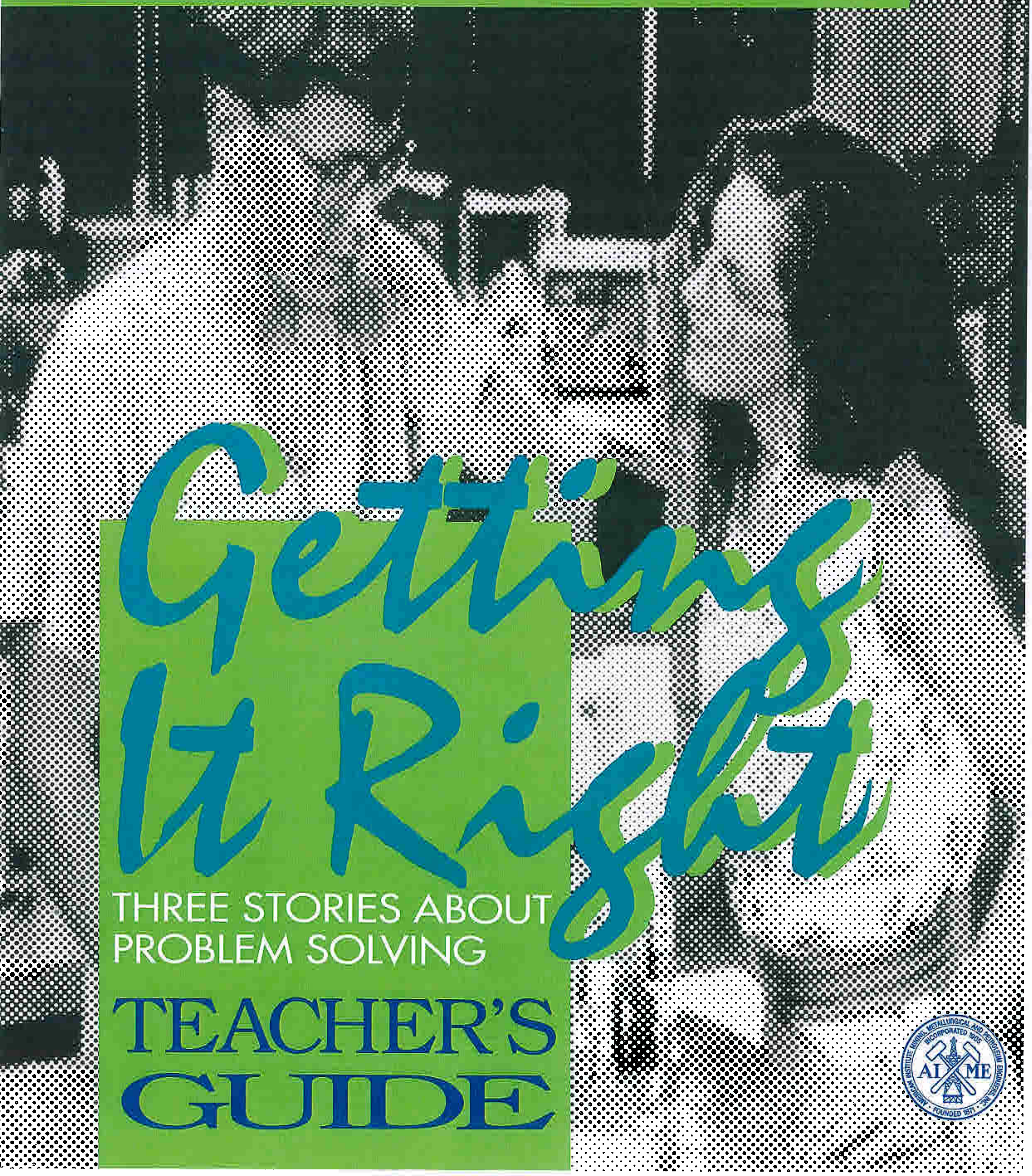
TRANSFORMATIONS

SCIENCE, TECHNOLOGY & SOCIETY



Getting It Right

THREE STORIES ABOUT PROBLEM SOLVING

TEACHER'S GUIDE

TRANSFORMATIONS: Science, Technology & Society

Program Goals

- ▲ to enhance and enrich science instruction in Middle School classrooms
- ▲ to explore ways that technology takes scientific knowledge and applies it to meeting society's needs and solving society's problems
- ▲ to foster among students a spirit of inquiry, encouraging and developing their problem-solving skills
- ▲ to help create citizens who are cricital thinkers, prepared to make informed decisions about complex social/technological issues that will confront them in decades to come

