Mathematics, Science & Technology

PART II.7

NOTE: This document is a work in progress. Parts II and III, in particular, are in need of further development, and we invite the submission of additional learning experiences and local performance tasks for these sections. Inquiries regarding submission of materials should be directed to: The Mathematics, Science, and Technology Resource Guide, Room 681 EBA, New York State Education Department, Albany, NY 12234 (tel. 518-474-5922).

NEW YORK
THE STATE OF LEARNING

http://www.nysed.gov

ELEMENTARY

Standards & Performance Indicators

How Gear Systems Work:

A Research Project

MST 1
- ▲ generate ideas/solutions
- ▲ plan and build

MST 5
- ▲ possible solutions
- ▲ plan and build
- ▲ test solution
- ▲ design/construct

MST 6
- ▲ analyze/construct/operate models
- ▲ different than real thing
- ▲ represent aspects of real world
- ▲ simple instruments

MST 7
- ▲ design solutions
- ▲ observe phenomena
- ▲ work effectively
- ▲ generate/analyze ideas
- ▲ realize results

Bradford J. Helmer, Jr., Richard T. Davis

Massapequa School District

Massapequa High School, 4925 Merrick Rd.

Massapequa, NY 11758

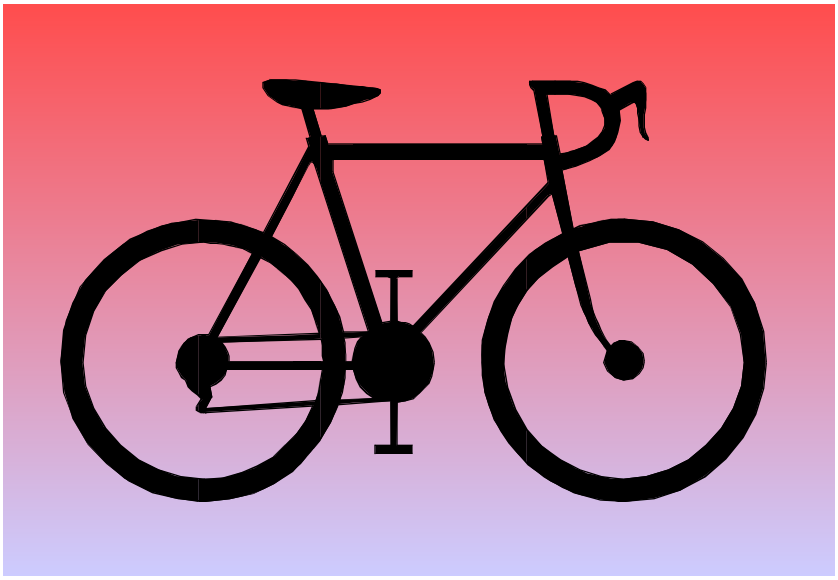
(516) 797-6110, (516) 797-6663

http://www.massapequa.k12.ny.us/msd/techdept/4thgr/fairnew.htm

Grade 4

Curriculum Connections

This learning experience has been developed to introduce fourth grade students to the major concepts contained within Technology Education curricula. Among these concepts are: mastering of curriculum by means of directed, hands-on learning; the manipulation of mathematics concepts and science theory to demonstrate real-world applications of their school curriculums; and the introduction of a structured method of brainstorming and problem solving, by which students can forward their own designs and solutions to real-world type problems.



Capsela Learning Systems

These learning systems contain all the gear systems, wiring, switches, wheels, and everything mentioned in our experiments. For a typical class of twenty two students, we use 12 of the *Capsela 1000* kits. We try to keep student teams limited to only two students, with one additional kit for instructor demonstrations, as well as emergency replacement parts. The kits, at a cost to us of $55.00, have provided good service at a reasonable cost.

There were several reasons for our selection of the *Capsela Learning Systems*. First and foremost was the usability issue with the fourth grade student population. All of the Capsela equipment is quick and simple to assemble, requiring no special hand tools since it has plastic connectors and plug-in type wiring connections. Another feature that made the *Capsela Learning Systems* attractive was how the motor, batteries, and all gear systems are contained in clear plastic, allowing the students the opportunity to see the various gear systems in operation. The final reason for the *Capsela Learning Systems* selection was the issue of expanding our curriculum with the vast number of different activities that could be supported by these relatively inexpensive systems.

