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ABSTRACT

One of the major focuses of science education reform is providing equal education to all students. One of the first steps in providing an equal education is informing teachers of classroom equity issues. This document is a training module developed to assist grades K-12 teachers in Alaskan schools in transforming their science classroom into a bias-free environment. The document contains the following: (1) a training session overview; (2) a listing of needed equipment; (3) information regarding how students perceive scientists; (4) ways of helping students obtain a positive attitude toward science; (5) a literature review of gender equity issues; (6) science activities; and (7) a listing of notable women in science. (ZWH)

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EQUITY in SCIENCE

For Alaskan Schools
K - 12

A TRAINING MODULE

Developed by

Alaska Department of Education
Division of Educational
Program Support

Funded by

Title IV Desegregation
Technical Assistance Grant

Equity in education
THE ALASKA PROJECT

SE055267

Acknowledgements

This revised Equity in Science Module (K-12) has been updated and expanded and includes an entirely new section of activities for secondary students. Those who helped with the 1991 revision include:

Pat Hartland Teacher Mendenhall River Community School Juneau School District	Patrice Lee Teacher Ryan Middle School Fairbanks North Star Borough School District
Anne Kessler Equity Project Director Alaska Department of Education	Peggy Cowan Science Curriculum Specialist Alaska Department of Education
Scott Foster Editor Juneau	Susan Kraft Graphic Design Juneau

The development of the original Equity in Science Module (K-6) was a collaborative effort between the Anchorage School District and the Alaska State Department of Education. Those who worked on the 1987 version include Anchorage School District officials Jeanmarie Crumb, Anita Robinson, Karen French, and Sharon Jaeger. Jan McCrimmon of Charter North Hospital also worked on the original project.

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Introduction

In Alaska schools gender equity means all students are given equal opportunity to succeed.

This Equity in Education series has been produced to provide training materials to help Alaska teachers and administrators in recognition that, for many reasons, there have been differences in the treatment and expectations for female and male students.

Nationally, leaders in science and science education have realized that quality science education is important for all students including those now under-represented in most science careers, females and minorities. According to Bassam Shakhashiri, former National Science Foundation Director for Science and Engineering Education, "We have a dual mission—to attract students to careers in science and to make sure the general population is scientifically literate."

All students will need to be prepared to make informed decisions about such issues as environmental pollution, energy sources, nuclear war and biotechnology. Alaskans make added science-based decisions on oil spill remediation, wildlife management, and resource extraction in Arctic environments.

A general student population with a firm foundation in science results in more informed citizens and competent decision makers. Personal lives will be enriched everywhere, but especially in Alaska, with an understanding of the natural phenomena that surrounds us.

In the past, female students have been excluded from the opportunity not only for worthwhile careers in science fields, but also from contributing meaningfully to society or their personal lives through an understanding of science.

We are beginning to understand the nature of science instruction which helps enfranchise girls. This new module is designed to provide science activities for all girls, those destined for science careers and those whose lives can be enriched through an understanding of science.

To promote gender equity in Alaska schools, the Alaska Legislature in 1981 passed one of the strongest state sex discrimination laws in the nation. Among other things it requires Alaska school districts to establish written procedures for the following:

1. Biennial training of certificated personnel in the recognition of sex bias in instructional materials and in instructional techniques which may be used to overcome the effects of sex bias;

2. Biennial training of guidance and counseling staff in the recognition of bias in counseling materials and in techniques which may be used to overcome the effects of sex bias;

3. Review of textbooks and instructional materials for evidence of sex bias; and

4. Replacement or supplementation of materials found to exhibit bias.

Since the implementation of these regulations, referred to as Chapter 18, many school districts now rely on the Department of Education to provide them with on-site inservice training in the area of sex discrimination. Recognizing that local school districts need their own cadre of equity trainers as well as materials, the Department of Education utilizes Title IV funds to develop a series of equity modules available to all Alaskan school districts. The modules are developed and written in such a fashion that district personnel even with a minimal amount of experience can conduct an equity inservice.

To date the following modules have been produced:

Women in American History (Elementary)	Computer Equity (K-12)
Women in American History (Secondary)	Foreign Languages
Language Bias (K-12)	Fine Arts (Elementary)
Science (K-12)	Health(Elementary)
Mathematics (Elementary)	Demographics

The Department is continuing the development of modules in other curriculum areas and is committed to helping school districts comply with the regulations outlined in Chapter 18.

Anne Kessler, the Alaska Equity Project Director in the Department of Education, says, "Equity is one of those things that can get forgotten during efforts to focus on content. Through our training with these specific content oriented modules, we want to keep gender equity at a conscious level."

School district personnel using the modules are requested to complete the evaluation sheet and return it to the Department of Education. This information will be used to update and improve the modules.

Table of Contents

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ORIENTATION 1

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Training Session Overview

TITLE: *Equity in Science for Alaskan K-12 Students*

PURPOSE: To emphasize to educators some continuing aspects of bias and discrimi nation in society and to provide information and activities that will help ensure continuous positive change in science education.

GOAL: To provide educators the opportunity to focus on sex equity issues related to teaching science.

EVENT	OBJECTIVE	PAGE	TIME	ACTIVITY	RESOURCES NEEDED
#1	Orientation	6	:10	Introduce participants and share agenda	Name tags Markers Flip chart Handout 1-1 Transparency Overhead projector
#2	Getting Involved	14	:30	Build the Highest Tower	Two piece paper per group 10 paper clips per group 1 pair scissors per group Masking tape and marking pen per group Handout 2-1
#3	Visualization	18	:30	Visualize a Scientist	Pencils 8-1/2 x 11 paper Crayons, colored pencils/markers Flip chart Transparency 3-A Tape Overhead Projector
#4	Describe Feelings	30	:15	Group lines up according to "feelings"	Two signs Marker
#5	Research Review	33	:30	Reading/ discussing research articles	Marker Overhead Projector Transparencies 5-A, 5-B Handout articles 5-1 to 5-6 Flip chart/newsprint Felt pens
BREAK		58	:15	Work station set-up	
#6	Work Stations	60	:45	Demonstrations of classroom activities	See handouts 6-1 through 6-16
#7	Closing and Evaluation	118	:05	Complete evaluation forms	Transparency Forms

Equipment needed
for Equity in Science Module

TITLE: Equity in Science K-12

LENGTH: Three hours

TARGET AUDIENCE: K-12 teachers

HANDOUTS:

Copy prior to workshop:
1-1 Agenda
2-1 Build the Highest Tower
5-1 to 5-6 Articles
(All Grades)
6-1A to 6-1E Research Material
(Elementary)
- 6-2 Chromatography and work sheet
- 6-3 Sink or Float and work sheet
- 6-4 Gravity and work sheet
- 6-5 Layer Hot and Cold Water and work sheet
- 6-6 Sink the Paper Clips
- 6-7 Classification of Animals/work sheet
- 6-8 The Balloon Kid
- 6-9 Plastic Bag in the Cup

(Secondary)
- 6-10 Name Women Scientists/work sheet/list
- 6-11 Pendulum and work sheet
- 6-12 Classifying Vertebrate Bones
- 6-13 Electromagnets and work sheet
- 6-14 Inference and work sheet
- 6-15 Take Me to Your Lost Liter/work sheet
- 7-1 Workshop and Trainer Evaluation

TRANSPARENCIES:

1-A Why All This Science?
3-A Gender: Children portray scientists
3-B Visualize a Scientist
5-A Boys Become Doctors
5-B Girls Become Nurses
6-A Work Station Questions
6-B Teaching Strategies
7-A Women of Achievement

MATERIALS:

Name Tags	Scissors
Flip chart	Masking tape, scotch tape
Markers	Marking pens/colored pencils, crayons
Overhead projector	Acetate Markers
5 boxes of paper clips	8-1/2 x 11 white paper

MATERIALS FOR WORK

Refer to each work station (number 6-1 to 6-15 for detailed listing of materials that are needed for the activities that are demonstrated.

☛ *NOTE*: The trainer should inquire in advance of the training session about the composition of the participants in order to select work stations which can meet the interests of either elementary and/or secondary teachers.

Introduction and Agenda Sharing

OBJECTIVE: To introduce yourself; to establish a climate where people feel included; to set norms; and to share expectations about the purposes and agenda for this training session.

GROUP SIZE: 10 to 30 people

TIME REQUIRED: Approximately 10 minutes

MATERIALS: Name tags (if appropriate)
- Handout #1
- Flip Chart
- Transparency #1
- Markers
- Overhead Projector

ROOM ARRANGEMENT: Large group setting, informal

PROCEDURES: Since this module contains both elementary and secondary activities, the trainer must survey participants to determine their grade levels and structure the inservice accordingly.

Since individual trainers have their own style of introducing a workshop, following are some suggestionsfor consideration.

1. Place cartoon Transparency #1 on overhead projector so participants can see it as they arrive.

2. Trainer asks participants to introduce themselves to each other.

   Optional: If you are working with staff from more than one school, you may wish people to identify their school and position.

   Optional: Name tags may help associate names with faces when participants do not know each other.