A GETTING IT RIGHT

Three Stories About Problem Solving

This unit models basic problem solving techniques and introduces the scientific method. Real life instances include a student from MIT (Massachusetts Institute of Technology) in a design competition and a trio of petroleum engineers at Amoco. The emphasis is on teamwork, estimating, modeling, and the acceptability of false starts and failures. Below are the topics for "Getting It Right," presented in this Guide.

- ▲ Problem Solving
- ▲ Scientific Models
- ▲ Scientific Method

Curriculum Connections: Earth Science, General Science, Physical Science; word problems or ratios (scale) in math, a literature unit on problems and Problem solving

Summary of the Video

Dissatisfied with a song they are working on, the band must come up with a solution quickly—they need to make a demo tape of the song in a few days. Problem-solving techniques and strategies are then played out in three interwoven settings:

- ▲ Chris, an MIT student, is in a design competition. Using sets of identical components, he and the other contestants have four weeks to design a machine that will outperform other entries at a prescribed task. Simone talks with Chris about his attitude toward the problem, his ideas and plans, his setbacks and advances.
- ▲ A team of petroleum engineers must decide whether to lease an offshore oil tract. AJ participates in team discussions with Debby, Jon, and Henry as they examine data, hypothesize, test their hypotheses, and reach a conclusion.
- ▲ The band members attack their dissatisfaction with the song by each drawing up a list of things wrong with it. Having a plan motivates them to move ahead.

Chris's machine competes effectively— he is a finalist; the petroleum team decides to lease the tract; and the band likes the song they have successfully reworked:

You say you don't know, it's all so stop and go
Come on, baby, let's try it again

It still isn't right, we've tried so many times
Well, let's work together to open up our eyes
A piece of the action
A moment of passion
Just a little satisfaction

The answers all are here
Maybe not so clear
But I think we're getting near
To a piece of the action
A moment of passion
A piece of the action
Just a little satisfaction.

Suggestion for Using Unit A: "Getting It Right"

Page 3 Introduction to the Teacher	Here you will find additional background information on the science and technology presented in "Getting It Right."
Page 4 Introduction to the Students	This section gives you material for introducing "Getting It Right" to your students, including a statement of the purpose of the unit; suggestions for connecting the unit to students' experience; definitions of key concepts and terms; and directions for the Video Study Guide (see below).
Page 5 Topic 1 Page 6 Topic 2 Page 7 Topic 3	These pages focus on the three major topics in "Getting It Right": Problem Solving; Scientific Models; Scientific Method. Each page furnishes options for introducing the topic to students and a wide array of ways for students to respond to the topic, including labs that are carried out through the Activity Masters. Choose any of the topics as your focus, depending on where you are in the curriculum.
Video Study Guide	You can use the video guide (Activity Master 1) to focus students' attention on and check their comprehension of the video.
Video	Running time for the video is18 minutes. You may want to preview the video and choose a Stop Point for conducting a discussion, carrying out an activity, or making a comprehension check. The video may also be show straight through.
Pages 8-13 Activity Masters	The first blackline master is the Video Study Guide. The other masters give students hands-on opportunities in the form or activities and labs.
Page 14 Extension	This final section includes suggestions for science fair projects and research topics, ones that build on concepts explored in "Getting It Right." Also listed are related resources for interested students to pursue.

GETTING IT RIGHT: An Introduction for the Teacher

"Getting It Right" helps students realize that problem solving is a process; that there is an "if at first you don't succeed" attitude involved; that problems can be attacked and solved in an organized way (the scientific method); and that there are various strategies to use, including the creation of scientific models.

Below is a more detailed explanation of concepts presented in the video and developed in this Guide.

What data might petroleum engineers collect to solve their problem—where to drill for offshore oil and gas?

