate.
    - Use fewer water squares (representing a drought).
    - Use fewer sunlight squares (representing lack of sunlight for young trees because of overcrowding).
    - Use fewer nutrient squares (representing poor quality soil).

    As before, each student should examine his or her results in each round. Older students can record those results and later graph or chart the results of each round and draw conclusions.

Providing Enrichment

For a visual way to portray water absorption by roots, try the following:

1. Explain that, for many species of trees, the diameter of the spread of the tree's roots is roughly equal to the tree's height. Have students measure themselves and then make a circle (using chalk or string) with a diameter equal to their height.
2. Play the tree game with each student standing in the center of his or her circle. Tell the student trees they can gather water squares only within their circle of roots.
3. Play the game again using root circles, but this time have trees stand in clumps. Afterward, discuss the results of root competition.

Assessing Student Learning

Assign values to the amounts of requirements the students gather. For example, a collection of three or more of each requirement could represent superior growth. Two of each requirement could represent average growth. And one or fewer of each could represent poor growth. Using these values as a basis, have students record the numbers of trees that are growing very well, fairly well, and poorly for each round. Older students can use graphs to show results.

Extending the Learning

Plant a Tree

What if you wanted to plant a tree outside your school? What kind of tree would you plant? What would you need to consider? With your students, brainstorm a list of the needs of trees. Here are some things you should include in your list: soil conditions, sun exposure, moisture, and space (i.e., how big the tree will be when it is full-grown).

Now look at potential planting spots around your building. Where is there room to plant a tree? What obstacles to growth are present (e.g., locations of sidewalks and power lines)? For a small fee, you can even have the soil tested by the ***Soil and Plant Analysis Lab***, 5711 Mineral Point Road, Madison, WI 53705, (608) 262-4364, (http://uwlab.soils.wisc.edu).

Now take a look at some trees you might plant. Make a chart so that you can compare their advantages and disadvantages on your particular site. Down one side, list the trees you are considering. Across the top, list the qualities and requirements you are comparing. Columns might include: soil conditions; sun exposure; moisture; hardiness in winter; height when mature; width when mature; resistance to pests, diseases, pollution, or salt; and comments (e.g., lovely spring flowers or breath-taking fall foliage).

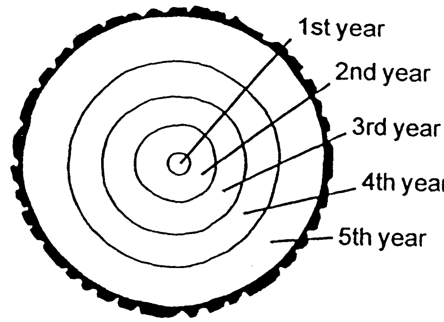
Divide into groups and allow each group to choose one or two trees to research. Provide your students with references on selecting the right tree for the right spot. You'll find some good ones in **Finding Out More!** later in this lesson. When the chart is complete, think about your site and circle all the matches. For example, if your site is in the full sun, circle all the places in the "sun" column that say "full sun." When done, look at the chart. Which trees are best suited to be planted on your site? In other words, which trees have the most circled conditions in their row?

Invite a local arborist or landscape specialist to talk to your class about how to choose a tree. Ask him/her to share basic information about how cultivars are developed and why people often choose them. If possible, follow through on your project and plant the tree you have chosen. You might ask for donations from a local nursery or raise funds to plant the tree.

Check out the ***Tree Musketeers*** website (www.treemusketeers.org) for information on how to plant a tree. Don't forget to register your tree in their "One in a Million" campaign.

Read a Tree's Rings

Interpreting the growth rings of trees can reveal a lot about the trees' growth and development. Here are several activities that make use of tree cross-sections:



Cross-section of a five year old tree

- The ***NatureScope: Trees Are Terrific!*** activity "Reading the Rings" asks students to match tree ring patterns with the factors that caused them, then to "read" the rings of a tree to solve a mystery. Grades 6 - 7.
- The ***Project Learning Tree*** activity "Tree Cookies" relates tree growth rings to environmental and historical changes. The assessment for this activity asks students to listen to a story about a tree's life and to draw its cross-section. Grades 3 - 8.
- The ***Lessons in a Land Ethic*** activity "The Good Oak" uses Aldo Leopold's writings to relate tree growth, environmental conditions, and historical events. Grade 6 and up.

Build a Tree

Not sure just how a tree really works? You and your students will understand it better after you've acted out the parts and functions of a tree. See the activity "Build a Tree" in Joseph Cornell's book ***Sharing the Joy of Nature***. If you can't find Cornell's book, try finding one of these adaptations of his activity: "Build a Tree" is in ***NatureScope: Trees are Terrific*** and "Tree Factory" is in ***Project Learning Tree***. Grades 3 - 6.

Finding Out More!

Selecting the Right Tree

A Guide to Selecting Landscape Plants for Wisconsin by E.R. Hasselkus. This booklet is available from your county's University of Wisconsin - Extension office. Ask for publication #A2865 or view it online.
www.uwex.edu/ces/pubs/trshrbcat.html

Landscaping for Wildlife by Carrol L. Henderson. This book is available from the Minnesota Department of Natural Resources, 500 Lafayette Road, Box 7, St. Paul, MN 55155, (651) 296-6157.
www.dnr.state.mn.us/information_center/books.html

Minnesota Power Electric - The Right Tree Handbook
www.mpelectric.com/treebook/

Wildlife and Your Land: A Series About Managing Your Land for Wildlife published by the Bureau of Wildlife Management. The booklet in this series titled "So, What Should I Plant?" gives good information for Wisconsin.

Wisconsin Department of Natural Resources
www.dnr.state.wi.us/org/land/forestry/nursery/order/descriptions.htm

University of Florida - The Right Tree for the Right Place
www.agen.ufl.edu/~foodsaf/dh104.html

Looking for Tree Cookies?

First ask your students if they or their parents cut firewood! Next try a local lumber mill or tree trimming service. You can also order tree cookies from several companies. The purchased cookies can save you time and frustration; they come dried and sealed with varnish, so they rarely crack.

Museum Products Co.
84 Route 27, Mystic, CT 06355
(800) 395-5400
www.museumproductsco.com

Nasco
901 Janesville Ave., P.O. Box 901, Fort Atkinson, WI 53538
(800) 558-9595
www.nascofa.com/prod/home

Collins

Magnificent Maples

A Lesson on Energy & Food Science

Grade level: 4-6

Time to complete: approximately 1 hour and 10 minutes

Rationale:

This lesson will acquaint children with the importance of sap as a source of food for the tree. Just as children need food to grow, so does the tree. We will explore how the tree produces this energy-giving sap and what it contains. This is important so children will understand that all living things need "food" to grow and will come to respect all living things, who like them need an energy source to survive.

Objectives:

1. Students will draw on a worksheet how sap is produced.
2. Students will list three things needed to produce sap in a maple tree.
3. Students will calculate the percent of water and sugar in samples of maple sap.

Procedure:

1. Anticipatory set: Gather children in a group for discussion. What does your body use to create energy? Do all living things make food? What about trees? Remember when we tapped the maple tree? What are we collecting from the tree? Explain to the students that sap is the maple tree's source of food that enables it to grow. (5 minutes).

2. Show children the sap production diagram and give them the handout to be done at their desks while you explain the diagram. Have the students follow along on their handout while you explain the diagram. Sunlight from the sky, carbon dioxide from the air and chlorophyll in the green leaves work together to make the sugar the tree needs. This is called photosynthesis. The sugar mixes with water absorbed by the roots and forms sap. The sap travels throughout the tree to feed it, help it grow, and bear new leaves as well as to keep the tree healthy. Have the children color those parts discussed. (20 minutes).

3. Gather students in one large group. Ask students to formulate a guess as to why syrup is so sweet while sap is not. Explain to children that sap is made mostly of water and very little sugar. Much of this water is boiled out to

make syrup that is over half sugar. Give an example such as the following: if sap tests 3%, that means in every 100 spoonfuls of sap, there are only 3 spoonfuls of sugar. Syrup made from that sap will have about 66 spoonfuls of sugar in every 100 spoonfuls of liquid. (15 minutes).

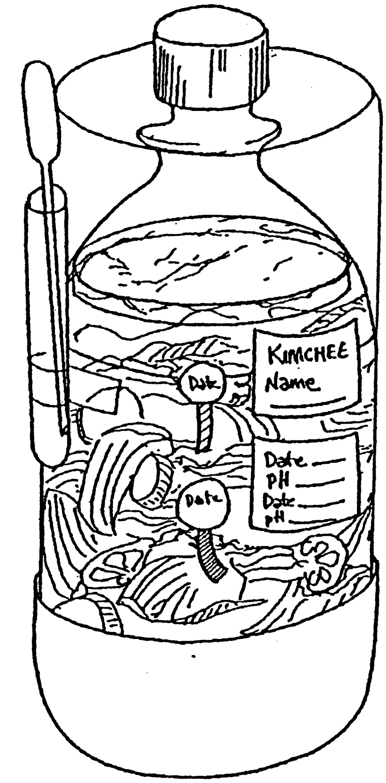
4. Now students will get into groups of threes and test the sugar content in the sap that you collected before class. Each group will be given some sap. They will take turns measuring the sugar content using the hydrometer. Do one measurement as an example for children to follow. The students will record readings and calculate how much water and sugar this sap contains using the formula on the worksheet. Children should complete the worksheet with their groups. (25 minutes).

5. Closure: Tell the students, "Now that we have found out how sap is made and measured the sugar content, we will find out if the weather is a factor in how much sap is collected. This will be our next lesson." (2 minutes).