3. Trainer gives background of the inservice - tells where it was developed and shares how it came to be offered to that school (or district or group). Equity in Science Education was initially developed by the Department of Education in 1986 with assistance of the Anchorage School District. It was revised in 1991 by a teacher in the Juneau School District, and a Fairbanks teacher added the secondary activities.

4. Trainer explains that Chapter 18, Alaska's Sex Equity Regulations, requires biennial training of staff in the areas of gender bias and gender role stereotyping and that this inservice satisfies that part of the law which mandates the training.

5. Trainer distributes Handout #1 or goes over agenda on flip chart.

6. Trainer asks for clarification questions or concerns. Example:

   "What do you expect from the workshop?"

   "Is there anything confusing about the agenda?"

   "Do you have any concerns?"

7. Trainer will post this pre-written goal:

   GOAL: To insure gender equity in the science classroom by heightening the consciousness and improving the teaching methods of classroom teachers and aides who teach science.

TRANSPARENCY 1-A

Why all this science? I was going to have one of those jobs where you just sit there and look pretty.

Equity in Science Agenda, Design and Purpose

AGENDA

Orientation

Build the Highest Tower

Visualization

Describe Feelings

Research Review

Break

Work Stations

Closing and Evaluation

INSERVICE DESIGN

This inservice and module are intended to bring the issue of gender equity in the classroom to the conscious level of each science teacher. The module offers a variety of activities, demonstrations, reading materials, discussion suggestions and resource lists. After completing this inservice it is hoped teachers will have increased equity awareness which will also help them increase equity in their classrooms.

INSERVICE PURPOSE

1. To provide educators with increasing awareness of gender bias in teaching science, and to offer techniques/activities addressing these biases.
2. To provide tools to promote the participation of women in science.
3. To offer materials and strategies for educators designed to increase all students' confidence and competence in doing science.
4. To relate the usefulness of science to future career choices.
5. To relate science instruction for girls to the usefulness of scientific knowledge and processes in making personal and societal decisions.

BUILD THE HIGHEST TOWER

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Build the Highest Tower

OBJECTIVE: Participants will explore creative problem solving.

Participants will discover ways to encourage enthusiasm in science.

GROUP SIZE: Small groups (2-3)
Groups/partners may be chosen by matching puzzle pieces made by cutting apart index cards or pictures.

TIME REQUIRED: 30 minutes

MATERIALS:
2 pieces of paper for each group
10 paper clips for each group
1 pair of scissors for each group
Masking tape and marking pen to measure towers
Handout 6-1

ROOM ARRANGEMENT: Each small group will need a work area to build their tower. This could be on tables or on the floor.

PROCEDURE:

1. Pass out the materials to each group.
2. Read the directions:
   a. Only the materials provided may be used in building your tower.
   b. The towers must be free standing. They may not lean against the wall or be held up.
   c. Towers must be brought to the tape on the wall for measuring. This means they will have to be transportable or easy to rebuild at the measuring site.
3. Divide participants into groups and assign a working area.
4. If group members ask questions, merely repeat the original instructions. The intent is to minimize instructions so participants will be encouraged to invent innovative ways to build the tower.
5. Discuss how this activity relates to girls/boys in problem solving. Were there differences in how males/females solved the problem in your group?
6. After the activity has been completed, discuss ways in which this activity could be used in the classroom.

TAKEN FROM: ***SPACES - Solving Problems of Access to Careers in Engineering and Science***, Dale Seymour Publications

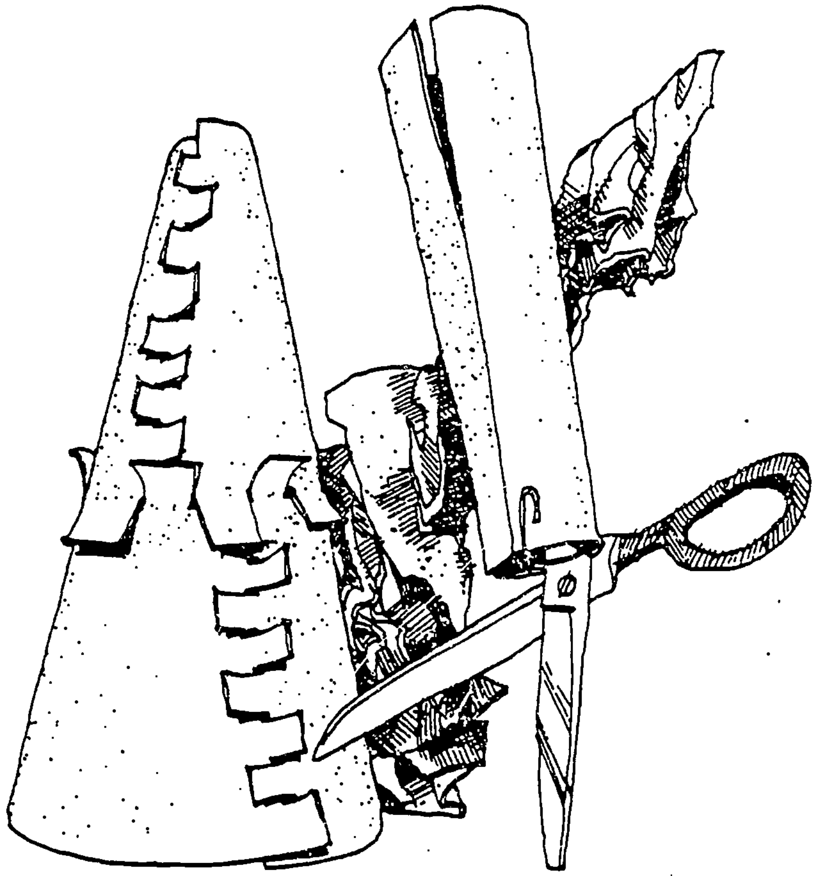
Build the Highest Tower

Skills
- *Brainstorming*
- *Cooperating*

Time
- *1 class period*

Participants
- *Groups of 2–4 students*

Materials
- *8½" × 11" paper*
- *Paper clips*
- *Scissors*
- *Masking tape*
- *Marking pen*



Students explore creative problem solving by using non-traditional materials to build a structure. The challenge is to build the highest tower using these materials.

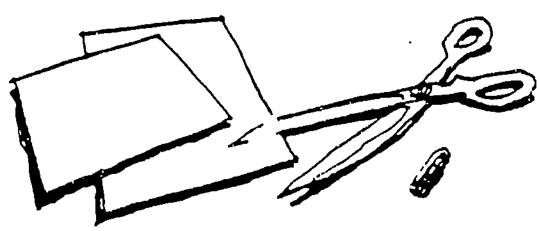
Preparation:

1) Divide the materials into sets consisting of:

2 pieces of paper

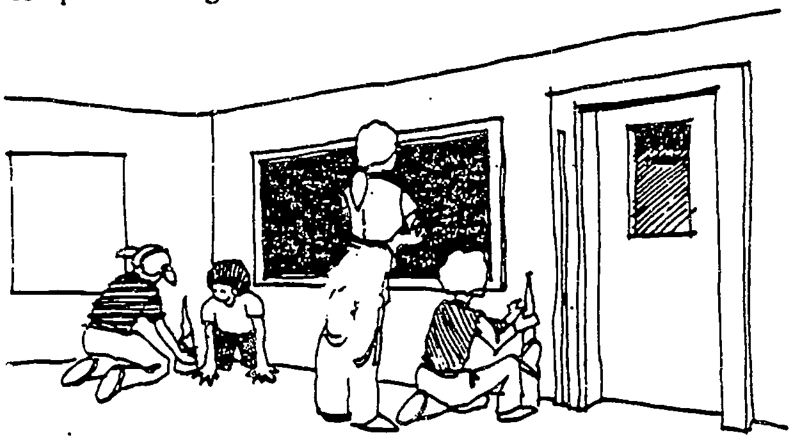
10 paper clips

1 pair of scissors



You will need a set for each group of students.

2) Apply a strip of masking tape to a wall or door jamb starting at the floor and extending up about 5 feet. This will be used to compare the heights of the towers.



Directions:

Give these directions to the students:

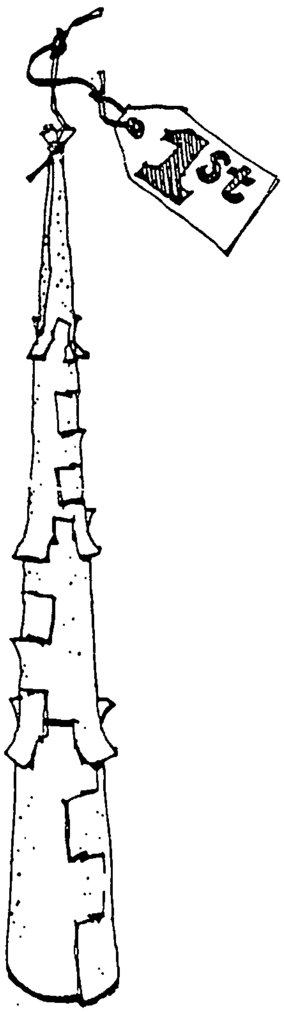
- Only the materials provided may be used in building your tower.
- The towers must be free-standing. They may not lean against the wall or be held up.
- Towers must be brought to the tape on the wall for measuring. This means they will have to be transportable or easy to rebuild at the measuring site.