Oil underground migrates upward in the water filled rock layers because it is lighter than water. When it comes in contact with an impermeable layer, typically a dense shale, it becomes trapped. The oil remains in the reservoir "trap" until it is discovered by drilling. The fluids trapped in the sandstone pores consist of water below and the lighter oil above; often, natural gas is present at the top of the trap. Offshore drilling must not only penetrate hundreds of feet of water, but often a few miles of earth's crust.

Before drilling, exploration teams gather information. Seismic surveys are a useful tool. Research ships tow cables equipped with hundreds of recording microphones. An air gun located just below the water's surface sends sound waves through the water and into rock layers. The sound waves bounce off the contacts between the layers and return to the water's surface, where they are recorded by the microphones. The time that it takes for the sound waves to return provides information about the type of rock in the various layers. All the information gathered is processed into seismic lines, which can reveal underwater structures, such as faults, salt domes, or potential oil traps.

Another piece of data used is the well log from a nearby well. A well log is a plot of electronic measurements of rock properties taken at different depths; the measurements convey characteristics of the rock encountered, such as its radioactivity level or ability to conduct electricity. The latter may indicate whether the rock's pores contain saltwater or oil. Well logs are usually made by lowering a particular measuring device on a cable down the well borehole; the device records as it is pulled back up.

Careful interpretation of data is especially important for wildcatters, people who drill for oil on sites that have not previously been drilled. Nine out of ten wildcat wells do **not** produce oil.

Does "the scientific method" describe one particular method that scientists always use?

The term does not refer to a single, inflexibly used system, but to a general attitude: the best way to work out a problem is to attack and study it in a logical, organized way. A general outline of the kinds of tasks involved, however, might be described this way:

1. Determine the problem by making observations;
2. Propose and test hypotheses;
3. Draw conclusions.

These tasks are likely to be cyclical: A number of hypotheses may be formed and rejected. One experiment is rarely sufficient to "prove" a hypothesis; experiments are usually repeated over a period of time to see if the same results can be obtained each time. And then, of course, skill, luck, trial and error, and intelligent guessing also play their part in successful problem solving.

What is the relationship between science and technology?

One way of expressing the relationship would be to make this analogy: science is to discovery as technology is to invention. Technology has also been described as the practical use of science or the application of science to improving the quality of our lives.

The relationship between science and technology is a two-way street. Scientific discoveries often lead to technological advances, of course, but the reverse is also true. The Voyager photographs, for example, presented scientists with new and fascinating data about the outer planets of our solar system.

GETTING IT RIGHT: An Introduction for Students

Introducing the Unit

Present the goals of "Getting It Right" to your students:

- ▲ to realize that problem solving is a process that can be accomplished in different ways;
- ▲ to learn some effective problem solving techniques and strategies, including the use of models;
- ▲ to get a sense of what it means to use the scientific method.

However, they should **not** feel responsible for the specific engineering data and processes presented in the video.

Connecting the Unit to Students' Experiences

To help students see how the need for effective problem solving permeates our society, put the sentence starters below on the board, and use them to generate discussion. Possible discussion points are given in parentheses.

- ▲ **When individuals have problems to solve, they** (work on them alone, ask friends or family for help, seek professional help, write to an advice column)
- ▲ **When nations have problems with one another, they** (go to war, conduct talks to try to work out a compromise, ask other nations or organizations—such as the UN—for help)
- ▲ **Examples of people coming together for the purpose of solving a problem include** (politicians trying to deal with the issue of urban violence; scientists trying to combat an epidemic such as AIDS; a town council trying to decide whether to have town wide curbside recycling)

Key Concepts and Terms

Students will be exploring and extending their understanding of the words listed below (in bold face) by topic area. You might write these words on the board and briefly discuss them to determine which are familiar to your students.

Topic: Problem Solving

- ▲ If a person is presented with a situation that calls for an obvious course of action, the situation is an exercise; if the course of action is not clear, the situation is a **problem**.
- ▲ General steps in effective problem solving include stating and defining the problem; exploring approaches—perhaps by **brainstorming** various possibilities; making a plan; carrying out a plan; assessing the result, and much more often than not, trying again.

Topic: Scientific Models

- ▲ A **model** is a simulation of a real object, process, system, or idea. It can be something that physically exists or something abstract (*e.g.*, mathematical).
- ▲ A model may be made to **scale,** a fixed ratio between the size of the model and the size of the thing modeled.