Assessment:

Students will hand in the worksheet about sap production. They will be asked to list on the back three of the four things a tree needs to make sap: water, sunlight, air or carbon dioxide, and chlorophyll. Students will be informally assessed on their guesses during discussion about why sap is not as sweet as syrup. The sap hydrometer reading worksheet will be collected and graded.

Chapter 17: Fermentation
Making Kimchee in Soda Bottles



Background Information for the Teacher

Pickling is one of the most ancient forms of preserving food. It involves the microbial conversion of sugars into lactic acid through the growth and activity of acid-forming bacteria known as *lactobacilli*. As lactobacilli grow, they convert the natural sugars in plant juices into lactic acid. Under the high acidity (= low pH) created by the lactobacilli other food spoiling organisms cannot grow. Lactobacilli are found almost everywhere in our environment and are known as *anaerobes*, because they grow under conditions in which oxygen is lacking.

Many foods can be preserved through natural pickling. Some common ones are sauerkraut, yogurt, dill pickles, and silage for cattle. The ancient Chinese and other cultures learned the value of pickling thousands of years ago. Today a spicy pickled Chinese cabbage product known as *kimchee* is a major part of the diet of Koreans.

You and your students can make kimchee and study lactic acid fermentation in a 2-liter bottle by using the following recipe and procedure.

Teaching Objectives

Beginning concepts:

- Bacteria are involved in the making of some of our foods.
- Acid-forming bacteria can live in an acidic environment in which other organisms cannot live.
- The release of a gas is a sign that a chemical reaction is taking place.

Advanced concepts:

- Acid-forming bacteria (lactobacilli) thrive in oxygen-lacking environments.
- Fermentation is the breakdown of sugars in the absence of oxygen to release energy, carbon dioxide and alcohol or lactic acid.

- The pH scale is a convenient method of expressing the acidity of a solution. A pH of less than 7 is acidic. The lower the number, the higher the acidity.

Time required for exercise: Construct the bottle: 1 hour; set up the fermentation chamber: 1 hour; making kimchee: 7 to 14 days.

Exploratory questions: Ask your students questions and discuss ideas they might have, such as:

- Where does the liquid come from?
- When you push down on the sliding seal, what gas is released?
- Why do you need the sliding seal?
- If cabbage doesn't taste sour, why does the kimchee that's produced taste sour?
- What other foods are made by this process?
- Why does pickling preserve foods?

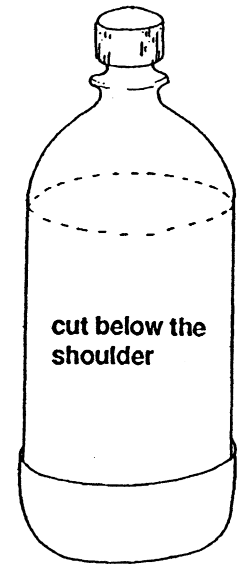


Figure 1

Exploration

1. Cut a 2-liter bottle as indicated in Figure 1. Be sure to cut the top of the bottle just below the shoulder so that it may be used to form the sliding seal (see Step 4).
2. Alternate layers of cabbage, garlic, red pepper and pickling salt in the soda bottle, pressing each layer down firmly until the bottle is packed full. The final layer should be a sprinkling of pickling salt (use up all of the salt). Notice the aroma of the garlic and pepper. These ingredients flavor the

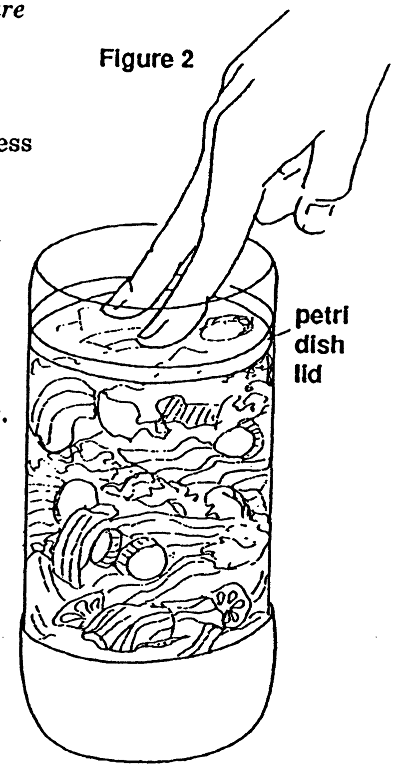
Materials needed:

- one 2-liter soda bottle with cap
- large lid (92 mm diameter) of a plastic petri dish or pint Hagen Daz® lid
- pH indicator paper (Hydrion brand, available from lab suppliers)
- small plastic pipet
- 1-1 1/2 kg head of Chinese cabbage (*Brassica rapa*; also called napa or petsai), leaves cut into 5-7 cm chunks. Do not wash the cabbage!
- 1 hot red chili pepper, chopped (or a small packet of dried red pepper, e.g., from a pizza parlor)
- 2 cloves garlic, thinly sliced
- 3 tsp or 1/2 film can of non-iodized (or pickling) salt

product. *Caution: If working with fresh chili pepper, take care not to touch eyes or mouth. Wash hands thoroughly when finished.*

3. Place petri dish lid, rim side up, on top of ingredients and press down again (Figure 2). Note: Within a few minutes liquid begins to appear in bottom of bottle as salt draws liquid from the cells of the Chinese cabbage.
4. Press down occasionally for an hour or two.* After that there should be sufficient space to fit the cut-off top of the soda bottle into the cylinder, forming a sliding seal (Figure 3).
5. Upon pressing firmly with sliding seal, cabbage juice will rise above the petri plate and air will bubble out around the edge of the petri plate.
6. The Chinese cabbage will pack to two-thirds or half the volume of the bottle. Press daily on the sliding seal. Keep the cabbage covered by a layer of juice at all times.
7. Notice bubbles of carbon dioxide (CO_2) gas escape each day when pressed. The gas is produced as lactic acid bacteria grow on the sugary contents of the Chinese cabbage juice in the salty solution.
8. Measure and record the acidity of the fresh juice on top each day with the pH paper. Tape the indicator paper on the bottle and write the pH (acidity level) above it.
9. Each day take up a quantity of the juice with a plastic pipet and observe the degree of *turbidity* (cloudiness) representing the growth of lactic acid bacteria in the fermentation solution.
10. Note the increase in turbidity and change in acidity together with the continued production of gas as the pickling proceeds.

Figure 2



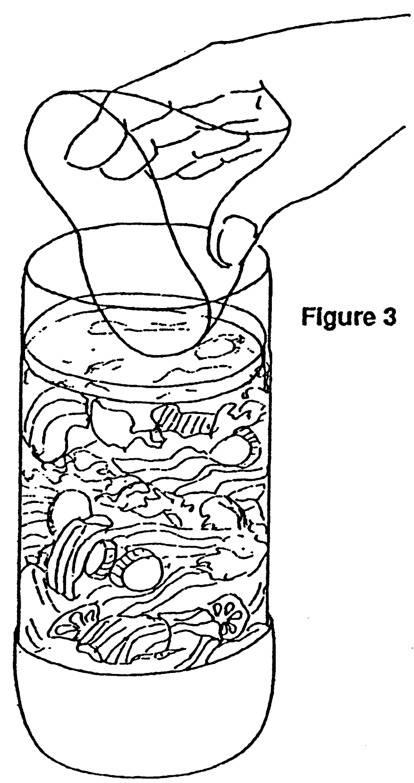


Figure 3

After a few days to a week or more (depending on the room temperature), the pH will have dropped from 6.5 to about 3.5, and you will have kimchee!

* petri dish lids sometimes crack while pressing. One-pint Hagen Daz® lids are perfect.

Accompanying Activities

- A gray-line turbidity strip (Figure 4) for measuring the increasing cloudiness of the juice can be drawn on the side of the plastic pipet with a fine-tipped black marker. Hold pipet with gray line strip away from you. Look through the cabbage juice-filled pipet to the lines on the opposite side. As turbidity increases, the finer, lighter lines will disappear. After some time, the darker lines will become less visible. This provides a quantitative measure of the turbidity.

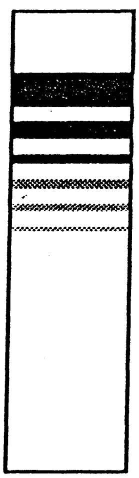


Figure 4: Gray-Line Turbidity Strip

- After the kimchee is mature (pH of 3.5 or less), remove the lid of the kimchee bottle. Let the kimchee bottle stand for one hour, then replace the lid. After a few days, check the chamber for evidence of bacteria or mold. Has there been any bacterial or mold growth in the chamber? Why or why not? Do the same with a can of sauerkraut or a jar of dill pickles. Compare what happens with the results obtained with the kimchee chamber.
- Research the food preservation methods of other cultures. Why and how do various cultures pickle foods?
- When the kimchee is ready, organize a multi-cultural lunch or ethnic food fair. Serve the kimchee, along with foods from other cultures.

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Nasco (1997)

HOO EATS WHO?

MAKING A FOOD WEB

ITEMS NEEDED:
- COPY OF ANIMAL FIGURES SHEET
- TAPE, GLUE, OR PASTE
- BLANK PAPER (11 x 17) OR POSTERBOARD
- SCISSORS
- PENCIL, PEN, OR MARKER

- TURN A LARGE SHEET OF PAPER LONG-WAY. DRAW GRASS, SEEDS, FLOWERS, AND PLANTS ON THE BOTTOM.