Our *A Research Project: How Gear Systems Work* challenges the students to apply information regarding simple machines introduced as part of their regular science curriculum along with a new mathematics concept for fourth grade students: ratios. The teacher introduces the concept that technology is, by definition, the application of scientific knowledge and mathematics concepts to solve a problem, resulting in an improvement in the human condition.

Students are introduced to the technology of the wheel and axle, and learn that by applying a new technology, the gear tooth, designers and planners were able to construct systems that could transfer a great deal of torque (*twisting force*—fourth grade term) without slippage. Next the students review, directly from their current science curriculum, how machines can alter a force, whether the source of the power be a gasoline engine, an electric motor, or the leg muscle of a bike rider. At this point, utilizing a 10-speed bike mounted on a platform, with wheel and pedal components marked to allow easy counting of their rotation, the concept of different gear ratios will be shown in a format the students can relate to their daily lives. Students respond to questions regarding why bikes have all these speeds, and what happens when you select different speeds. Many of the students demonstrate a sound understanding of the effects of different speeds on a bike's gear system. By the end of our lesson, they realize they really understand the mathematics concept of ratios.

At this point we introduce the students to our five planned experiments. We discuss why experiments are an important part of understanding how something works. This Technology Education activity is likely the first school-based research any of the students have ever attempted, and they approach these experiments with serious determination. They are instructed to double check all the data they collect, as wrong data can only yield incorrect conclusions. They are required by experiment questions to apply the mathematics we have reviewed concerning ratios. Finally, they are reminded to base their answers on the scientific concepts regarding machines they have learned about during their science lessons, and which we have reviewed recently during our introduction to simple machines.

The experiments require the students to produce written explanations of their impressions of data collected. This now brings additional curricula and their related skills into this *AResearch*

http://www.massapequa.k12.ny.us/msd/techdept/4thgr/fairnew

Fairfield Schools Technology Newsletter

Spring 1996

News from Fairfield's Discovery Room - *TECHNOLOGY*

Educating Today's Students for the 21st Century

Technology is Learning Through Doing!

Our technology class is fun. We learn a lot with Mr. Helmer as our teacher. The Capsela kits are cool, we learn how to hook up motors, wheels, lights and more.

This class is only for fourth graders in Fairfield School. We think it would be a good idea to use it in all schools. The classes are forty minutes long and in the Discovery Room. We learn a lot by hearing, seeing, practice, and with our teacher's help.

Sometimes we feel like scientists when we do things with the gears in the Capsela kit. Mr. Helmer is funny and nice. -*Written by Mr. Hludzinski's Class*

As a point of interest, our web page was seen by a children's education magazine in China. The editors thought enough of our fourth grade Technology Education Program to write an entire magazine article, complete with our web page graphics, explaining to their young readers how you can understand difficult concepts if you reduce them to simple terms you understand.

Project: How Gear Systems Work. Their creative writing, spelling, and ability to express their viewpoints by written word are all being called upon during this activity. In addition, the classroom teachers have used this Technology Education Program (two units of study in our case), as an opportunity to utilize the computer writing lab, have students express their reactions to this new program on a word processor, and then edit their opinions into a *Fairfield Technology Newsletter*.

The Technology Education Department has also taken this opportunity to introduce the students to the power of the Internet. Their newsletter was added to the Technology Education's Department's web page, showing the students that people from all over the world can now read of their opinions concerning this program, or anything they wish to write about in the future.

If this were to be the first unit of a program, the teacher, who would be totally new to these fourth graders, would begin the first class meeting by having the students complete a short, *What Do You Know About Technology Worksheet*. This worksheet was designed to be enjoyable, allowing the students to have a good time trying to answer the questions. At the same time, the teacher is given some feedback as to the student's background knowledge. Once completed, the teacher collects the papers and talks about what really is technology. The class period ends with the promise of showing the students a very important technology and something they all have seen, but perhaps not really understood.

What Do You Know About Technology?

Complete this questionnaire by answering each of the following questions to the best of your ability. This questionnaire is to see how much you already know about technology. Good luck and may the Force be with you!

1. What does the word technology mean to you?
2. In the movie, "Snow White," how many dwarves lived in the cottage with her?
3. What is the fastest speed on a mountain bike? Why is it the fastest speed?
4. Can plants grow without soil? Why or why not?
5. What is your favorite electric toy and how many batteries does it use?
6. How is your home heated? (Examples: oil, gas, wood, solar)
7. Name the things that a plant needs to grow.
8. In the cartoon "X-Men" what is the name of the man in the wheelchair?
9. What color was added to the M&M candies last year?
10. How does electricity work?