Topic: Scientific Method

- ▲ Using the **scientific method** means working on problems in a logical, organized way.
- ▲ After identifying the problem and making observations, a scientist will make some **inferences,** judgments based on observations and the scientist's own knowledge and experience.
- ▲ These inferences help the scientist to come up with a **hypothesis**—a proposed answer to the problem that can be tested.
- ▲ An **experiment** is an organized process used to test a hypothesis. The **conclusion**, a decision based on interpreting observations and data from the experiment, may or may not support the hypothesis.

VIDEO STUDY GUIDE

To focus or direct students' viewing of the video, distribute Activity Master 1, the Video Study Guide. You might have your students work individually, or small groups could each be responsible for a particular section of the Study Guide. Allow time—stopping the video at various points or after the video is over—for students to discuss their responses.

GETTING IT RIGHT: Problem Solving

Introducing the Topic: Options

▲ Write the famous Thomas Edison quotation on the board: **Invention is 1% inspiration and 99% perspiration.** Under this write **attitude** and **process**. Use these to initiate a brief discussion of how scientists and inventors go about solving problems. Make sure to cover how the idea of "if at first you don't succeed" is reflected in both attitude and process.

▲ Materials needed for each group: **250 mL beaker; 100 mL graduated cylinder; 100 mL water; 25 mL vinegar; 5 mL baking soda; 5 raisins, 2 of which are cut into 8 pieces.** Divide students into groups, and give them an exercise in observation. After students have mixed the water, vinegar, and soda in the beaker, have them add the raisin bits. They should observe the raisins rising to the surface and sinking back. Ask them to observe further and form a hypothesis to explain the raisins' motion.

Answer: Carbon dioxide bubbles produced by reaction of vinegar and baking soda lift raisin bits to surface, where bubbles burst and raisin bits sink again.

▲ Have students conduct small group brainstorming sessions. Each group should come up with at least one problem that a group member has solved in the last 24 hours. Groups should state the problem clearly, include the actual solution, and propose at least one alternative solution. Allow time for sharing results.

STUDENT INVOLVEMENT: OPTIONS

- Indicates an activity that would take less than a class period.
- Indicates an activity that could take most of a class period.
- Indicates an activity that would go beyond the class period.

Discuss the Video

Video Guide notes can be used to help students answer these and other straightforward questions:

▲ What problem does the band have to solve, and how long do they have?

To fix up a song "by Friday," a few days away.

▲ What Problem solving techniques and strategies do they use?

Make a list of everything wrong with the song, "draw" the song to see where it is out of balance.

▲ How does their attitude toward the song change?

Frustrated and negative at first, especially Simone; become more enthusiastic, pulling together again as a group.

▲ What are the results?

The song is successfully reworked, in time.

Group Discussion: Looking at Failure

Trying and failing and trying again is integral to Problem solving. Challenge students to discuss both sides of failure: How can failure **interfere** with problem solving? How can failure **help** you solve a problem? How does **attitude** play an important part in dealing with failure?

Activity: The Classic Black Box

Pair students, and give each pair a sealed shoe box. Inside is a common object, or set of objects, with definite physical properties, (*e.g.*, some paper clips, hammer, sneaker, plastic bottle). Teams spend the rest of the class recording their observations, actions toward the box, and conclusions as to size, shape, density, etc., of the object. They should also make an educated guess as to the object's identity. Set aside time for a box opening ceremony and discussion.

Activity: Balancing Acts

Materials needed for each group: **cinder block**. Divide students into large groups (6+), and challenge each group to figure out the maximum number of people they can get to balance on a cinder block for 10 seconds. This is best performed outdoors.

Activity: What's the Pattern? (Activity Master 2)

Students must try different perspectives as they look for patterns in numerical sequences and groups of words. Have students work in cooperative pairs, and set aside time for them to challenge one another with the pattern puzzles they have created.

Answers: 1. 45, 9x; 12. 7, prime numbers >3; 3. 25, + odd numbers (3,5,7,9); 4. *e.g.* river, bodies of water; 5. *e.g.*, thin, sets of opposites; 6. *e.g.* shake, words that can have hand added to them.

Homework: How Is It Done?

Have students take home their science books to solve this problem: How thick is a single textbook page? Ask them to keep a journal of their thoughts and of attempts to find the solution. Next day, discuss these processes as well as proposed solutions.