Divide the students into groups and assign a working area for each group of students. Distribute sets of materials and let the students start building.

Some questions may arise, such as, "Can we tear the paper?" or "Can the scissors be part of the structure?" The best response is to repeat the beginning instructions, without giving further information. The intent is to minimize instructions so students will be encouraged to invent innovative ways to build the tower.

As pairs of students finish their structures, have them bring the towers to the measuring site. Write the initials or names of students beside their tower's mark on the tape.

When all towers have been measured, announce the winners. You may want to discuss with the class some of the successful or not-so-successful strategies used to hold the towers together and upright.



Extensions:

Allow time for experimentation. Give the students 15 minutes to experiment with scratch paper before they actually begin building their tower.

VISUALIZATION 3

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Visualize a Scientist

OBJECTIVE: The following article, "How Students See Scientists" is to provide the trainer with background information for the "Visualize a Scientist" activity, which is located after the article.

The trainer may wish to share portions of this article at the end of the activity. The "Age and Gender" section on the first page of the article gives pertinent information on the perception that a scientist is male.

GROUP SIZE: Large group — Introduction

TIME REQUIRED: 5 minutes

MATERIALS: Transparencies 3-A and 3-B

How Students See Scientists: Mostly Male, Mostly White, And Mostly Benevolent

By Deborah C. Fort and Heather L. Varney

Over the past year or so, more than 1,600 students from grades 2 to 12 have responded to invitations in NSTA's journals and to appeals at conventions and other meetings to produce some intelligent, thoughtful, and revealing portraits—in words and pictures—of what children imagine scientists to be and do. The results were predictable in some ways—New York, the state with the two science high schools, the most Westinghouse Science Search winners, and many NSTA members, produced more responses than any other state. And most of the students wrote about white male scientists (a pattern that unfortunately reflects reality). But we failed to predict one welcome result—the stereotypical image of the evil "mad" scientist appeared comparatively rarely, and *never* when the student depicted a real rather than imaginary scientist.

The Appeal

Advertisements in *Science and Children*, *Science Scope*, and *The Science Teacher* invited responses as follows:

> Calling all science students! What do you think scientists do—either real or fictional ones? According to what you see on TV and in films, what you read in books, magazines, and newspapers, and what you hear on the radio, what image comes to your mind when you think of a typical scientist?

We then asked students to write 50–100 words and draw a picture of what they think a typical scientist looks like. Parts of the "statistical" picture we received appear graphically below. As a whole, that picture invites some tentative analysis (to follow).

We emphasized that teachers should make this assignment voluntary; although it is true that students had to hand in their papers to their science teachers for those papers to reach us, we hoped that the fact that children decided on their own to complete the task would free them to be as creative and as honest as possible.

Demographics

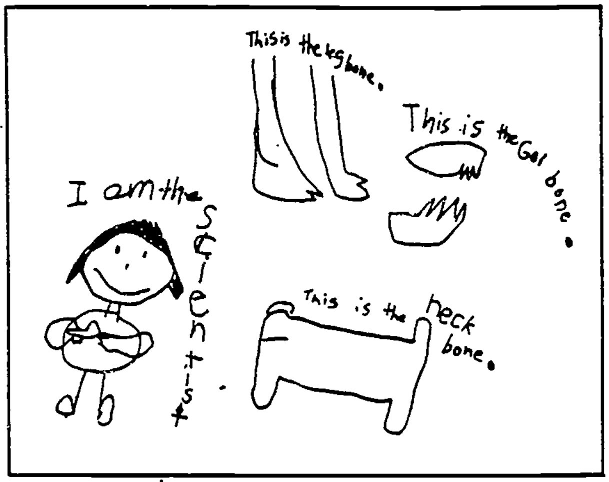
A number of patterns emerge. One is geographical. More than half our respondents came from only four states—New York, Ohio, Florida, and Maryland, in that order. About a sixth of our NSTA journals go to teachers in these states. New York, with over 4,000 NSTA subscribers, sent us 344 responses—or almost one-fifth of the total. On the other hand, California, whose movies are the source of many children's thoughts about scientists and with nearly 5,000 subscribers, sent us only 33 responses. Why 16 percent of our subscribers produced 50 percent of our data is a puzzle.

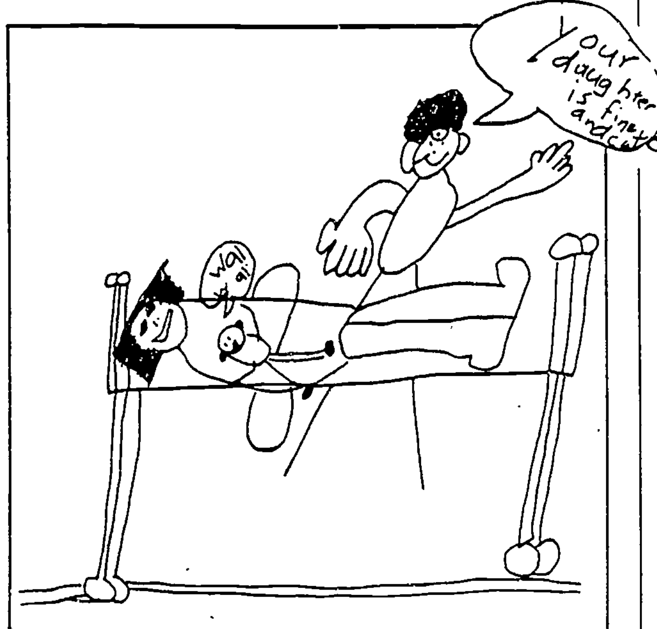
Age and Gender . . .

Our raw data fell into some other interesting peaks and valleys. Three states—Ohio, New York, and Florida—had entries in 10 of the 13 grade levels; however, e received no entries from first grade or kindergarten. Only a handf of second graders responded, but two were especially worth waiting for (see opposite page). Sixth graders produced the most entries (333).

More dramatic than geographic and age distributions, however, are those of gender. Nearly 60 percent of the respondents were girls. Nonetheless, a vast majority of students of both sexes described male scientists. Eighty-six

We asked students to portray a scientist in words and pictures. Their varied and provocative responses follow.

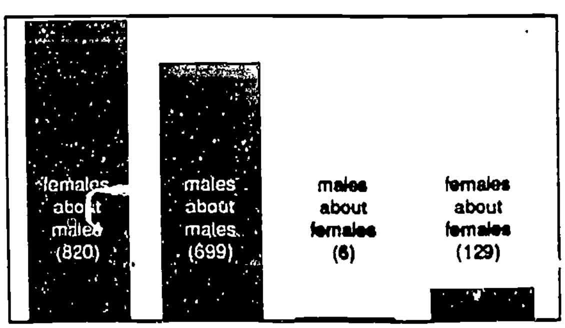




Jennifer Hector's drawing, above, was accompanied by the words "I am a scientist that studies dinosaurs. These are the bones I found." Christina Ort, her drawing at right, wrote, "People who work in the hospital are great scientists. You can't disturb spectacular scientists."

percent of the girls pictured male scientists. Maryland led in the category of girls describing women scientists, with 17 respondents. The numbers are even more startling for the boys—of the 705 essays by boys, 699 concern male scientists, a whopping 99 percent. Out of 1,654 respondents, only 135 (about 8 percent) pictured female scientists. While the media and the classroom may both by chance or choice promote this image, it is unfortunately a realistic one. Jane Butler Kahle (1983) has pointed out that while women make up 50 percent of the work force, they constitute only 6 percent of scientists and engineers. So the 8 percent depicted by our respondents is close to reflecting reality.

Gender: Children portray scientists as males significantly more often than as females.



. . . and Race and Nationality

The fact that fewer than 20 students out of more than 1,600 drew minority scientists—eight of them George Washington Carver—does not reflect the reality that Asian minorities (none were depicted) are excelling dramatically in science. As Lew Lord and Nancy Lennon (1988, March 14) wrote about winners of the Westinghouse Science Search (1942 to the present),

> Prodigies uncovered in the early years tended to be children of Jewish immigrants, many of them refugees from Nazi-ruled Europe. Knowledge, they were reminded again and again, was a passport to success in America. In this decade, the competition is dominated by offspring of immigrants from India, Taiwan, South Korea, and Vietnam. (p. 48)

And after high school, the pattern continues. Frank H. Shih (1988) reports on "the growing rate of Asian enrollment at top universities: 14 percent at Harvard, 20 percent at MIT, and 25 percent at Berkeley, percentages so dramatic that many are afraid schools have placed limits on Asian admissions" (p. 356). Current research (1986 figures) suggests that Asians make up 5 percent of the scientists and engineers (in comparison to 2 percent of the population) but the figures are slippery: no one is certain which of the Asians are temporary or permanent residents of the United States (National Science Foundation, 1988, p. 22).