At the next class, the technology teacher begins by asking students many questions related to mountain bikes:

- Why do they have so many speeds?
- What do the speeds do? How do the speeds change?
- What does the speed change do for the rider?
- If the bike is a machine, what is the rider?
- How else could we power the bike?
- The bike chain and sprocket resemble what simple machines?

The teacher then brings out a bike mounted upon a platform and demonstrates to the class, with a great deal of student assistance, what happens as speeds are changed. The students are introduced to a new term: gear ratio. The term in this case is related to a bike' s gear system: the number of tire rotations for each rotation of the pedal crank. The class also discusses other applications of the ratio concept; mixing glues, canned fruit juices, etc. The teacher ends the class by asking the students to try and find out what a research project is before their next class meeting.

At the third meeting, the students are presented with the paperwork for the *Research Project: How Gear Systems Work*. Students talk about what a research project means to them, and how it might help them in understanding technologies.

After this discussion period, the students are grouped in teams of two or three students and given a container filled with Capsela components. (Aword of explanation: this is our second unit of study. During the first unit of *Electrical Circuits*, the students are introduced to the Capsela Learning System and spend time developing different circuits. Had this not been already accomplished, the teacher would have to invest a class period to allow the students an opportunity to investigate how the Capsela components hook together.) Having experience working with the Capsela, the students are eager to begin working on these experiments. At this point, both the regular classroom and technology teacher assume the role of mentors. They move about the classroom checking student progress, lending assistance as needed, providing direction as the teams complete each experiment, and completing the scoring rubrics for each team. The number of experiments the students complete (There is a total of five.) will depend

upon the ability of each team. Two additional class periods are allotted to this activity, with a solid majority of the students completing all five experiments in this time.

Upon the completion of the research project, the students are given a performance task to complete. This last phase challenges the students to apply everything they have learned from the two units of study: *Electrical Circuit Design* and *Research Project: How Gear Systems Work* to solve a real world type problem, working with the Capsela system. The students are presented with a *Performance Task: Construction Warning Light*. The technology teacher reviews the performance task with the students, answering questions, clarifying the problem statement requirements, until the students consider themselves ready. Before the class meeting, the technology teacher assembles a large assortment of Capsela components, enough to provide each group with many possible solutions to the problem statement. Once the students begin work, the two teachers again assume the role of mentors, offering suggestions and confirming student understandings.

As part of the programs activities, the students write their reactions to the activities and the impact of the teacher's approach to the subject matter. During the Spring 1996 Pilot Program, the teachers took their classes to the computer lab, where the students worked to develop a *Fairfield Technology Newsletter*.

This activity was designed to be conducted in a "laboratory room" setting. For our pilot program we selected a seldom utilize "general-purpose" room. To that classroom we added six work tables (36" x 60"), chairs and a storage cabinet for the Capsela components

Introduction

This activity has been designed to challenge your group's ability to solve real world type problems. Over the past few weeks you have been working with electrical circuit designs and wiring layouts. Recently you have explored how different gear systems are used to increase the power or speed of an electric motor. This activity will demonstrate your group's skill at applying this new information and technology in developing a solution to a problem.

Problem Statement:

A construction company has come to you with a problem they would like you to solve. The workers are fixing a bridge on the Long Island Expressway. The work is very dangerous because of the traffic. The company needs your team, specialists in technology, to construct a model of a warning light they might place on the roadway to warn traffic, and protect their workers. This device must meet several design requirements:

- **It must have a flashing light to warn motorists that there is construction work ahead.**
- **The device must be able to stand on its own.**
- **The device must be easily movable from one job site to another.**
- **The light must be able to turn on and off with a switch.**
- **The light and motor must be on different power sources.**

Experiment #1 System Power / Twisting Force

INFORMATION

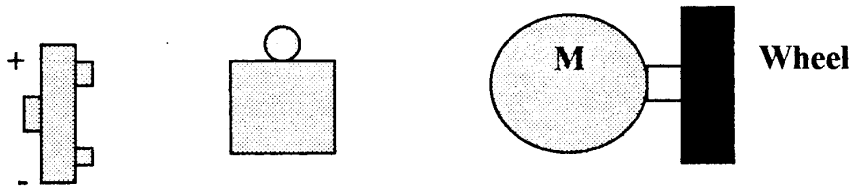
In this part of the research project we will look at the Capsela motor unit. The motor rotates at 9,600 rpm and uses only 3 volts of electricity. This means that the motor has a limited amount of power or twisting force.