- CUT OUT THE ANIMAL FIGURES. AFFIX THE OWL TO THE TOP OF YOUR FOOD WEB.

- ARRANGE THE OTHER ANIMALS ON THE PAGE WITH SPACE TO DRAW ARROWS IN-BETWEEN. PUT GRASS AND SEED EATERS NEAR THE BOTTOM. WHEN THEY ARE ALL ARRANGED, PASTE OR TAPE THEM IN PLACE.

- DRAW ARROWS FROM EACH ITEM TO THE ANIMAL THAT EATS IT. YOU MAY WANT TO DRAW IN OTHER ITEMS SUCH AS WORMS (EATEN BY MOLES, SHREWS, AND BIRDS).

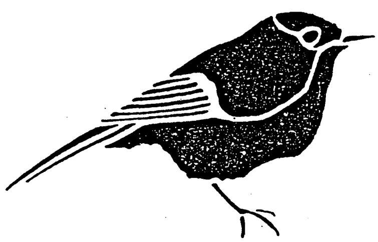
FIGURING OUT HOO EATS WHO:

OWL	eats	FIELD MOUSE, VOLE, BIRD, SHREW, MOLE, LIZARD, GRASSHOPPER, BEETLE, MOTH
FIELD MOUSE	eats	GRASS and SEEDS, GRASSHOPPER, BEETLE, MOTH
VOLE	eats	PLANT ROOTS, GRASS and SEEDS, GRASSHOPPER, BEETLE, MOTH
BIRD	eats	SEEDS, GRASSHOPPER, BEETLE, MOTH
SHREW	eats	GRASSHOPPER, BEETLE, MOTH
MOLE	eats	GRASSHOPPER, BEETLE, MOTH
LIZARD	eats	FLOWERS, SEEDS, GRASSHOPPER, BEETLE, MOTH
GRASSHOPPER	eats	LEAVES, GRASS, SEEDS
BEETLE	eats	LEAVES, FLOWERS, SEEDS
MOTH	eats	FLOWERS

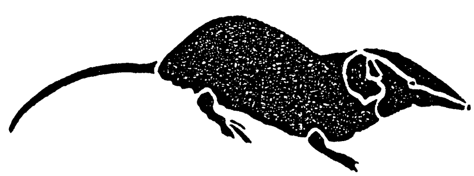
FIELD
MOUSE

VOLE

OWL

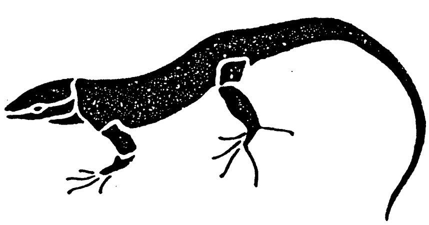


BIRD



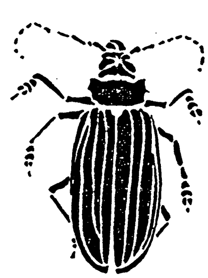
SHREW

MOLE



LIZARD

GRASSHOPPER



BEETLE

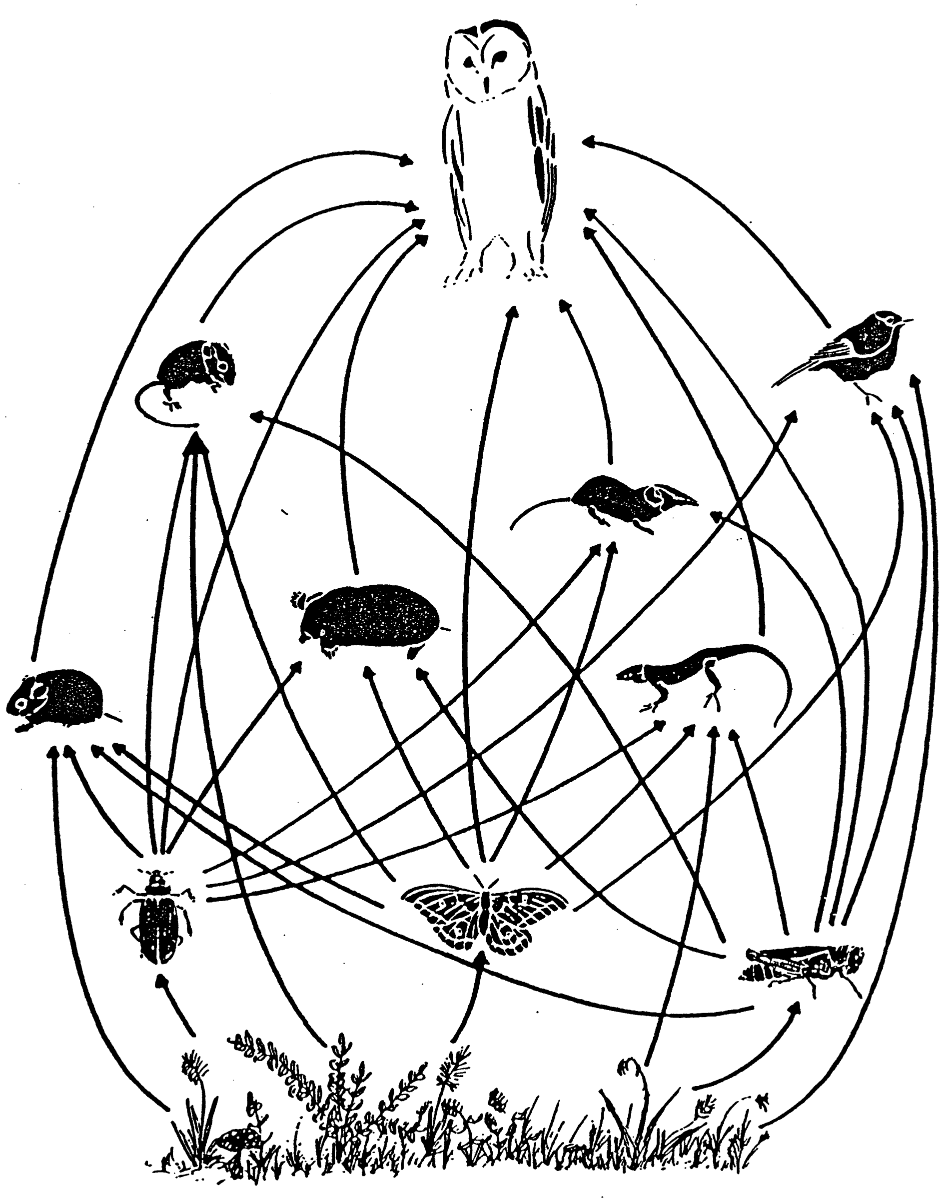
MOTH

HOO EATS WHO?

SAMPLE FOOD WEB AND ACTIVITY SUGGESTIONS

Below is a sample food web using all of the figures provided. If needed, you can simplify the food web by using fewer animals. For example: Owl, Vole, Bird, Shrew, and Grasshopper.

Another option is to make the food web a class activity. The figures can be placed on a sheet of posterboard. Students can draw in additional animals such as worms, frogs, and rats.



Collins

Lesson: Energy Food Science

Grade level: 3
Time to complete: approximately 1 hour and 10 minutes
Rationale:

This lesson will acquaint children with the importance of sap as a source of food for the tree. Just as children need food to grow, so does the tree. We will explore how the tree produces this energy-giving sap and what it contains. This is important so children will understand that all living things need "food" to grow and will come to respect all living things, who like them need an energy source to survive.

Objectives:
1. Students will draw on a worksheet how sap is produced.
2. Students will list three things needed to produce sap in a maple tree.
3. Students will calculate the percent of water and sugar in samples of maple sap.

Procedure:

1. Anticipatory set: Gather children in a group for discussion. What does your body use to create energy? Do all living things make food? What about trees? Remember when we tapped the maple tree? What are we collecting from the tree? Explain to the students that sap is the maple tree's source of food that enables it to grow. (5 minutes).

2. Show children the sap production diagram and give them the handout to be done at their desks while you explain the diagram. Have the students follow along on their handout while you explain the diagram. Sunlight from the sky, carbon dioxide from the air and chlorophyll in the green leaves work together to make the sugar the tree needs. This is called photosynthesis. The sugar mixes with water absorbed by the roots and forms sap. The sap travels throughout the tree to feed it, help it grow, and bear new leaves as well as to keep the tree healthy. Have the children color those parts discussed. (20 minutes).