There are, however, some happy exceptions to this trend to see scientists as entirely a white, male club. An eighth-grade girl from New York contributed the paragraph that follows to accompany her drawing, which is shown on the cover:

> These are the things that Doctor Cassamea McPiggle does in the laboratory. She must do a lot of research on her problem. Dr. McPiggle has to look up previous work that has been done on the particular problem. Next, Dr. McPiggle must decide how she will go about solving the problem. She must make an educated guess or hypothesis on what she believes will be the solution to the problem. Dr. Cassamea McPiggle also has to experiment [with] the problem and study it from every angle. Once Dr. McPiggle has finally found an answer to the initial problem, she has everything she did recorded and gives her notes to other scientists. These scientists repeat the experiments and prove it [the hypothesis] right. Lastly, Dr. McPiggle has her work published for all scientists and people to learn about.

This girl understands that women and minorities belong in a traditionally male-dominated field; so do a number of our other respondents for whom the image is changing. One described "Tatianna":

> a handsome woman in her early fifties. . . . Her jet black hair is now graying, and she has become hardened after her husband's demise and many years in a Siberian detention center. Earlier, she had lived in East Germany, working on an artificial intelligence project for the government. Tatianna always considered politics a waste of time, but became involved when she tried to defect during a European convention in 1967. Since then, she has been living in a colony of dissident scientists in the Oruigan Mountains and has no ambition of escape.

Role Models?

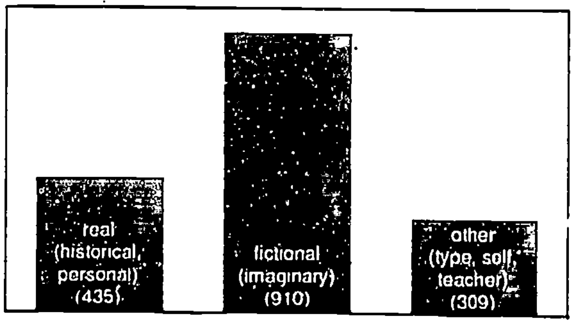
A number of students turn to historical figures as models. Many students—43 of our respondents—think of Albert Einstein when they imagine a scientist, but they don't always picture the traditional, white-haired figure. For some, he's a young man with a full head of dark hair. And great as Einstein was, our respondents made him even more so, crediting him with inventing electricity, the automobile, and the atomic bomb.

Einstein's nearest competitor among real models is still with us. Following his 32 years of science teaching as television's Mr. Wizard, Don Herbert is now instructing a second generation of viewers on cable's *Nickelodeon*; for 41 students, Mr. Wizard came to mind as the typical scientist. Other recognizable scientists included Thomas Edison, Louis Pasteur, Benjamin Franklin, Jacques Cousteau, Marie Curie, Isaac Newton, George Washington Carver, Galileo Galilei, Alexander Graham Bell, Jonas Salk, Philip Morrison, Carl Sagan, and Aristotle.

Some children who discuss real figures describe their mothers and fathers—one third grader explains that his dad is a "nonfictional scientist." Others look to their teachers. A good number see as scientists any individuals with a keen interest in and curiosity about the world—this category sometimes takes in themselves and their friends as well as adults.

Sixth grader Sara Pippert researched scientist Joy Adamson at the library for this portrait.

Origins: Children perceive scientists as real or as fictional people.



Bad Mad Scientists—All Fictional

As noted, one stereotype that our results challenged was that of the evil mad scientist—*as a real figure*. We could find no students depicting real "mad" scientists. A fairly substantial number of fictional ones, yes. But even those children relying on the image projected by certain uncritical films and Saturday morning television stereotypes made significant distinctions and had thoughtful reservations. Our analysis of the students' sources of information showed that the children's stereotypical image of the "mad" scientist came from books and magazines, television, or movies. While their individual imaginings were, of course, affected in significant ways by these print and electronic media, all of the "mad" scientist essays directly cited one or all of these three sources.

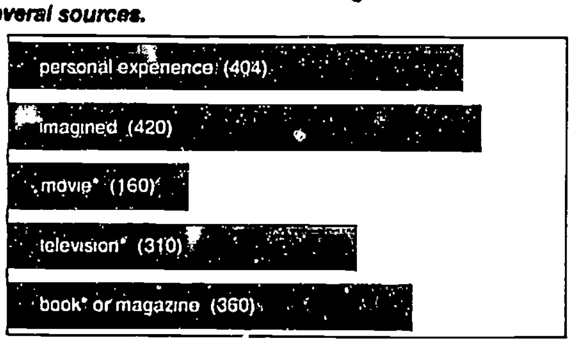
Frankenstein is a good example of this kind of influence. Mary Shelley's novel was made into a movie and then migrated to television programming. As a result, many children have been saturated with a confused impression of a scientist as "mad" (the monster and the doctor tended to appear interchangeably and uncritically). Children often viewed the doctor as insane because of his creation—the maker was as bizarre as his product. Of the 54 children who chose "Frankenstein" as their quintessential scientist, one, a ninth grader, explained, "The first time I saw a scientist was on Dr. Frankenstein. I think the first time I hear scientist, that he is an evil madman, [who] experiments on things, especially animals and humans and tries to switch their brains and things like that. . . ." In regard to a movie version, a seventh grader commented "I've always thought of scientists being smart, crazy, and scary looking."

Another popular "mad" scientist favorite depicted by 17 students, Dr. Jekyll and Mr. Hyde, also made his/their first appearance in a book. Robert Louis Stevenson's original novel then became a movie, and, finally, in many guises, appeared on television. A 12th grader stated "Dr. Jekyll does his work in his basement. It is a very unclean place. Most of his work is done at night when it is very dark. . . . I assume he does this type of work because he likes spooky things." Some variations on the Jekyll/Hyde theme move frankly toward the notion of split personality. One junior was especially articulate:

> The fictional scientists I have learned about were usually trying to do one of two things. If they were "good" scientists, people with morals who really wanted to help others, they usually were trying to find a cure for cancer or some other disease. They are dedicated and hard-working—usually found stooping over a microscope or studying a petri-dish.
>
> The evil scientists, the bad guys in the books, are only interested in money. They experiment with animals, stealing people's pets to perform tests on. They create deadly drugs and chemicals. They never seem to care who they hurt and can be seen injecting some fatal disease into an innocent person.

Sources such as Frankenstein and Dr. Jekyll and Mr. Hyde suggest an evil "mad" scientist image. However, the students differentiated clearly between an evil "mad" scientist and a real scientist. The respondents were aware that

Sources: Children base their images of scientists on several sources.



*Frankenstein and Jekyll/Hyde classified according to how the student encountered the characters (on film, on TV, or in a book)

Ryan Blessing, another sixth grader and creator of this unflattering portrait, said scientists aren't really "monsters and blobs."

real scientists are not in the habit of switching peoples' brains about or concocting monsters. Even in regard to Frankenstein, however, a 10th grader stated,

> The image that many see as a result of Mary Shelley's character is [of] an unkempt genius within an enormous underground laboratory hewn from damp, moss encrusted stone. He mixes obscure chemicals in bubbling beakers to achieve his twisted goal. This image is easy to envision, but far from an accurate description of an actual scientist. Scientists are everyday people who specialize in a specific area of science and either study or investigate in their field.

The character "Doc" in the film *Back to the Future* appears as a turning point between the two—the 64 students who chose "Doc" as their exemplar all, of course, saw him as fictional; all also believed him mad; but they tended to see this madness as kind, not malicious. One ninth grader said the film gave her the impression that "the true scientist is devising formulas to help the world and community." *Back to the Future*, the most popular source of students' responses, is the most recent and most widespread of the three top contenders. (Now available as a home video, it was a very popular movie when our survey was made.) This phenomenon also seems not unusual. Children often respond in terms of their most recent exposure to a model.

An inconsistent sixth grader drew a "mad" scientist and then explained, "really scientists aren't monsters and blobs. They are people who figure out things." A ninth grader wrote, "*I think each one of us is a scientist at one time or another* [italics added] and, every once in a while, I get the urge to go mix some chemicals, just to see what they do. . . "

More Good Than Bad

Most students find a scientist's typical characteristic to be positive, whether real or fictional. There were 790 good scientists vs. 230 mad/bad ones. Six hundred and sixty-four were shown neither as noble (in search of a cure for AIDS, for example) nor evil (out to destroy the world). This category encompassed the many scientists depicted at work on unspecified experiments.

None of the 435 real scientists (that is, historical and/or personal—for example, Thomas Edison or someone's neighbor, a biochemist) were shown as evil, while 230 of the 910 fictional ones were. This positive drift seems a change from what past observers have found. A summary of a 1978 symposium of the American Association for the Advancement of Science opened as follows:

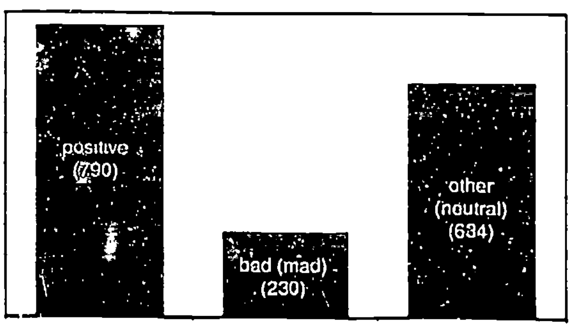
> Science and scientists, many observers argue, have been taking a beating in the media. The press, the movies, and, especially, television convey the image that scientific progress is hazardous and that scientists are frequently foolish, inept, or even villainous. (Maugh II, 1978)

And, as recently as 1984, Bradley S. Greenberg summarized Saturday morning viewing as follows:

> Those identified as scientists or technicians or professors, placed in laboratories and white coats, would be called stupid or silly by youngsters. They may be technical geniuses but they have no control over what they are doing. They are all inept at dealing with the problems they create. . . . (p. 23)

We simply did not find children buying this negative picture uncritically. (A third category of 309 individuals were, in a sense, neither real nor fictional and neither positive nor negative. These were the unspecified teachers, mechanics, students with microscopes—in short, miscellaneous people with high curiosity.) Perhaps students have spent more time learning "techniques" than meeting real scientists, and perhaps this leads them to describe fictional scientists rather than real scientists. Still, in spite of negative stereotypes, most students that wrote about fictional scientists did so in a friendly way.