PROCEDURE

Record your findings in the space provided and answer the questions to the best of your ability. You must use complete sentences and spelling does count. ***May the Force be with you!***

Step 1:

Connect the motor capsule to the large wheel. Connect the electrical circuit as shown below.



Note : Make sure that the batteries are placed into the power pack correctly.
Ensure that the teeth of the motor and the teeth of the wheel are interlock firmly.

Step 2:

Start the motor and watch the wheel. Record its motion (fast or slow).

_____

Use your fingers to cause enough friction to stop the wheel. Does it stop easily or do you have some difficulty?

_____

Step 3:

In terms of power or the ability to turn, how would you rate this system's performance? (very good, good, okay, bad, or very bad)

_____

Experiment #2 Gear Reduction

INFORMATION

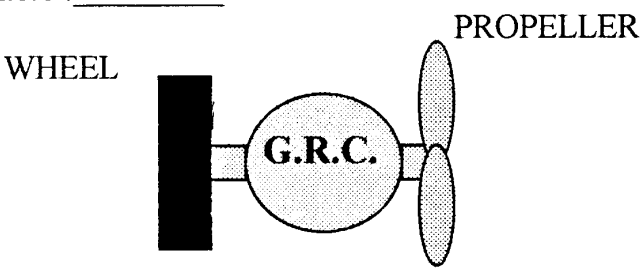
In this experiment you will look at the Gear Reduction Capsule and how it changes the force of the motor. Engineers and designers use different size gears (number of teeth) to allow them to change the speed and twisting force of their motor or engine.

PROCEDURE

Record your findings in the space provided and answer the questions to the best of your ability. You must use complete sentences and spelling does count.

Step 1:

Locate the gear reduction capsule. Place the green propeller on the gray shaft connector and the large wheel on the white shaft connector. Rotate the propeller and count the number of turns it takes to rotate the wheel one time. Place your answer here :_____

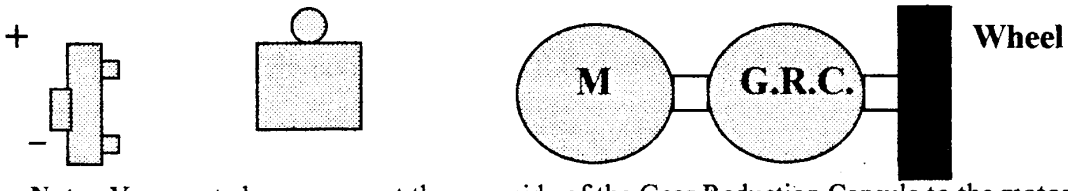


Using your information, how many times does the motor have to turn to make the wheel turn 9 times? (Show your math calculations below.)

Answer:_____

Step 2:

Connect the Capsela components and the electrical circuit as shown below.



Note : You must always connect the gray side of the Gear Reduction Capsule to the motor or the motor will not be able to twist the shaft.

Experiment #3 Worm Gear Capsule

INFORMATION

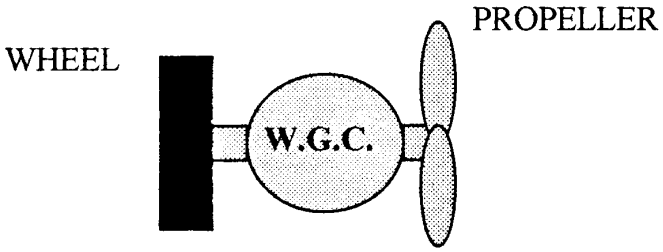
In this experiment you will look at the Worm Gear Capsule and how it changes the force of the motor. This capsule is very special because it uses a screw to move other gears. Pay close attention to how the screw is used inside the capsule.

PROCEDURE

Record your findings in the space provided and answer the questions to the best of your ability. You must use complete sentences and spelling does count.
"Transformers! More than meets the eye!"

Step 1:

Locate the worm gear capsule. Notice that the capsule has two gray shafts and two white shafts. Place the green propeller on one of the gray shaft connectors and the large wheel on one of the white shaft connectors. Rotate the propeller and count the number of turns it takes to rotate the wheel one time.
Place your answer here :_____

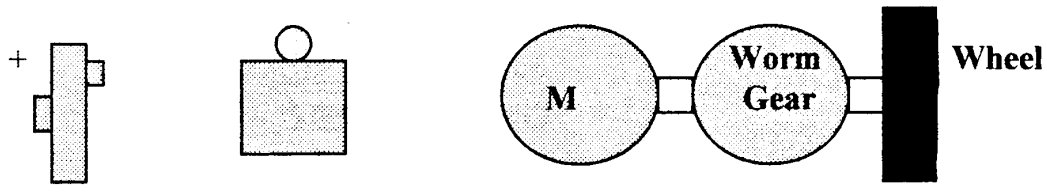


Using your information, how many times does the motor have to turn to make the wheel turn 3 times? (Show your math calculations below.)