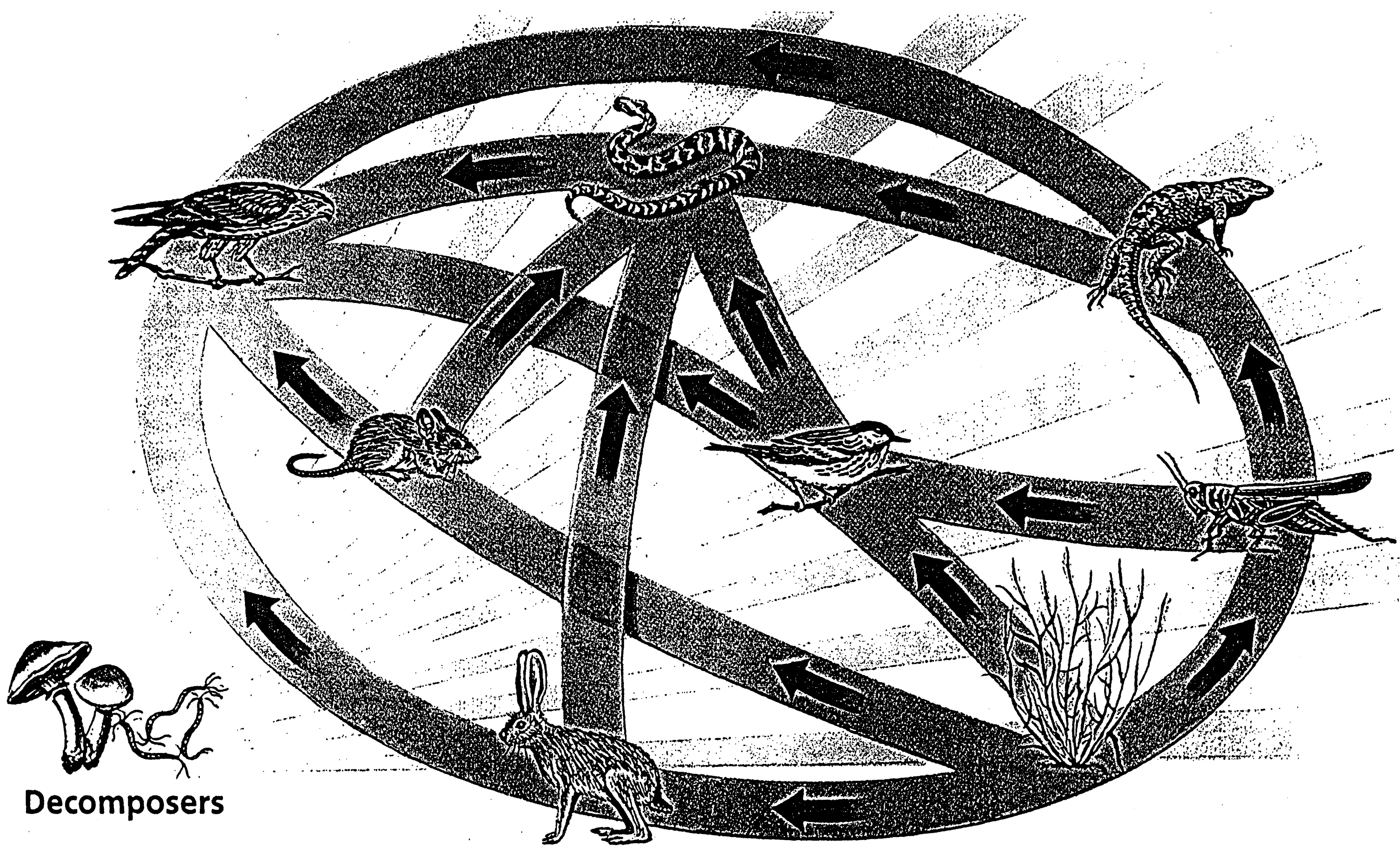
3. Gather students in one large group. Ask students to formulate a guess as to why syrup is so sweet while sap is not. Explain to children that sap is made mostly of water and very little sugar. Much of this water is boiled out to make syrup that is over half sugar. Give an example such as the following: if sap tests 3%, that means in every 100 spoonfuls of sap, there are only 3 spoonfuls of sugar. Syrup made from that sap will have about 66 spoonfuls of sugar in every 100 spoonfuls of liquid. (15 minutes).

4. Now students will get into groups of threes and test the sugar content in the sap that you collected before class. Each group will be given some sap. They will take turns measuring the sugar content using the hydrometer. Do one measurement as an example for children to follow. The students will record readings and calculate how much water and sugar this sap contains using the formula on the worksheet. Children should complete the worksheet with their groups. (25 minutes).

5. Closure: Tell the students, "Now that we have found out how sap is made and measured the sugar content, we will find out if the weather is a factor in how much sap is collected. This will be our next lesson." (2 minutes).

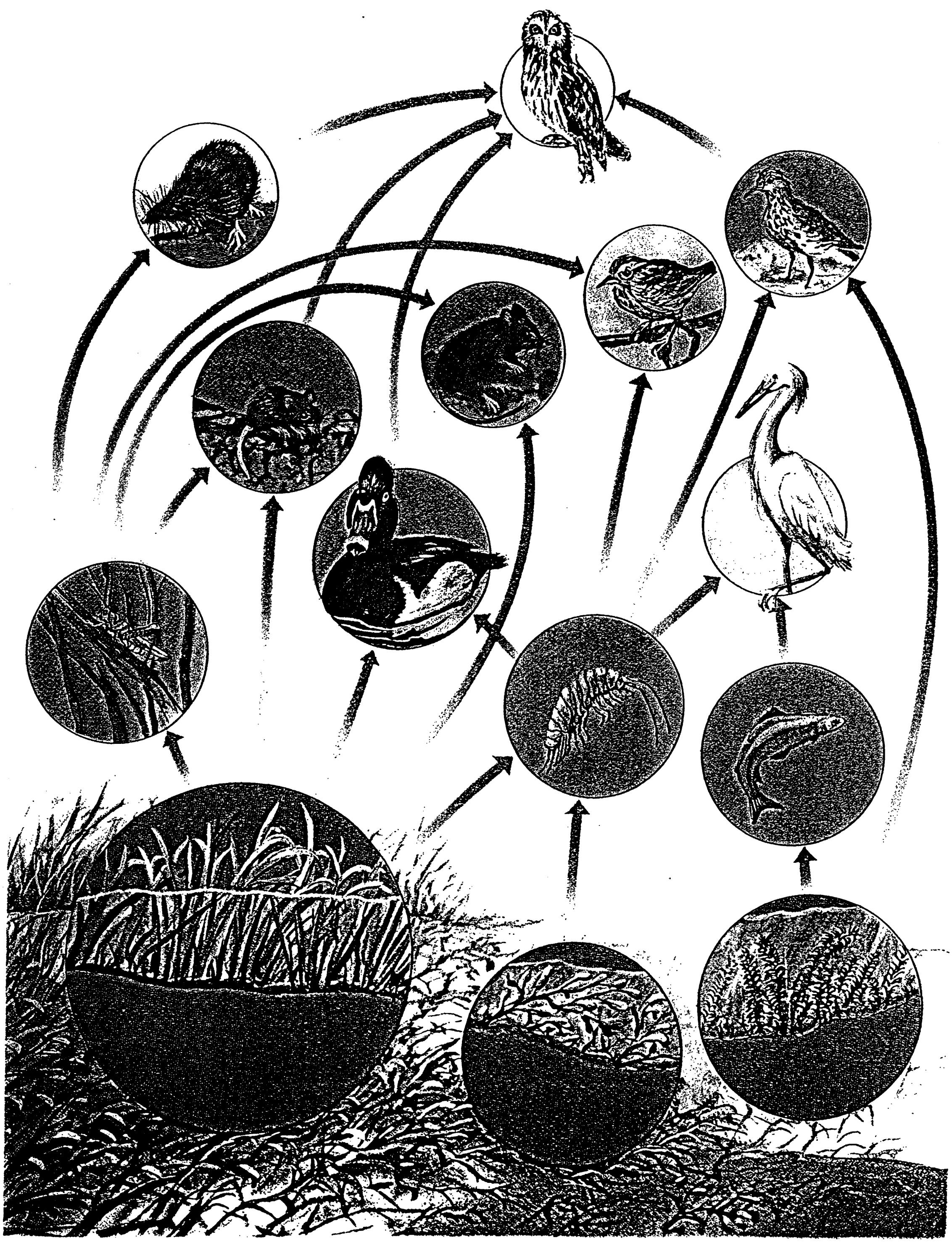
Assessment:

Students will hand in the worksheet about sap production. They will be asked to list on the back three of the four things a tree needs to make sap: water, sunlight, air or carbon dioxide, and chlorophyll. Students will be informally assessed on their guesses during discussion about why sap is not as sweet as syrup. The sap hydrometer reading worksheet will be collected and graded.


Decomposers

(1996)

TIDAL MARSH FOOD WEB



rax, and the posterior metathorax. Each part bears a pair of jointed legs, and the meso- and metathorax each a pair of wings. Identify the leg segments indicated in Figure 1. The anterior wings of the grasshopper are thickened, acting as shields for the larger pair of flight wings. The wings are derived from the cuticle and have thickened portions (veins) which strengthen the wings. Stretch out one pair of wings and examine the anterior protective wings and the flight wings.

The slender abdomen consists of 11 somites, the terminal ones being modified for reproduction. The male has a blunt terminal segment while the female has four conical prongs, the ovipositors, which are used in egg laying (Figure 1). Along the lower sides of the thorax and abdomen are ten pairs of small openings, the spiracles. These connect to a system of elastic air tubes, or tracheae, that branch to all parts of the body and constitute the respiratory system of the grasshopper.

B. INTERNAL ANATOMY

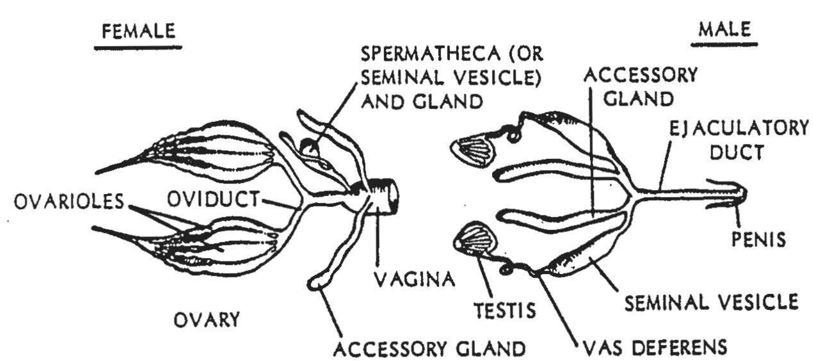
It is difficult to preserve the internal organs of the grasshopper because the preservative often fails to penetrate the exoskeleton. Careful dissection is necessary to study the internal anatomy.