Characterization: Children often depict scientists in positive images.



Inventors, Biologists, Chemists, Doctors

The four most popular scientific professions—with 300 or more students envisioning a typical scientist at work in each field—are inventing, biology, chemistry, and medicine. We can only speculate on the reasons for these preferences. The students' choice of inventors as the most common field of science perhaps corresponds with the high number of students relying on their own imaginations as their source of information. Two students described scientists hard at work on useless products—mechanical palm trees and a device for removing newspaper ink from the reader's fingers. Both real and fictional inventors are instructive: A ninth grader who chose to discuss Thomas Edison's contributions summarized: "Thomas Edison gave the world the light bulb, improved the telephone, and made the phonograph. He made the world a better place with his inventions." One helpful fifth grader described the work of Dr. A. Ladd Dinn (pictured opposite), who is "probably the most well known by school children everywhere." She writes:

> It started out as just an ordinary day for A. Ladd Dinn, except that his fifth grader complained a lot more than usual about her schoolwork. Finally, Dr. Dinn couldn't stand it, and he stormed from the kitchen table through the hall and into the basement. Shutting the door behind him with a slam, he said, "I won't come out until I have a cure for homework."
>
> He had his wife put a sandwich and a bottle of root beer under the basement doors every time Dr. Dinn screamed, "I'm hungry!!" Oh, the noises that came from his workroom. Pounding, hammering, sawing, and the laughing! That went on three times a day for two months, three days, and 59 minutes. Finally he came out. "Work's completed! You'll never complain about Mr. Malecki's assignments again. My homework machine is a success."
>
> Unfortunately the machine wasn't appreciated by his daughter. Her only response was, "Dad, why now? It's the last day of school!"
>
> Everyone doesn't appreciate a scientist.

However, biologists run a close second to inventors; does this reflect the reality that more students study biology than other scientific fields? We can only guess. And maybe the next largest group, chemists, grew in part because of the ease of illustrating—with beakers and bubbles—the "chemist at work." Given the fact that almost everyone has seen a physician at some time, a large group of medical doctors is not surprising, though the 34 AIDS specialists among them signify students' awareness of this particular disease.

A Man's World

Regardless of the scientist's occupation, a majority of our respondents described male scientists with stereotypical physical characteristics. In this, the students follow precedents uncovered in many similar studies, including one done by Margaret Mead in 1957. Another, by Wade Chambers (1982), highlighted the seven key parts of the image: the white lab coat, eyeglasses, facial hair, symbols of research (scientific instruments and equipment), symbols of knowledge (for instance books and filing cabinets), relevant captions such as formulae, and the "eureka!" syndrome. A ninth grader suggested that "A scientist is a little on the crazy side with white hair that has not been combed

Fifth grader Bridget Kelly LaNoir drew this popular scientist.

in 40 years, and he wears a white overcoat with a pocket protector."

Accent on the Positive

But stereotypical or not, scientists are not always perceived as frightening. One eleven-year-old sums up well:

> The fictional scientist I learned about was dressed in a long white coat, gray hair, big eyeballs, black pants, and glasses. I always think of him doing crazy experiments in his laboratory. I picture him living in his laboratory. He is always doing experiments to try to change things. Nobody knows how he does his experiments, but a lot of kids like him.

The real scientists can be even more reassuring. Witness one high school senior's friend Christi, who

> has told me she would like to be a scientist so she could discover cures for serious human ailments such as cancer or AIDS. This is a picture of her and the Peace Bomb. The Peace Bomb does not kill people. It puts into a coma only those who cannot handle world-wide peace. They come out of their coma when they are able to handle it. All the proceeds from the bomb, including the money from the Nobel Peace Prize and money saved from making nuclear weapons will go toward medical research and feeding the starving people around the world.

The following list mentions only a very few of the 1.654 students and their teachers who contributed their words ...d drawings. NSTA thanks all th.se whose generosity and work made this study possible.
Jylle Alessandra. 12th grade. Wayne Sakal's class. Notre Dame. Fairfield. CT: Ryan Blessing. sixth grade. Jeanne B. Monteau's class. Maple Hill Middle School. Castleton. NY: Joe Clifford and Art Tolis. 11th grade. Avi Ornstein's class. Berlin High School. Berlin. CT: Heather Corbley. 11th grade. Barbara Fragasso's class. Central Regional High School. Bayville. NJ: A. Russell Gregory. 12th grade. Michelle Currier Atkinson's class. Godby School. Tallahassee. FL: Jennifer Hector. second grade. Sandra Cheng's class. Narrowsburg (NY) School: Kristine Hopkins. eighth grade. Barbara N. D'Errico's class. Floral Park (NY) Memorial High School: Bridget Kelly LaNoir. fifth grade. Joan Baehm's class. Jackson Heights School. Glen Falls NY: Margaret Lasko. 12th grade. Wayne Sakal's class: Notre Dame. Fairfield. CT: Mike Merckx. 11th grade. Jeanne E. Niswonger's class. Marian High School. Mishawaka. IN: Christina Ort. second grade. Sandra Cheng's class. Narrowsburg (NY) School: Sara Pippert. sixth grade. Joy Erik...'s class. DeForest (WI) Middle School: Mariellen Stitts. 11th grade. Priscilla Balint's class. Villa Angela Academy. Cleveland. OH: Randy Volkel. eighth grade. Ken Uslabar's class. Shattuck Junior High School. Neenah. WI.

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Deborah C. Fort is a Washington-based writer, editor, and teacher whose most recent work was as association editor on NSTA's **Gifted Young in Science: Potential Through Performance.** *Heather L. Varney, an NSTA intern from SweetBriar College, will receive her bachelor of arts degree in biology this spring. Credit for compiling some of the raw data goes to Peter Andersen.*

Visualize a Scientist

OBJECTIVE: Lead participants to an awareness of their perceptions of a scientist.

GROUP SIZE: Small discussion groups (4-5 per group)

TIME REQUIRED: 25 minutes

MATERIALS:
Pencils
8-1/2 x 11 white paper (or smaller)
Crayons, colored markers or colored pencils
Flip Chart
Transparency 3-A, 3-B
Overhead Projector
Tape

ROOM ARRANGEMENT: Individual and small group setting, work tables.

PROCEDURE:

1. Pass out materials (paper, pencils, colors).

2. Trainer asks each participant to close their eyes and relax. Ask them to visualize a scientist. Slowly talk them through as you say:

   "Visualize a scientist. Visualize the hair. The eyes. The nose. The mouth. The chin. Any other facial characteristics. What is the scientist wearing? Where is the scientist located? Continue to visualize your scientist completely. When you are ready, open your eyes and draw your scientist." (Allow 10 minutes for drawing.) (Avoid the use of male pronouns).

3. When the drawings are complete, form a group of 4-5 and discuss your scientist. Find a scientist that is similar to yours. How is it similar? How is it different? Are the scientists stereotyped? Mostly, white, black, other? Male, female? Old, young? Show transparency to group. (Ask "Do any of your pictures look like this?")

4. Share findings from each group with the group as a whole. Discuss and write any significant results on flip chart to hang on wall.