Answer:_____

Step 2:

Connect the Capsela components and the electrical circuit as shown below.



Experiment #4 Crown Gear

INFORMATION

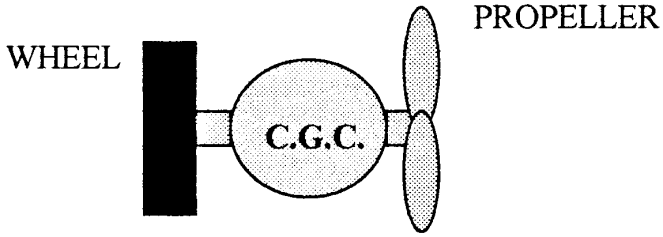
In this experiment you will look at the Crown Gear Capsule and how it changes the force of the motor. Notice that the teeth on the crown gear (the largest gear in the capsule) are on the side of the gear.

PROCEDURE

Record your findings in the space provided and answer the questions to the best of your ability. You must use complete sentences and spelling does count.

Step 1:

Locate the crown gear capsule. Place the green propeller on the shaft connector with the crown gear (largest gear in the capsule) and the wheel on the shaft connector with the small *follower* gears. Rotate the propeller and count the number of turns it takes to rotate the wheel one time. Place your answer here :_____

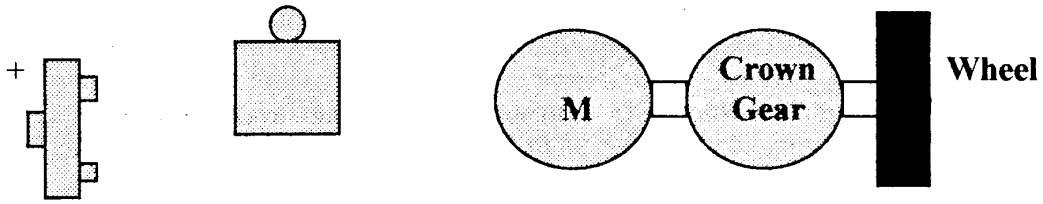


Using your information, how many times does the motor have to turn to make the wheel turn 17 times? (Show your math calculations below.)

Answer:_____

Step 2:

Connect the Capsela components and the electrical circuit as shown below.



Experiment #5 Internal Gear

INFORMATION

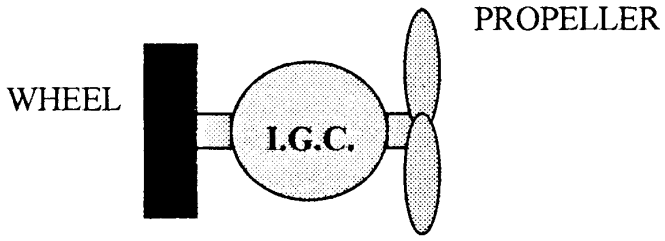
In this experiment you will look at the Internal Gear Capsule and how it changes the force of the motor. Notice that the teeth on the internal gear are on the inside.

PROCEDURE

Record your findings in the space provided and answer the questions to the best of your ability. You must use complete sentences and spelling does count.

Step 1:

Locate the internal gear capsule. Place the green propeller on the shaft connector with the driver gear (smallest gear in the capsule) and the wheel on the shaft connector with the internal gear (large gear with the teeth inside). Rotate the propeller and count the number of turns it takes to rotate the wheel one time. Place your
answer here :_____

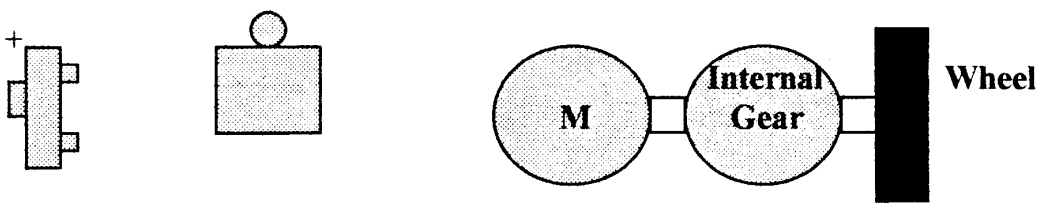


Using your information, how many times does the motor have to turn to make the wheel turn 11 times? (Show your math calculations below.)