After removing the wings, start at the posterior end and make two lateral cuts toward the head with a pair of scissors or fine scalpel as indicated in Figure 1. Remove the dorsal wall. Locate the muscles on the inside of the body wall, noting their arrangement. What is their function? There is a space between the body wall and digestive tract, the hemocoel, which is a blood space filled with colorless blood.

1. Digestive System

Study the digestive tract and identify its parts (Figure 3). Beginning at the anterior end is the mouth which opens between the mandibles and continues through a short esophagus into the crop. This is followed by the stomach to which are attached six, double, finger-shaped, digestive glands (gastric caeca). The latter produce enzymes which are secreted into the stomach to aid digestion. The digestive tract continues as the intestine which consists of a tapered anterior part, slender middle portion, and enlarged rectum that opens at the anus. During feeding, food held by the forelegs, labium, and labrum is lubricated by secretions from the salivary glands and chewed by the mandibles and maxillae. Chewed food is stored in the crop, digested in the stomach, and absorbed in the intestine. In the rectum, excess water is absorbed from any undigested food.

FIGURE 4. REPRODUCTIVE SYSTEMS OF THE GRASSHOPPER



Nasco (1994)

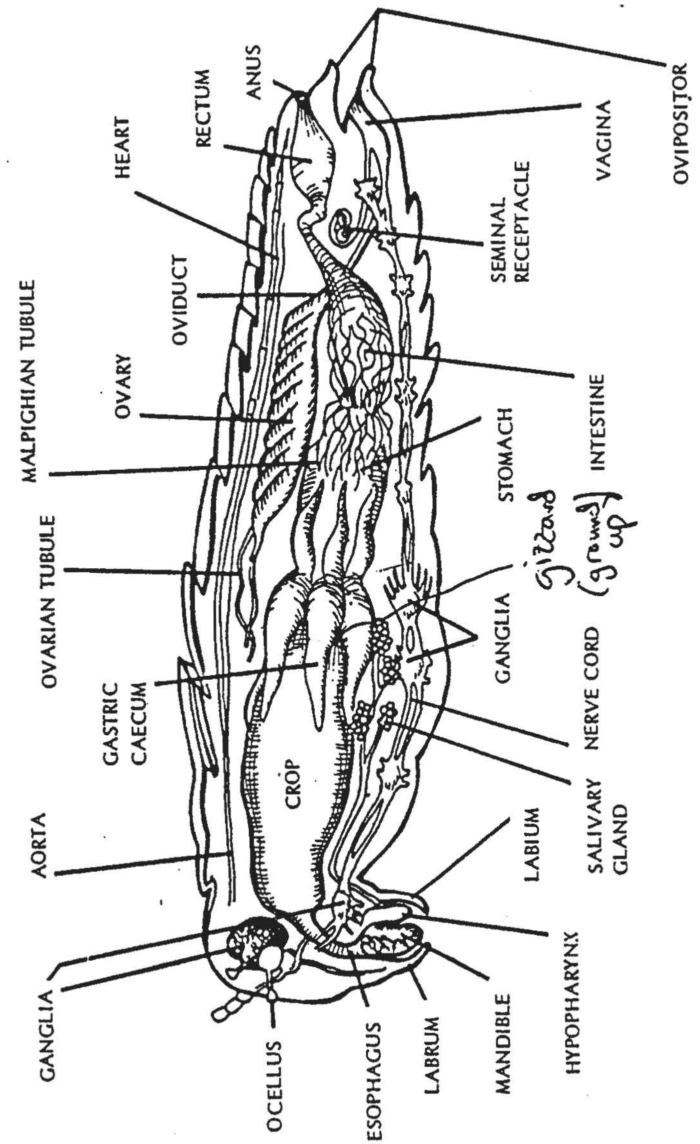


FIGURE 3. INTERNAL ANATOMY OF THE GRASSHOPPER

Jaeger

Energy Jeopardy Questions

Grab Bag

100- What type of energy does our body use? Chemical
200- What is the name of a hybrid car? Prius, Insight, Civic Generator Use / Turn into.
300- Sing 1 School House Rock song. Electricity, electricity, or Energy
400- Sing the other School House Rock song.
500- What state did the SHR song "Energy" say that oil was discovered in? Pennsylvania

Potentially Kinetic

100- What type of potential energy is in a stretched rubber band? Elastic p.e.
200- What type of potential energy is in a book on top of a bookshelf? Gravitational p.e.
300- Can kinetic energy ever be greater than potential energy? No.
400- Why doesn't kinetic energy=potential energy in a bouncing ball? Some energy is lost as heat to the air and some into the ground
500- List the 4 types of potential energy. Elastic, electrical, chemical, gravitational

Alternative Energy

100- List 2 types of alternative energy. Solar, geothermal, hydro, biomass, nuclear, etc.
200- Describe how a wind turbine works. Wind turns turbine which is connected to a generator
300- What are biomass fuels? Energy in organic (once living) things. (Not fossil fuels, things like wood, corn, manure, etc.)
400- What is geothermal energy used to make electricity? Heat from the earth is used to heat water to make steam.
500- What are 2 drawbacks to using nuclear energy? Storage of waste, radioactivity, possibility of meltdown

Labs

100- Name 3 labs we did. Pendulums, generators, rollercoaster, simple machines, mining coal,etc

200- Why did we build the roller coaster? To show k.e. and p.e. and how it changes

300- What did the cookie represent in the mining coal lab? Chips=coal cookie=earth

400- What did the pendulum lab show? P.e. changing to k.e. and how it increases the higher you lift the pendulum

500- List 5 of the 6 types of simple machines

Energy Production

100- What are 2 things burned to make electricity? Coal, natural gas, garbage, etc.

200- Why do you need to burn things to produce electricity? To heat water for steam

300- How do you get electricity to travel long distances through wires? Increase voltage

400- What does a transformer do? Changes voltage

500- How does a generator work? Spins wire coils in a magnetic field which produces elec.

Energy Terms

100- kinetic energy- energy of motion

200- potential energy- stored energy

300- turbine- a fan used to spin a generator

400- static electricity- energy at rest

500- Law of conservation of energy- energy cannot be created or destroyed

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Lesson 1 Introduction to Energy Time estimate: 5 days

Goals and Objectives:

1. Understand the basic language and terminology related to energy.
2. Understand the different types of energy as well as kinetic and potential.
3. Understand how energy can be converted from one form to another.
4. Understand that energy is not created or destroyed.
5. Practice making adjustments to settings on rubber band cannons to hit a desired target.

Simple Machines

Procedure:

I will begin by assessing what the students' previous knowledge of energy and energy concepts is. Then, we will go into notes and discussion about the main topics related to energy. I would have them do vocabulary to reinforce the terminology of the section. I would also do an activity with rubber band cannons that allows them to see differences with potential and kinetic energy with projectiles.

Assessment Strategy:

I would give a test on concepts and vocabulary. For the rubber band cannon activity, I would grade it based on the student's ability to make adjustments to their settings to improve their capability to hit a desired target. This would be approached as a lab activity.

Lesson 2 Energy Conversions Time estimate: 5 days

Goals and Objectives:

1. Understand how energy can be converted from one form to another.
2. Be able to recognize the different types of energy.
3. Be able to recognize the different types of energy in a closed system.
4. Build a catapult and understand how it works and how it converts energy.
5. Build a roller coaster and recognize where potential and kinetic energy are the greatest.

Procedure:

I would start this section by reviewing the different types of energy and reviewing Newton's law of energy conversion. A worksheet on this topic reinforces the ideas and gives them practice recognizing types of energy conversion. I would then provide materials for the students to build small models of working catapults used to launch ping pong balls. The students would build these in teams of 2 to 4. Then, we would build a model roller coaster out of K'nex, and study the ways potential and kinetic energy change throughout a roller coaster track.

Assessment Strategy:

Assessing the worksheet would simply be done by grading. The catapult and the roller coaster exercises are done as labs and can be graded by seeing how the students put their things together and if they are taking energy into account as they design their projects. Oral quizzes along the way can also measure if real learning is taking place. Each group would have to demonstrate their machines and describe how they work to get full credit. They need to know what is going on to be able to do this.

Lesson 3 Energy Production Time estimate: 4 days

Goals and Objectives:

1. Understand how energy is produced and what steps are used.
2. Understand the process of mining coal and its effects on the environment.
3. Understand how coal is used in Wisconsin.
4. Understand the problems associated with coal mining.
5. Understand how certain devices have better energy efficiency than others.

Do Generator Lab.

Procedure:

To begin this lesson, I would talk about the steps needed to produce the majority of the electricity in Wisconsin. I would discuss the steps in producing electricity for a power plant. I would also discuss how electricity gets from the power plant to a person's home. Then, we would do the mining cookies experiment so students could see how mining can affect the surrounding land. They also would experience how difficult it can be to restore the land to its natural state. After that activity, we would talk about how inefficient things in our home can be by doing the Diminishing Returns Activity.

Assessment Strategy:

To assess how students are learning about the steps in electricity production, we could have a quiz or open discussion about it. I also might have them write about the steps in a journal or have them draw diagrams to reinforce the learning as well. For the Mining Cookies experiment, I would assess them by their answers to questions posed after the experiment was over. The questions asked in this exercise really makes them think about what the significance of the cookie was and how it pertains to the land. For the last activity, I would just have a discussion with each student about their feelings about their own home and how efficient it is as well as having them write a report rating their own home for energy efficiency.