   Example: Visualize a Scientist

   a. Most scientists were men/women
   b. Most were older/younger
   c. Most were (Ethnicity) - Anglo, Asian, Hispanic, Afro-American
   d. Most were what age

5. Using transparency 3-A, share research findings.

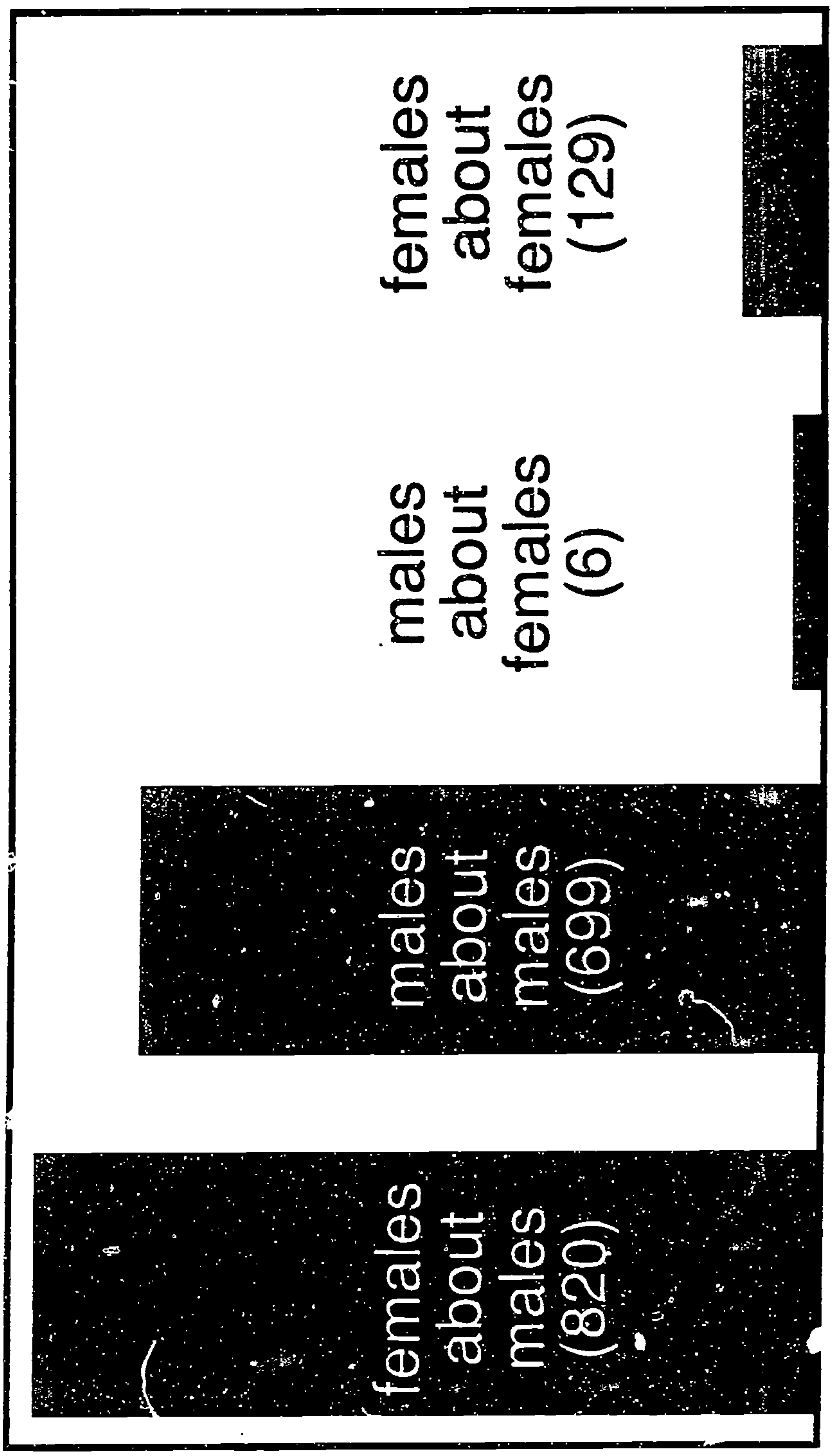
6. Discuss how realistic are the drawings of the working scientist? What are the biases?

7. Discuss as a whole group the ways these findings may affect a class room. What results might they obtain in their classroom. (5 minutes)

8. Using transparency 3-B, share pictures drawn by some students.

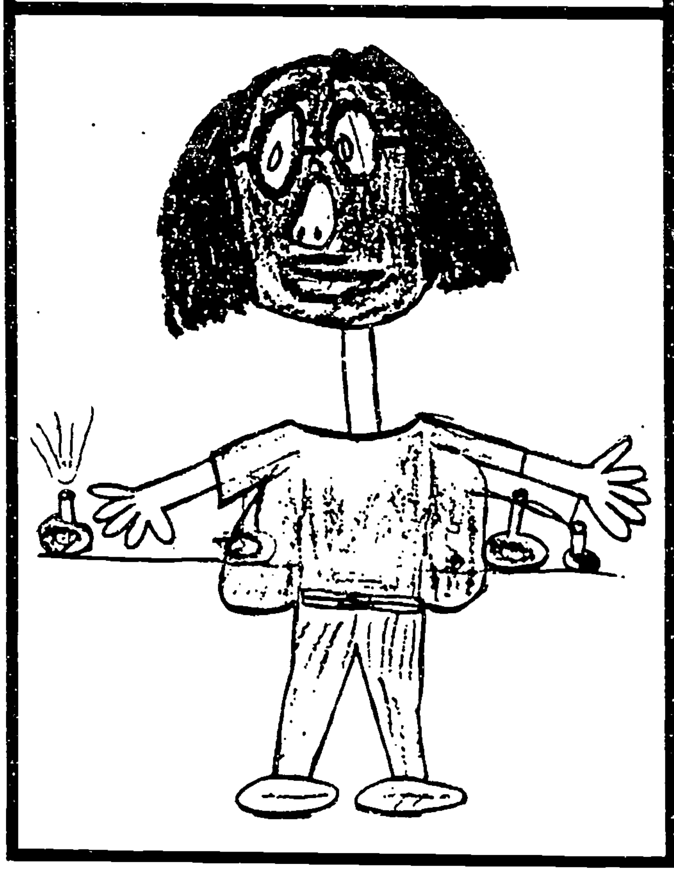
9. Encourage participants to try this activity in their classrooms.

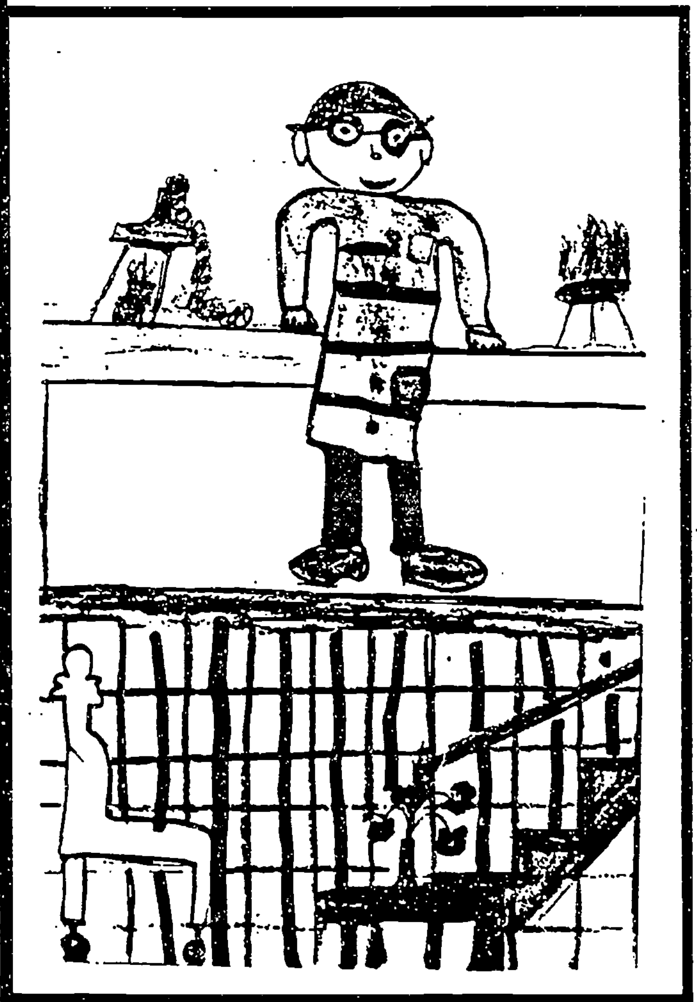
Gender: Children portray scientists as males significantly more often than as females.



May 1989 Science and Children

Visualize a Scientist





Grade 4
Mendenhall River Community School
Juneau

32

DESCRIBE FEELINGS 4

3 3

Describe Feelings

OBJECTIVE: To have participants bring their own knowledge to creating a positive attitude toward science.

To have participants acknowledge their perceptions about science and record what gave them positive feelings and what could prevent the negative feelings.

To have participants share whether any of the positive or negative feelings were caused by gender.

GROUP: The large group will move about according to where they stand on the continuum.

TIME: 15 minutes.

MATERIALS: Two signs. One says, "Agree", the other says, "Disagree".

PROCEDURE:

1. Put the "Agree" and "Disagree" signs about 20 feet apart.. The trainer tells participants to listen a statement to be read and then line-up in a continuum according to what they think about the statement. Participants should stand in a line closest to the sign best representing their feelings.

2. **Statement:** *"When time is tight, science is left out of instruction."*

   After the continuum is set, the trainer may want to ask one or two participants to share why they stood where they did.

3. **Statement:** *"When I was in high school I was successful in science, and it was my favorite topic."*

   Again, the trainer may want to ask one or two participants to share why they stood where they did in the continuum. Is there a difference between where men and women in the group stood? Why or why not?

4. **Statement:** *"Boys usually get better grades in science than girls do."*

   The trainer may for participants to explain why they chose to stand where they did.

5. **Statement:** *"Knowledge of science can help people make better decisions about their lives."*

   The trainer may ask for another reaction about the value of science education.

6. **Statement:** *"Teaching science is fantastic."*
   The trainer may ask why or why not?