Answer:_____

Step 2:

Connect the Capsela components and the electrical circuit as shown below.



Experiment # Gear Reduction Continued

How has the speed been changed? _____

_____

Using your finger, is it harder or easier to stop the wheel? How has the amount of the force been changed? _____

_____

How has the direction of the force been changed? _____

_____

_____

ASSESSMENT

This activity contains two very distinct components: research project and performance task. During the research project experiments, student progress is assessed by their responses as they precede through each of the five experiments. Another opportunity to assess student progress is by the total number of the experiments completed during the time provided. The final assessment is provided by the attached MST Scoring Rubric, completed by the classroom and technology teachers as the students work.

The performance task requires students to develop a drawing of their design layout, followed by a *Design Review* of their completed warning light system. The task finishes with the students completing a *Student Response* form.

Design Review

How well has your design team met the following performance task requirements?

1. Does the device have a flashing warning light?
2. How often does the light blink every minute?
3. What changes could your team make in your design to change the number of blinks per minute?
   - Explain how it would change blinking speed.
4. Does the device stand on its own?
5. Can the device be moved easily from one job site to another?

Student Response Form

1.. Did you have enough time to complete the design tasks?
2. What did you like most about this task and why?
3. What did you like least about this task?
4. Did you think this task was easy?
5. Did you think this task was hard?
6. Do you like science?
7. Do you think this was a fair test of your science ability?
8. Did you like this new unit of Technology Education you have had for eight weeks?
   - **a)** What did you enjoy the most?
   - **b)** Do you think this task was a fair test of your technology ability?

In addition to the written evaluations, the technology and regular classroom teachers each evaluate the students' progress during the class periods for: construction quality, the accuracy of data collection, and the final responses to questions.

At the conclusion of the three-unit program, the students take a comprehensive test of the information and concepts presented. This test includes multiple choice, completion, and fill-in questions. Student success with this testing instrument has been extremely positive and reflective of student success with the program's activities.

GEAR SYSTEMS : RESEARCH PROJECT

MST Scoring Rubric

Name:_____ Class:_____

ACTIVITY		SCORE ACHIEVED		
RESEARCH EXPERIMENTS				
1 - ADDRESSES PROCEDURE STATEMENTS	1	2	3	4
2 - CORRECTLY SELECTS GEAR SYSTEM COMPONENTS	1	2	3	4
3 - CORRECTLY COMPLETES WIRING DIAGRAM	1	2	3	4
GEAR SYSTEM CONSTRUCTION				
1 - ACCURATELY REPRESENTS DIAGRAM	1	2	3	4
2 - COMPONENTS CORRECTLY PLACED INTO ASSEMBLY	1	2	3	4
3 - COMPONENTS CORRECTLY WIRED FOR TESTING	1	2	3	4
4 - CIRCUIT PERFORMS AS DESCRIBED ON DIAGRAM	1	2	3	4
WRITE - UP OF ACTIVITY				
1 - WORK CLEARLY LABELED	1	2	3	4
2 - CORRECT CONCLUSIONS	1	2	3	4
3 - RESPONSES DEMONSTRATE UNDERSTANDING OF CONCEPTS	1	2	3	4

RUBRIC SCORING KEY

1 - REQUIRED EXTENSIVE TEACHER ASSISTANCE - WORK QUALITY FAIR

2 - REQUIRED MODERATE ASSISTANCE - WORK QUALITY GOOD

3 - MOSTLY INDEPENDENT WORK - VERY GOOD WORK QUALITY

4 - INDEPENDENT STUDENT WORK - SUPERIOR WORK QUALITY

REFLECTION:

REFLECTIONS

Our observations of the fourth grade student's ability to solve problems and carry out our experiments lead us to believe that we must take advantage of the opportunity we have to develop an early appreciation for technology education and the lifelong skills it instills.

I cannot stress enough the importance of bringing the fourth grade elementary teachers into the planning stages of this program as early as is practical. They should view this program as an enhancement of their curricula, not a new pull-out program, or just another invasion of their classroom time with their students. Our elementary teachers have been fully supportive, both with assisting during our activities, and by offering constructive suggestions to improve the quality of our activity worksheets.