Lesson 4 Conservation and Wise Use of Energy Time estimate: 3 days

Goals and Objectives:

1. Understand the main types of pollution and how they affect our environment.
2. Understand ways to reduce the main types of pollution through personal activities.
3. Understand the need for maintaining our natural resources.
4. Understand why burning is not the best solution for everything.
5. Calculate the energy use of appliances in their home and compare them.
6. Analyze ways they might be able to save energy

Procedure:

First, I would discuss the different types of pollution with the students. I would go over book material and give them a lot of information on the production and dangers of pollution. We would also discuss why resource conservation is important. I particularly would emphasize that everyone can do something in helping reduce pollution and save resources. I would spend a short amount of time on the Energy and the Environment Energy Spark and then move on to the At Watt Rate? activity.

Assessment Strategy:

To assess the students learning about pollution, I would give them various situations or factories and ask them to tell me what type of pollution may be produced. I also may have them write about ways they could reduce pollution that they or their family might produce. I would have them complete an appliance survey of their home and ask them to give a report to the class about the types of appliances they have and their energy efficiency. They also should suggest ways they could increase the energy efficiency of their home.

Lesson 5 Alternative Energy Sources Time estimate: 6 days

Goals and Objectives:

1. Understand the different types of alternative energy sources.
2. Understand how electricity can be generated using these sources and a turbine.
3. Research design a project using a solar cell.
4. Understand how to build a solar oven and how to use it.

Procedure:

I would begin this section on alternative energy sources by presenting information on different types of energy sources like solar and wind power. I would present information on the benefits and drawbacks of each type. We then would learn about how turbines are used with these alternative energy sources to produce electricity. Once we have learned about these, we would do a project where students would research a project and design a machine that would be powered by solar cells. After this, then we would build solar ovens to finish our unit on energy and energy sources.

Assessment Strategy:

To assess student learning after talking about the different energy sources, I would give the students a quiz and then ask them to write about the energy types in a journal. I would also have them draw turbines and describe the basic parts of them. I would assess their efforts on the research and design project by how possible it might be to actually build and its feasibility. I would have them present their projects to the class. For the solar oven, I would grade that based on their ability to cook food. If their oven works, then it is a success. I would grade the entire unit on a final exam and a one page writing assignment where they would describe what part of the unit meant the most to them and why.

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GENERATOR LAB

Problem: How do generators transform energy?

Materials: generator, wire leads, light bulb, compass, motor

Procedure:

1. Wind one of the two wire leads around a compass with the wire running in the direction of the needle. Clip the clips together. Turn the generator's crank slowly and observe what happens. Turn the crank in the other direction. Observe the direction of needle deflection. Record these observations on your lab.

2. Attach the A lead of one generator to the B lead of another generator. Then attach the B lead of the first one to the A lead of the second. Turn the crank of <u>ONE</u> generator and observe what happens. Turn the crank in the other direction. Observe.

3. Attach the leads of the generator to a light bulb assembly. Turn the crank at varying speeds. Do not turn it too fast. Observe the changes in the light bulb. Switch the leads and turn the crank again. Observe.

4. Attach the wire leads to the wires of a motor and turn the crank at varying speeds. Observe.

Questions:

1. What happens to the compass when you turn the crank? Did the direction of the needle deflection change when you turned the crank in the other direction?

2. What happens when you turn the crank of one generator? Why? What happened when you turned the crank the other way?

3. What happens when you turn the crank when it is clipped to a light bulb? What happens when you turn the crank faster? Why?

4. What happens with the motor when you turn the crank? What would you normally hook a motor of this type up to? Why is the motor working with the generator?

5. What does a generator do? What type of energy is it converting in these experiments? What does the light bulb convert electrical energy into?

6. How does the amount of mechanical energy put into the generator affect the amount of electricity produced? (How fast you turn the crank.)

7. How would your life change if you could no longer use electricity? Describe what you would do.

Schoolhouse Rock Lyrics - 1973

ENERGY

Energy, sometimes I think I'm running out of
Energy, seems like we use an awful lot for
heating and lighting and driving reading and writing and jiving.
Energy you'd think we'd be saving it up.

Energy you can get it by damming up a river.
Energy a windmill can make the breeze deliver.
But even with milling and damming our needs are much more demanding
for energy we have to use some kind of fuel.

Chop, chop, chop the cave men used wood to start their fires.
Chop, chop, chop they made all the tools that they required.
Chop, chop, chop inventions got more and more inspired.
The fires got higher and higher, the clearings got wider and wider.
Energy they were burning about all their wood up.

Then one day, men discovered that coal would do it better.
Mining starts and it looked like it just might last forever.
It seemed like the final solution.
It started the industrial revolution.
Energy we could just keep on digging it up.

Spoken:
Now in 1859, way out in western Pennsylvania, a man had built a rig that got some laughs from folks who came there. But suddenly a mighty roar came up from under the ground. Soon a gusher ~~of oil~~ gushing oil soaked all who stood around. Now noone knew, when that gusher blew, that the petroleum years were on us. Or that so many cars and trucks would come and cause a crisis.

Sung:
Energy we're looking to try and find some new kinds.
Energy exploring to try and ~~find a new kind~~. make a new find
Nuclear and thermal and solar,
If we miss we'll get colder and colder.
Energy we gotta to stop using you up.

So don't be cross when momma says turn that extra light out.
Just turn it off 'til we find a fuel that never runs out.
If everyone tries a bit harder
our fuel will go farther and farther.
Energy we're gonna be stretching you out.

ELECTRICITY, ELECTRICITY

When you're in the dark and you want to see. You need, Electricity, Electricity
Flip that switch and what do you get? You get, Electricity, Electricity
Every room can now be lit, with Electricity, Electricity
Where do you think it all comes from, this powerful Electricity, Electricity
Through high wires to here, it comes we're bringin' the Electricity, Electricity
Every building must be wired to use it. Electricity, Electricity
Power plants most all use fire to make it. Electricity, Electricity
Burning fuel and using steam they generate, Electricity, Electricity
Turn that generator by any means you're making Electricity, Electricity

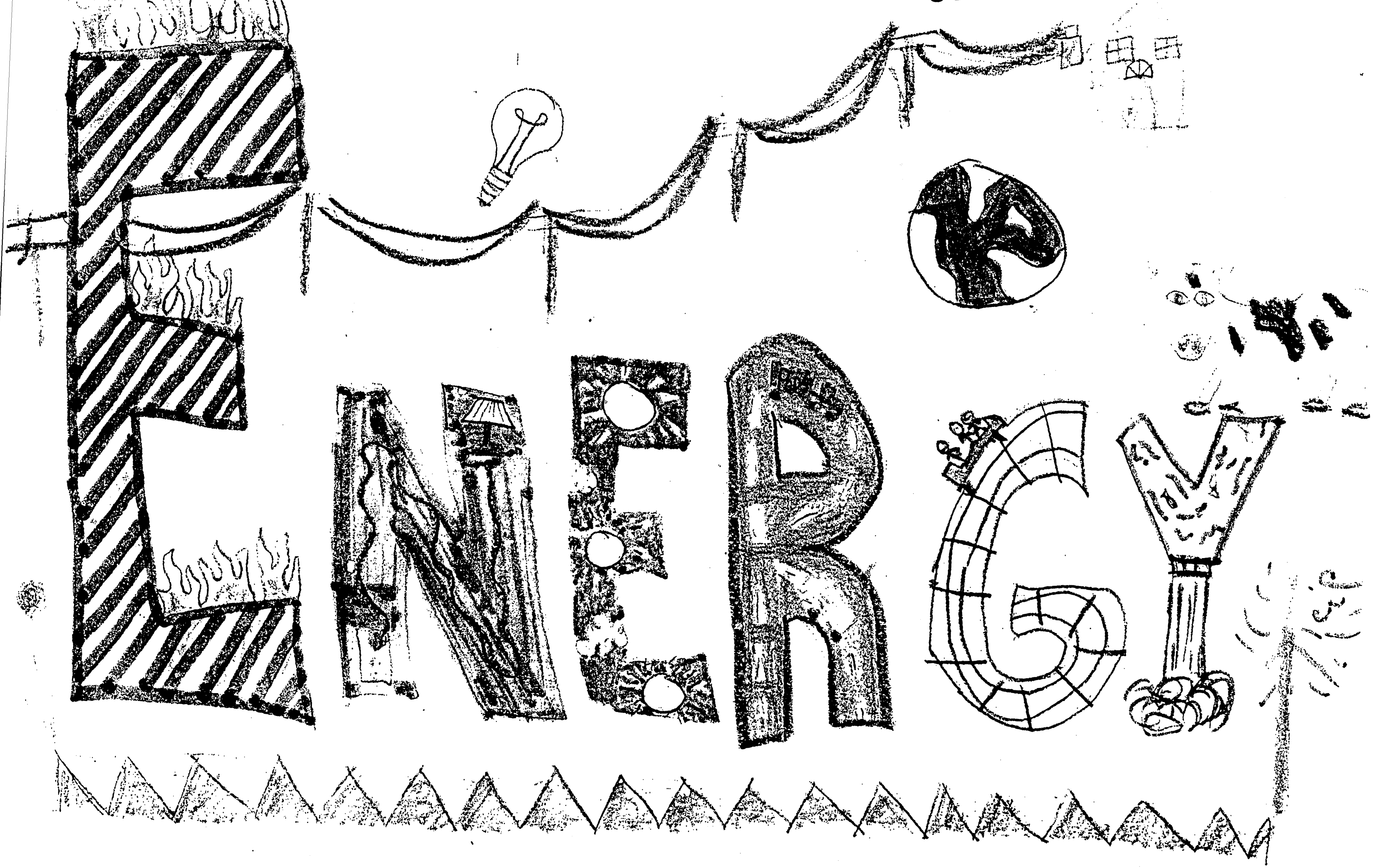
Spoken:
A generator is a machine that contains a powerful magnet that creates a magnetic field. When wires are rotated rapidly through this field, then a current of electricity is produced. Now, if we only had a superhero who could stand here and turn the generator real fast, then we wouldn't need to burn so much fuel to make Electricity.