Answer: A likely solution is to measure the thickness of a large number of pages and then to divide by the number of sheets used.

GETTING IT RIGHT: Scientific Models

Introducing the Topic: Options

- Do a quick web building activity with students around the word **model** (meaning "a representation of an actual idea or object"). After students come up with several associations, have them group these associations using categories such as **purposes, examples, characteristics of, process.** Modify the web accordingly.
- Materials needed: **models of Earth—maps, globes, and, if possible, a model of the solar system.** Gather a range of maps (political, physical, weather, ocean currents,). Present students with the various models, and encourage them to compare and contrast the models. For example, What needs would dictate the use of one Earth model over another?
- Have students work in small groups to come up with a working definition of the word **scale** (listed in Key Concepts and Terms on page 3). Direct them to supply examples of 1) a model with a scale that is larger than the object represented (examples: atom, DNA molecule); 2) a model with a scale that is smaller than the object represented—with a sample scale given (example: model car where 1 cm on the model equals 250 cm on actual car). Put students' suggested scales on the board as ratios (model scale: actual scale) so that students see the proper form.

STUDENT INVOLVEMENT: OPTIONS

Indicates an activity that would take less than a class period.

Indicates an activity that could take most of a class period.

Indicates an activity that would go beyond the class period.

Discuss the Video

Video Guide notes can be used to help students answer these and other straightforward questions:

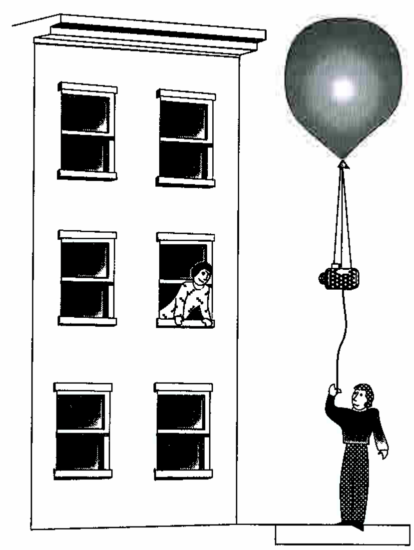
- What problem does Chris, the MIT student, have to solve? How long does he have?
  Has to design and build a model machine using given components for a competition four weeks away.
- What problem solving techniques and strategies does he use?
  Sketches 5 ideas and chooses one, trial and error—has to revise design when first one won't work.
- What are the results?
  He is a contest finalist.
- Describe Chris's attitude throughout.
  Example: nervous but determined.

Activity: Design Time.

Materials needed per team: **paper.** Divide students into teams, and give them the chance to imitate Chris, the MIT student. The goal of their competition is to design a paper airplane that will perform a certain function (*e.g.*, longest glide time or highest speed). Urge them to think, plan, and make sketches before they begin to build. Set aside time for students to compete and to evaluate one another's designs.

Activity: What Is It?

Materials needed: **2 locations, copy of drawing on this page.** Divide students into two groups. Display the drawing for one group; leave them to explain in a paragraph what the machine illustrated might be. For the other group, slowly read aloud the description twice—and have them write a paragraph telling what the machine might be. After 15 minutes, bring the groups together. As students compare results, have them consider: What were the problems of interpreting the verbal description? What was the advantage of the visual model?



Description: The machine is parallel to the building. A cable extends from the operator to the imaging device, which is focused on the participant in second story window. The imaging device is suspended from a flotation device approximately 1 meter in diameter.

Homework: Graphic Sports

Pair up students, and have teams use the sports score board in a newspaper to generate a graphic display. (You may want to review bar graphs, pie charts, line graphs, and pictographs before students are given this assignment.) Set aside time the next day for students to present their displays and to discuss why they chose to present the information in that particular graph.

GETTING IT RIGHT: Scientific Method

Introducing the Topic: Options

▲ Write the following list on the board (without parenthetical numbers):

scientific method=logical, organized approach to problem solving

(5) draw conclusions

(4) analyze the results

(3) test ideas

(1) identify the problem

(2) propose an idea (hypothesis)

(6) report the results

Have students put the steps in the logical order. Ask them to identify steps that may be repeated every time a proposed solution turns out to be faulty (steps 2–5).