7. Ask group to comment on the following:

   (a) What caused your positive feelings about teaching science?

   (b) How could you instill positive feelings about science for your students?

   (c) How could you prevent your students from having negative attitudes about science?

   (d) How could enrollment of students in science courses be increased?

8. Use the findings to bridge into the reason for this module. The conclusions drawn by the participants may reflect the information that is stated in the "Research" activity which follows this lesson.

Some reasons for positive feelings may be:

Learning styles
Cooperative Learning
Hands-on
Process
Positive Teachers

RESEARCH REVIEW 5

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Research Review

OBJECTIVE: To review the literature relating gender equity to science and what makes good science teaching.

To discuss and determine approaches helpful in making science teaching better and more equitable to all children.

GROUP SIZE: Small discussion groups (2-5 per group), up to six groups.

TIME REQUIRED: 30 minutes

MATERIALS:
Overhead projector
Acetate markers
Transparencies 5-1 and 5-2
Six different research articles, handouts 5A-5F
Flip chart or newsprint
Felt pens

ROOM ARRANGEMENT: Small group setting, work tables

PROCEDURES:

1. Show cartoon transparencies 5-1 and 5-2: "Boys Become Doctors" and "Girls Become Nurses."

2. Trainer asks participants to form up to six groups of equal numbers in each.

3. Trainer asks groups to select recorder; passes out flip chart/newsprint and felt pens.

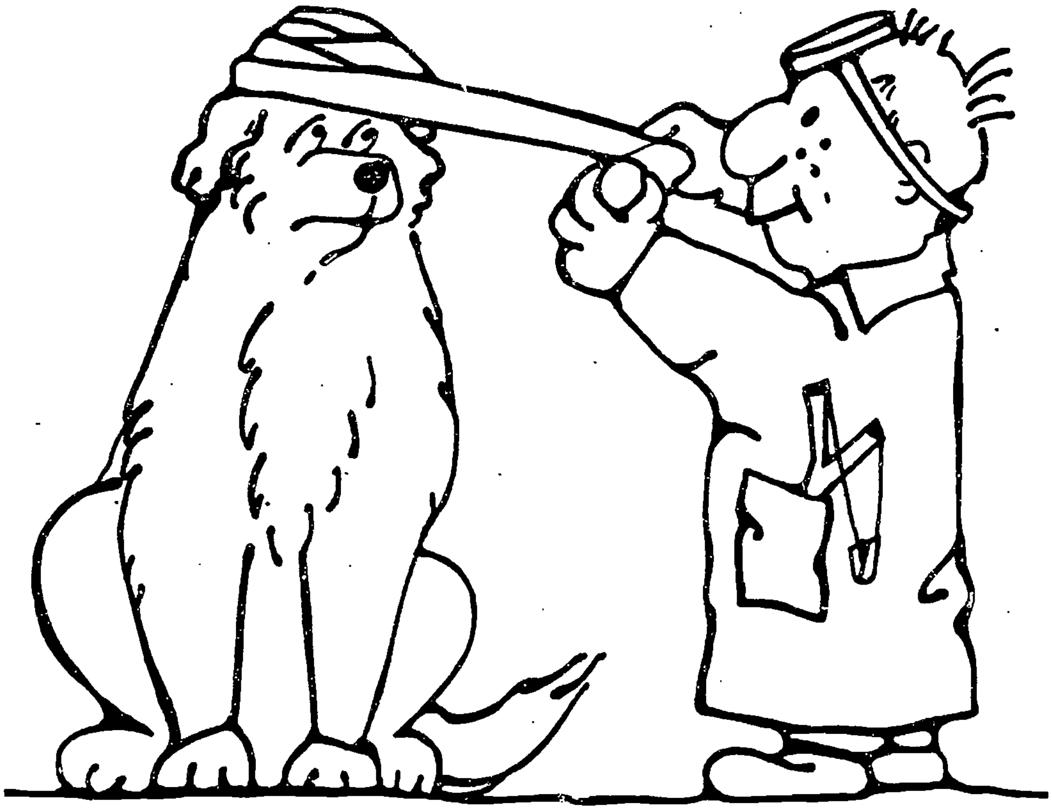
4. Trainer passes out one research article to each group.
   Group 1 receives handout 5-A
   Group 2 receives handout 5-B
   Etc.

5. Groups review the article for about 10 minutes and then record the key findings of the researchliterature that was read.

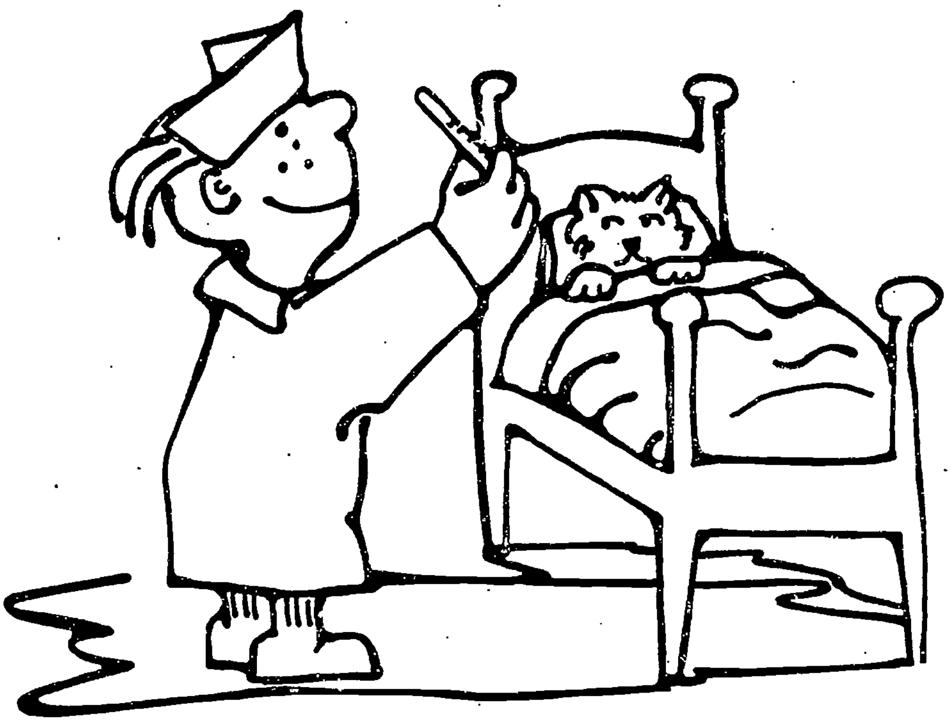
6. Each recorder describes the group'sfindings. The trainer should encourage participants to discuss the the research that supports their classroom observations.

☛ NOTE: Do not be alarmed if all group members do not agree with the findings. Allow time for group members to express their opinions either positive or negative on the research.

7. Trainer may conclude the activity by having participants generate a list of problems which block girls frombecoming active in science. The group should then offersolutions. What factors prevent all children from becoming active in science?



Boys become doctors.



Girls become nurses.

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What Research Says

. . . About Girls and Science

By Carol A. Klein

If we are to improve science education for girls and young women, we must begin early. As the assessment tests and the research studies indicate, differences between boys' and girls' achievement, attitudes, and interest begin in the middle elementary school years.

Current research studies and national and state assessment tests show that after the fourth grade, girls are less likely than boys to have an interest in science, to elect a science class, or to experience success in the science classroom. This development contributes to the fact that women represent only 9 to 10 percent of the scientific and engineering work force in the United States, Great Britain, and Canada.

What factors influence the interest and achievement of girls and young women in science? What can educators do to improve the situation?

The summary of research presented below is based on an extensive review of the literature and analysis of assessment tests (see Resources). This review was the first step in a project (partially funded by *The Bush Foundation*, May 1986) designed to provide concrete strategies for teachers to improve science education for girls and young women.

Classroom Experience

The results of the National Assessment Test, the Minnesota Assessment Test, and the British Columbia Assessment Test indicate that girls in grades 4, 8, and 11 have had less direct experience with materials than they would like. Observers in elementary, junior high, and senior high school science classes see progressively less active involvement by girls as their age increases. As early as fourth grade, girls tend to take the role of recorder or passive observer in laboratory activities.

Responses to the "recognition of equipment" questions from the Minnesota Assessment Test reflect the different types of experiences boys and girls have. Fourth-grade boys answered these questions correctly only 1.2 percent more frequently than girls did. By eighth grade, however, the margin grew to 5.6 percent. The increase may be due to boys' tendency toward a more active role in the science classroom and to their participation in a greater number of outside-the-classroom science activities. Eleventh-grade boys recognized equipment 12.5 percent more frequently than did the girls. This may be related to the approximately 5:1 male to female ratio of students enrolled in physics and the 2:1 male to female ratio of students enrolled in chemistry, where students actually work with the equipment.

The Nature of the Test

Areas of the British Columbia Assessment Test showing the greatest differences between girls and boys were examined. At grade four, boys scored better on items related to activities that boys participate in more often than girls, such as using flashlights and batteries and making inferences about the motion of balls struck or thrown. Erickson and Erickson (1984) suggest that although girls also play with balls, they do not do so to the same extent. Thus they have a lesser context of experience in which to place subsequent class discussions about motion. Girls, however, did better on items such as opening a jar, using heat, and recognizing a word as a mirror image, again reflecting relevant experience outside of class. By twelfth grade, there were 34 points difference between the achievement of boys and girls in questions about functions of fuses and circuit breakers and 54 points in questions about carburetors in car engines. Boys scored higher in both cases.