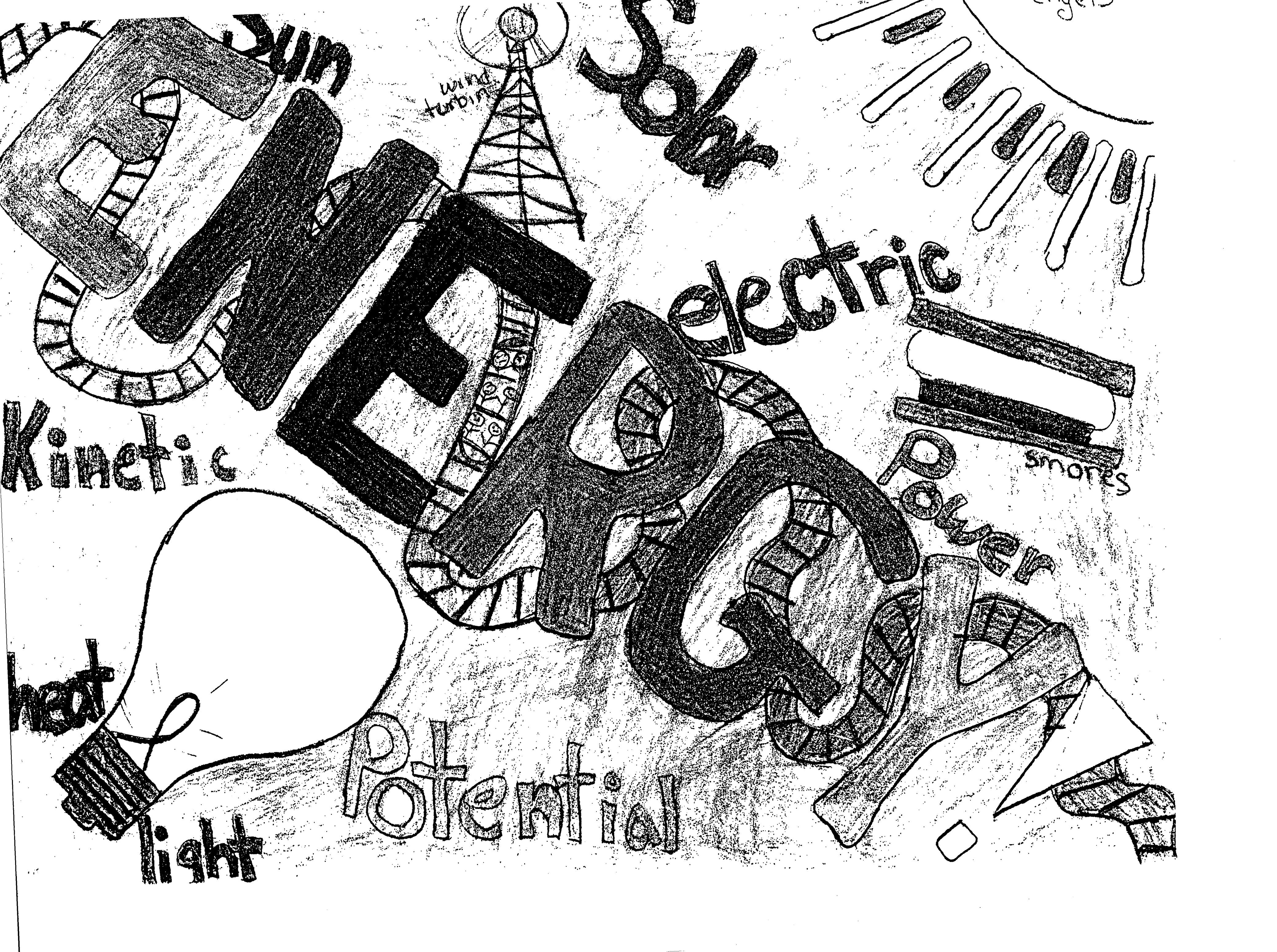
Sung:
Benjamin Franklin flyin' his kite, he was searchin' for Electricity, Electricity
He knew it had something to do with lightening it's all Electricity, Electricity
Rubbin' a comb with wool or fur will give you a charge of Electricity (Static) Electricity
Strokin' a cat to make ~~him~~ it purr, your building up static Electricity, Electricity

Spoken:
Electricity at rest is called static electricity. Like in the winter when you're wearing a heavy coat, and you get a shock off the door knob. Or you scrape across the carpet and sneak up on your very best friend and zap him on the ear with a shock or electricity.

Sung:
Current flowing to and fro makes a curcuit of Electricity, Electricity
Voltage is the pressure that makes it go its pushing the Electricity, Electricity
Watts will tell you just how much you'll be using of Electricity, Electricity
Powerful stuff so watch that plug! It's potent Electricity, Electricity
Electricity, Electricity
Electricity, Electricity

ENERGY COLLAGES - JAEGER




ENERGY
Sun
wind turbine
Solar
electric
Kinetic
Power
smores
heat
light
Potential

Appendix D

Energy Activities and State Standards
Correlation Matrix

Energy Activities and State Standards

	Eagle Population	Bears in the Forest	Grasshopper dissection	Generators	Pendulums	Cell Kool-Aide	Winne-the-Pooh Video	Fruit Of the Trees	FoodWebs	Alternative Energy
Science Standards										
A.8.8	X	X					X	X	X	X
D.8.5				X	X					X
D.8.7	X	X	X	X	X	X	X	X	X	X
D.8.8				X	X			X	X	X
D.8.9			X			X				X
D.8.10				X						X
F.8.1	X	X	X			X	X			
F.8.8	X	X	X				X	X	X	
EE Standards										
B.8.1	X	X	X				X	X	X	
B.8.2	X	X	X						X	
B.8.3			X						X	
B.8.6			X					X	X	
B.8.7			X			X		X	X	
B.8.8	X	X	X						X	
B.8.9	X	X	X							X
B.8.10	X		X							X

Appendix E

Energy Test

What Do You Know About Energy?
Survey Sheet

Answer the following questions **on the answer sheet only. DO NOT MARK ON THIS SURVEY SHEET!!** For each question, fill in only the one circle that corresponds to the best possible answer. Try your best to answer each question, but if you really don't know the answer, mark "don't know.

1. What is the Earth's primary source of energy?
   1. Coal
   2. Oil
   3. Sun
   4. Natural gas
   5. Don't know

2. Which of the following energy resources is NOT a renewable energy resource?
   1. Geothermal energy
   2. Natural gas
   3. Solar energy
   4. Wind energy
   5. Don't know

3. Each and every action on Earth involves....
   1. energy
   2. food
   3. sun
   4. water
   5. don't know

4. An animal that can get its energy from either producers or consumers is a...
   1. carnivore
   2. herbivore
   3. omnivore
   4. severe
   5. don't know

5. A rabbit eats some corn. The energy from the corn goes into the rabbit. The next day a fox eats the rabbit. The fox gets very little of the energy that was in the corn. Why?
   1. Corn doesn't have much energy.
   2. A Fox can't digest corn.
   3. Most of the corn's energy was used by the rabbit.
   4. The rabbit has already digested the corn.
   5. Don't know

6. Which of the following would give humans the most food energy from 1,000 pounds of plants? (Assume the plants are good for people to eat.)

   1. Feed the plants to insects; feed the insects to fish, then humans eat the fish.
   2. Humans eat the plants.
   3. Feed the plants to cattle, then humans eat the cattle.
   4. Feed the plants to fish, then humans eat the fish.
   5. Don't know

7. Heat transferred by contact from a warm object to a cooler object is called...

   1. convection
   2. radiation
   3. conduction
   4. decomposition
   5. don't know

8. Many people say that the Earth's average temperature is increasing. The say that one important cause of this change is ....

   1. acid rain
   2. rising ocean levels
   3. the sun is moving closer to the earth
   4. using fuels like gasoline that burn and release carbon dioxide.
   5. Don't know

9. Burning coal for energy ...

   1. decreases needed acid rain
   2. is a renewable resource
   3. reduces the amount of ozone in the stratosphere
   4. releases carbon dioxide and other pollution into the air
   5. don't know

10. Acid rain is a problem because ...

   1. it may break down the layer of ozone in the Earth's atmosphere
   2. it may cause a slow change in Earth's temperature
   3. it may harm plants by affecting their leaves and changing the soil they grow in
   4. people may have to stay indoors when it's raining
   5. don't know

11. Coal and petroleum are examples of...

   1. alternative energy sources
   2. fossil fuels
   3. recycled resources
   4. renewable energy sources
   5. don't know

12. An example of a non-renewable energy resource is ...

   1. animals raised for food
   2. ocean water
   3. petroleum
   4. trees
   5. don't know

13. One suggested advantage of using nuclear power plants instead of coal or oil for energy production is…

1. Nuclear power plants are not expensive to build
2. The waste products are easy to store
3. There is less air pollution
4. They are totally safe
5. Don't know

14. Wood was the main energy resource used in Wisconsin to heat homes in the 1700's. When Wisconsin became an industrial society in the mid 1850's, which of the following became the primary energy source for heating homes?