▲ Assign small groups a task: They must come up with "A Proposed Scientific Method."—*i.e.*, their own idea of a logical sequence of steps to use to attack and solve a problem. Have them keep this question in mind: "Will people have to repeat all or only some of your steps if a proposed solution fails?" Set aside time for groups to share and compare efforts.

▲ Materials Needed: **an egg timer**. Challenge students to attack everyday problems in an organized manner by being part of a new game show called "It's Only Logical." Play moderator as you take turns assigning students to one of two 3 member panels: the posers and the solvers. Posers have, say, 3 minutes to come up with an everyday problem for the solvers to handle. If the moderator okays the problem, the solvers have, say, 3 minutes to confer and come up with a solution. The "audience" claps to signal that they think the solution **is** logical.

STUDENT INVOLVEMENT: OPTIONS

Indicates an activity that would take less than a class period.

Indicates an activity that could take most of a class period.

Indicates an activity that would go beyond the class period.

Discuss the Video

Video Guide notes can be used to help students answer these and other straightforward questions:

▲ What problem does the petroleum team have to solve? How long do they have?
Whether to lease offshore oil tract; 5 weeks.

▲ What Problem solving techniques and strategies do they use?
Examples: team work; talk it out; collect, compare, and analyze data; form hypotheses; look for patterns; guess and check.

▲ What are the results?
They agree to go ahead and lease the tract.

▲ What does the petroleum team mean by the word **story**?
Hypothesis.

Class Discussion: Science Fair Project

Use this opportunity to discuss the nature of a good science fair project. Have students think of themselves as judges rather than competitors—What would they look for? What would catch their eye? Interest them? Impress them?

Activity: Build a Better Mousetrap

Explain that if the science cliche is finding a cure for the common cold, the technology cliche is building a better mousetrap. Set teams of students to this second task. Begin with a class brainstorming session about current mousetraps and possible problems (*e.g.*, inefficiency of mechanical ones, danger of chemical ones, humaneness to mice). Each team should come up with a design, draw a model of it with directions for use, estimate a selling price, and submit their design to the class. If time allows, teams can "go back to the drawing board" to modify their traps based on class input.

Activity: Think About It (Activity Master 3)

Have students read through the master; check to make sure they have a sense of the distinction between science and technology and between observation and inference. Students may need access to reference materials to find examples of scientific discoveries and technological inventions. Set aside time for them to discuss their responses.

Answers: 1. answers will vary; 2. O, I, I, O, O, I; 3. sample topic—automobiles give us freedom and mobility but also cause noise/air pollution, congestion, accidents.

Lab: Science Swing Time (Activity Master 4)

Materials needed: **see Master**.

Divide students into lab groups, and give them time to read through the 2 page master. Tell them to check with you before they begin testing their hypothesis (so you can be sure their hypothesis is workable). Set aside time for groups to "report" their results to the class.

VIDEO STUDY GUIDE

This guide is designed to help you get the most out of the video for "Getting It Right." Look over the questions below before you watch the video. Use the space under the question to take notes. What does the video tell you in answer to the question?

1. What problem does the band have to solve? How long do they have?

   What problem solving techniques and strategies do they use?

   What are the results?

2. What problem does Chris, the MIT student, have to solve? How long does he have?

   What problem solving techniques and strategies does he use?

   What are the results?

name: ______________________ class: ________ date: ___________

VIDEO STUDY GUIDE, continued

3. What problem does the petroleum team have to solve? How long do they have?

   What problem solving techniques and strategies do they use?

   What are the results?

   What does the petroleum team mean by the word **story**?

4. What parts of the video did you like best? Why?

name: ______________________ class: ________ date: __________

WHAT'S THE PATTERN

One way of analyzing a problem is to look for a pattern. Study each group of boxed elements below, and answer the questions that follow.

1. 9, 18, 27, 36, ____ What is the next number in this series? ____
   How are these elements related? ________________

2. 5, 7, 11, 13, ____ What is the next number in this series? ____
   How are these elements related? ________________

3. 1, 4, 9, 16, ____ What is the next number in this series? ____
   How are these elements related?
   ____

4. lake ocean sea brook pond ____
   Add a word that fits with the group.
   How are these words related? ____ ________________

5. night day soft hard fat ____
   Add a word that fits with the group.
   How are these words related? ____ ________________

6. stand pick cuff kerchief writing ____
   Add a word that fits with the group.
   How are these words related? ____ ________________

7. Design a pattern puzzle of your own on the back of this sheet. See if your teacher, family members, classmates, or friends can solve it.

name: ________________ class: ________ date: ________

THINK ABOUT IT

1. **Science or Technology?** Science and technology are related. Technology takes the results of scientific investigation and uses it to create commercial and industrial products and tools, designed to improve the quality of life. Come up with 3 examples of each from real life. Write them on the lines below.

Science	Technology
ex: Ben Franklin uses a kite in an experiment in electricity.	*ex:* Thomas Edison invents the electric light.
____________________	____________________
____________________	____________________
____________________	____________________

2. **Science:** Scientists must often make careful observations and use them to make inferences. Their inferences lead them to come up with possible solutions (hypotheses) to test. How good are you at telling the difference between an observation and an inference? Write an *O* for observation or an *I* for inference beside each statement below.

____ Ants can carry 1050 times their own weight.

____ Dogs are loyal to their masters.

____ Plants respond to music—they prefer classical to rock.

____ Plants respond to light—they grow toward it.

____ Light waves bend in water.

____ The color blue relaxes people.

3. **Technology:** Sometimes a technological advance can have an unintended side effect that may be harmful. For example, aerosol cans are convenient and efficient, but the chlorofluorocarbons they contain interact with ozone. Some scientists feel that the CFC's released from sprays thin the protective ozone layer around Earth. Think of another example of a technological advance with a good and bad side. Use the back of this paper to present your example.

name: ____________________ **class:** ________ **date:** ________

A "GETTING IT RIGHT"

Producer/Director......Lee Richmond
Scriptwriter ....Lee Richmond
Composer ....Mark Spencer
Lyrics:
"Transformations" Lee Richmond
"Piece of the Action" Lee Richmond
Line Producer...Polly van den Honert
Casting ....Collinge/Pickman

CAST

A.J. ....**Anthony Ruivivar**
Billy...............................**Jonathan Deily**
Laurie...................................**Eisa Davis**
Simone ....**Linda Balaban**
M.I.T. 2.70 Design Contest
Engineering Student ....**Chris Hoffelt**
Amoco Production Co.
Petroleum Engineer ....**Henry Avila**
Geophysicist...........................**Jon Gross**
Geologist ....**Debbie Neuberger**

LOCATION CREW

Director of Photography .....**Dean Gaskill**
Sound Engineer ....**Mike Pfeiffer**
Script Supervisor..........**Etienne Martine**

STUDIO CREW

Director of Photography......**Bestor Cram**
Sound Engineer ....**Chris O'Donnell**
Video Engineer ....**Eliat Goldman**
Gaffer ....**Ken Perham**
Key Grip............................**Jack McPhee**
Set Designer ....**Frank Gaide**
Wardrobe ....**Carlene Lee**
Props ....**Fairlie Myers, Carlene Lee**
Makeup ....**Marleen Alter**
Script Supervisior ....**Eve Wrigley**
Instrument Mix ....**Rob Scott**
Audio Playback ....**Tim Lay**
2nd Camera (film) ....**Mike Majoris**
Assistant Camera ....**Mary Anne Jenke**
Grips ....**John Maliscewski, Arnold Brown**
Carpenters ....**Larry Batherwitch, Terrance Gaide**
Electric ....**Mark Bialas, Jeff Hanel**
Production Assistants ...**Sharon Hibbert, Jimmey Frieden**

POST-PRODUCTION & PRINT

Editor ....**Mark Fish**
Sound Designer ....**Ken French**
Teacher's Guide ....**Joanne Fedorocko, Andrew Amster**
Designer ....**David White**
DesktopPublisher **SullivanCreativeServices**

TRANSFORMATIONS was created and produced by
Galileo Studios, 50 Hunt Street, Watertown, MA 02172 (617) 923-0912

TRANSFORMATIONS:
Science, Technology and Society © 1991 was produced under the auspices of the American Institute of Mining, Metallurgical and Petroleum Engineers, Inc.

345 East 47th Street
New York, NY 10017
1-212-705-7677