1. Coal
2. Oil
3. Natural gas
4. Propane
5. Don't know

15. Humans use energy from coal and oil by burning them. Another source of energy for humans is…

1. a furnace
2. a well-insulated home
3. cold water
4. the sun
5. don't know

16. Which type of energy will be available for human use for the longest period of time?

1. Coal
2. Oil
3. Solar energy
4. Don't know

17. Lights, many kitchen appliances, televisions and computers all require electricity to work. The energy needed to produce electricity comes from…

1. burning fossil fuels or nuclear resources
2. dams on rivers
3. windmills
4. all of the above
5. don't know

18. Which energy source do scientists think will in short supply in the next several hundred years?

1. Oil
2. The sun
3. The wind
4. Water flowing over a dam
5. Don't know

19. Fewer resources are wasted when shoppers buy things that...
   1. **are disposable**
   2. **are in containers that can be used again**
   3. **are wrapped separately so they stay clean and new looking**
   4. **have a label saying they are made from natural products**
   5. **don't know**

20. Which form of energy is involved in writing?
   1. **Kinetic energy**
   2. **Mechanical energy**
   3. **Potential energy**
   4. **Both 1 and 2**
   5. **Don't know**

21. How do you know that a piece of wood has stored potential energy?
   1. **it can be converted into other things such as paper and furniture**
   2. **it is a stationary object**
   3. **it releases heat when burned**
   4. **it was once a living thing**
   5. **don't know**

22. Electric current is the flow of...
   1. **atoms**
   2. **electrons**
   3. **neutrons**
   4. **protons**
   5. **don't know**

23. The process of photosynthesis in green plants...
   1. **changes chlorophyll into sugar**
   2. **changes light energy into chemical energy**
   3. **is a process used to burn sugar stored in plants so the plants can grow**
   4. **uses sunlight to burn energy in plants**
   5. **don't know**

24. What is the primary renewable energy resource used in Wisconsin?
   1. **Hydroelectric power**
   2. **Petroleum**
   3. **Solar Power**
   4. **Wood**
   5. **Don't know**

25. Which of the following items found in many homes uses the most electricity per hour of use?
   1. **Lights**
   2. **Refrigerator**
   3. **Telephone**
   4. **Television**
   5. **Don't know**

Name ____________________________ Grade _____

What Do You Know About Energy?
Answer Sheet #2 (May 2002)

From the colored survey sheet, read the question and all possible answers completely. Then on this answer sheet, fill in the circle of the best possible answer.

1.	1	2	3	4	5
2.	1	2	3	4	5
3.	1	2	3	4	5
4.	1	2	3	4	5
5.	1	2	3	4	5
6.	1	2	3	4	5
7.	1	2	3	4	5
8.	1	2	3	4	5
9.	1	2	3	4	5
10.	1	2	3	4	5
11.	1	2	3	4	5
12.	1	2	3	4	5
13.	1	2	3	4	5
14.	1	2	3	4	5
15.	1	2	3	4	5
16.	1	2	3	4	5
17.	1	2	3	4	5
18.	1	2	3	4	5
19.	1	2	3	4	5
20.	1	2	3	4	5
21.	1	2	3	4	5
22.	1	2	3	4	5
23.	1	2	3	4	5
24.	1	2	3	4	5
25.	1	2	3	4	5
26.	1	2	3	4	5
27.	1	2	3	4	5
28.	1	2	3	4	5

Appendix F

Energy Test Results
Raw Data

CONTROL GROUP			EXPERIMENTAL GROUP		
6th grade Pre-Test	6th grade Post-Test	Change	6th grade Pre-Test	6th grade Post-Test	Change
8	8	0	8	11	3
9	13	4	10	16	6
16	16	0	9	20	11
8	9	1	3	18	15
14	15	1	10	15	5
9	9	0	14	17	3
15	13	(-2)	8	18	10
12	17	5	12	17	5
4	17	13	4	10	6
8	11	3	17	18	1
16	18	2	11	15	4
18	19	1	10	18	8
10	14	4	9	21	12
14	13	(-1)	7	17	10
7	12	5	10	16	6
3	10	7	10	11	1
12	15	3	20	25	5
11	20	9	13	17	4
14	18	4	10	20	10
13	8	(-5)	12	11	(-1)
15	16	1	8	8	0
6	9	3	16	17	1
13	14	1	8	15	7
11	9	(-2)	9	20	11
16	10	(-6)	8	8	0
13	15	2	6	21	15
12	16	4	7	8	1
12	10	(-2)	9	10	1
15	9	(-6)	8	11	3
16	21	5	13	18	5
11	8	(-3)	15	17	2
16	16	0	7	14	7
9	13	4	8	19	11
17	13	(-4)	15	17	2
13	21	8	10	12	2
9	9	0	10	16	6
12	13	1	5	15	10
14	15	1	16	15	(-1)
15	19	4	14	21	7
6	5	(-1)	14	18	4
19	16	(-3)	7	19	12
14	11	(-3)	8	19	11
20	23	3	11	11	0
12	15	3	11	16	5
19	19	0	12	20	8
4	9	5	12	19	7
2	6	4	12	13	1
12	17	5	6	15	9
12	15	3	8	9	1
11	8	(-3)	8	16	8
11	16	5	10	19	9
5	8	3	11	14	3
8	9	1	12	20	8
4	6	2	10	7	(-3)
10	15	5	13	16	3
9	9	0	13	17	4
9	8	(-1)	8	14	6
8	7	(-1)	8	16	8
15	15	0	13	18	5
10	19	9	10	13	3
11	14	3	10	17	7
16	17	1	14	20	6
20	22	2	11	20	9
16	17	1	9	15	6
6	9	3	11	15	4
13	16	3	12	20	8
13	18	5	7	15	8
15	15	0	16	17	1
12	19	7	6	9	3
9	14	5	3	23	20
12	12	0	9	11	2
13	14	1	14	13	(-1)
12	16	4	9	18	9
18	21	3	11	16	5
6	10	4			
8	10	2			
10	12	2			

CONTROL (class of 2003)			EXPERIMENTAL (Class of 2004)		
7th grade Pre-Test	7th grade Post-Test	Change	7th grade Pre-Test	7th grade Post-test	Change
11	12	1	5	7	2
8	11	3	13	14	1
13	12	(-1)	16	19	3
17	14	(-3)	6	10	4
8	6	(-2)	19	23	4
13	18	5	5	8	3
13	15	2	12	18	6
11	9	(-2)	13	17	4
12	13	1	16	19	3
13	14	1	12	16	4
18	15	(-3)	11	8	(-3)
15	14	(-1)	17	19	2
13	18	5	16	19	3
16	16	0	18	20	2
9	10	1	10	15	5
11	16	5	11	12	1
10	10	0	17	19	2
11	15	4	15	17	2
12	11	(-1)	17	12	(-5)
9	10	1	19	17	(-2)
10	14	4	17	20	3
11	6	(-5)	10	10	0
14	17	3	12	9	(-3)
18	19	1	11	12	1
10	15	5	6	11	5
8	2	(-6)	14	18	4
11	14	3	7	8	1
18	16	(-2)	8	11	3
9	13	4	16	21	5
12	16	4	9	15	6
18	22	4	15	16	1
16	16	0	14	18	4
11	9	(-2)	11	12	1
15	17	2	13	15	2
13	15	2	11	13	2
15	16	1	13	17	4
24	23	(-1)	15	19	4
22	22	0	14	18	4
16	17	1	20	23	3
17	14	(-3)	17	19	2
15	12	(-3)	18	23	5
21	18	(-3)	15	16	1
9	14	5	11	13	2
16	16	0	14	7	(-7)
19	16	(-3)	12	15	3
14	18	4	13	16	3
10	8	(-2)	8	12	4
10	12	2	19	21	2
14	14	0	7	3	(-4)
18	15	(-3)	18	17	(-1)
9	12	3	12	14	2
15	15	0	12	17	5
9	9	0	13	9	(-4)
9	11	2	9	10	1
15	12	(-3)	14	19	5
9	6	(-3)	19	19	0
14	17	3	16	16	0
13	14	1	12	16	4
15	18	3	19	22	3
5	7	2	18	20	2
9	11	2	8	16	8
14	16	2	13	20	7
3	8	5	17	20	3
8	13	5	17	19	2
15	13	(-2)	10	14	4
12	9	(-3)	16	18	2
3	7	4	12	18	6
21	20	(-1)	15	17	2
9	15	6	15	19	4
13	19	6	17	17	0
16	18	2	13	9	(-4)
12	16	4	18	20	2
10	12	2	9	14	5
14	17	3	9	13	4
19	10	(-9)	10	15	5
17	17	0	13	18	5
6	13	7	12	9	(-3)

Appendix G

T-test procedure

T-test Procedure

Written Procedure:

Step 1: Calculate average difference in means of two data sets

Step 2: Calculate t-statistic, based on the variance and the number of subjects in each group.

Step 3: Convert the t-statistic into a probability value of the null hypothesis being true

Step 4: Accept or reject null hypothesis. Use t-table to calculate probability of hypothesis being true.

Sample data (from 6th grade difference in mean test scores):

Step 1: Avgdif = 5.58 – 1.91 = 3.67

Step 2: tstat $= \text{avgdif} \div \text{sqrt}(\text{var}_1/n_1 + \text{var}_2/n_2)$
$= 3.67 \div \text{sqrt}(10.54 / 77 + 14.72 / 74)$

Step 3: prval (tstat, df = 100) = 3.4513 e^{-9}

Step 4: tstat > 3 99% probability hypothesis is true