In both the Minnesota Statewide Educational Test in Science and in the

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National Assessment Test, the focus of the question influences performance. Boys did better on test items that had to do with mechanics, forces, and model construction. Girls did better on those about plants or health-related topics.

Science as Masculine

Science, particularly physical science, is viewed as "masculine" by many of the girls and boys responding in both the assessment tests investigated and the research studies reviewed.

As girls reach adolescence, the view of science as masculine is most pronounced. At this age, girls have the most intensified interest in sexual identity and the greatest need to conform to what they believe to be the model of "femininity." Physical science is seen as masculine because of its perceived emphasis on industrial and military applications. Biology may be more acceptable because of its involvement with living things and protection of the environment. (In the National Assessment Test results, for example, girls proved more willing than boys to help improve the environment.) Because of these perceptions, fewer girls enroll in science courses in secondary schools.

The image of science as masculine comes from many sources. Studies of textbooks, particularly for physical and Earth science, convey this message through their illustrations and narrative statements. Texts, both at the elementary and secondary level, show many more male than female figures. The males, in most cases, are actively engaged in science with direct hands-on ativities. Females, when shown at all, are usually passive observers or recorders of data. More than one researcher described the males as "doing" and the females as "posing" in the illustrations.

Other masculine images of science come from the idea of "sex-appropriate" toys. Chemistry sets, mechanical toys, models, and puzzles are usually packaged with illustrations of male figures, and the advertising media focus on their use by males. Certainly some exceptions were found, but traditional packaging and advertising continues to send a sex-appropriate message.

Involving girls in science requires direct classroom experience like that pictured above.

Spatial Abilities

Many educators feel that the ability to mentally manipulate or rotate an object in space and the ability to construct three-dimensional models are necessary skills in science. Understanding microscope cross-sections, recognizing a crystalline form in order to identify a rock, and constructing a molecular model as a three-dimensional figure are applications of such skills. There is no consensus among researchers as to the degree and nature of the differences in spatial abilities between boys and girls. The majority of research indicates that spatial ability differences do not appear until age 14 or 15. A few studies suggest these differences are genetically sex-linked and that males have a definite advantage. Most researchers, however, believe that the disparity comes from differences in the in-school and out-of-school activities of boys and girls.

Many studies showed that girls have equal or better spatial abilities than boys do in the early elementary grades. In Piagetian spatial ability tasks, males were superior in block rotation at the ages of 7, 9, and 14, but there were no sex-related differences in mental rotation or shape assembly tasks. In other studies, the spatial abilities of both boys and girls were improved by periods of classroom instruction in model building, working with three-dimensional objects, and solving spatial visualization puzzles. By the beginning of senior high school, boys began to show, on the average, a slight performance advantage in spatial ability skills tasks. Many researchers attribute the advantage to typically male activities, such as constructing models (car, plane, building), map making in Boy Scouts, and using telescopes.

Lack of Role Models

Some studies show that the number of women science teachers influences enrollment, while other studies show no relationship. However, studies clearly indicate that the lack of role models in the science and engineering professions affects girls' perceptions of those careers. Several studies report that girls don't want science careers because they see science as cold and impersonal, and they believe women scientists are just the same—noncaring people who live "in their own world." The students were not surprised at the small number of women in the science fields; they felt that these women were probably like the stereotype in the preceding description.

As girls move ahead in the school system, they express even less interest in science as a career. Assessment tests show that little career education exists in science courses at any level.

Girls need to take an active role in laboratory activities, not passive observation.

Adult Expectations

If society considers science to be masculine, then parents probably won't encourage their daughters to pursue science in school or as a career. While these factors were relatively difficult to assess in their influence on girls and women, several studies outline the effect of expectations. In Saudi Arabia, for example, where society limits the number of acceptable career choices for women, only 5 percent of women pursue science-related careers. In Poland, societal views differ, and 60 percent of the women go into science. Some studies are in progress where early intervention has occurred and girls have been encouraged in science. These programs focus on early career counseling and active parent involvement. So far, secondary science enrollment has increased, but more time will be needed to find out if college course choices and career plans were affected significantly. The studies show that the schedule structure of many schools also conveys expectation messages to girls about their enrollment in science. In many cases, physics or chemistry classes are scheduled at the same time as advanced language, writing, or art courses. Girls participating in the studies frequently report this forced choice as their reason for not electing chemistry or physics. This scheduling is not an accident of the computer nor a necessary concession to time constraints. In many instances, the schedule is set this way deliberately because of the perception that it doesn't matter—chemistry and physics are boys' subjects and language and art are girls'.

Many studies have compared achievement in, attitude toward, and perception of science in single-sex schools with that in coeducational schools. The achievement level of girls in single-sex schools was generally better than the achievement level of either boys or girls in coeducational schools. Girls in single-sex schools achieved as well or better than boys in single-sex schools. In single-sex girls' schools, many more students take physical and biological science, and when available, Earth science. More girls in single-sex schools select careers in the sciences. Families of girls in these schools, as well as the school personnel, don't appear to bear any sex-role prejudices, and the career options presented to students clearly include science.

The Classroom Approach

Studies indicate that a problem-solving approach is used most often in physics and chemistry, with more of a lecture and directed laboratory approach in biology. For the most part, the girls in the studies liked the more directed approach and "felt intimidated" by the more open-ended process approach. Some researchers suggest that physical science formats should be made less open-ended to appeal to girls, while others thought it important for girls to learn to approach science as problem solving. Many studies also suggested that the problem-solving approach intimidates girls not because of their inability to do it, but because of their lack of confidence in science.

This lack of confidence and reluctance at problem solving is not apparent on the part of girls in elementary school. In the 1981-82 National Assessment Test, 65 percent of the girls answered that they would rather find out an answer themselves than have it told to them, compared with 57 percent of the boys. It is after grade four that other factors have an influence on this skill.

What We Can Do About It

The following strategies should help improve the interest, achievement, and attitudes of girls and young women in science if started in the early elementary grades and continuing through high school.

Increase direct experience in the classroom. Provide more hands-on experience for girls by doing science in single-sex groups. This should begin in the elementary school and continue until girls have had enough experience to be confident in taking the active role in laboratory experiences. Before using new equipment, such as batteries and bulbs, allow students time to become familiar with it. Do this particularly in areas that are traditionally male or where boys have more experience, such as using a compass.

Take the bias out of assessment tests. Work through local and state science organizations or professional teacher organizations to apply political pressure to testmakers. The questions need to be balanced between traditional boys' and girls' activities or be gender-neutral. Work with groups who are assessing standardized tests for sex-bias.

Change the perception of science as masculine. Evaluate text and curriculum material for sex-bias both in the illustrations and narrative sections of elementary and secondary science materials. Refuse to use those that are sex-biased. Enlist local, state, and national organizations in education to apply political pressure to the publishers. Get together with the entire faculty and administration to plan a strategy to eliminate sex-bias from the curriculum.

Correct disparity in spatial abilities. Beginning with grade one, implement programs devised to improve spatial abilities. Understand how spatial abilities are developed and use appropriate strategies for different developmental levels.

Make up for lack of role models and mistaken expectations. Implement a K-12 plan for career education in science. Devise a scheduling plan that does not force choices between arts and language and science.

Adjust your classroom approach. Focus on inquiry skill development in the elementary school. Incorporate single-sex laboratory groups.

In Conclusion

Numerous factors influence the achievement of girls and young women in science, their interest in science, and their attitudes toward science. Now that research has isolated the negative factors, we can at least begin the task of eliminating them. If girls and young women are not to remain the "disadvantaged majority" (Kahle 1982), then a commitment to improve their science education must become a joint effort for all of us. Since many negative factors come from society at large, people—including parents, guardians, and people in business and industry—need to become more actively involved. In addition, college and university faculties who work in science education for preservice teachers must concern themselves with answering the special needs of girls and young women. This goes for those leading inservice workshops as well. Once taken, these steps should result in a much needed increase in the number of girls in science.

Resources

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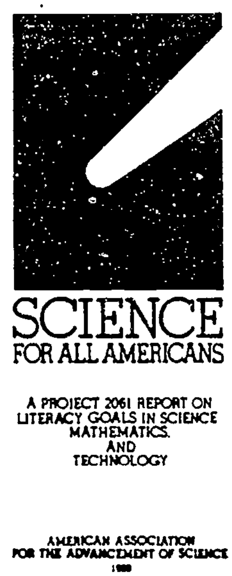
CHAPTER 13

EFFECTIVE LEARNING AND TEACHING



Although *Science for All Americans* emphasizes what students should learn, it also recognizes that how science is taught is equally important. In planning instruction, effective teachers draw on a growing body of research knowledge about the nature of learning and on craft knowledge about teaching that has stood the test of time. Typically, they consider the special characteristics of the material to be learned, the background of their students, and the conditions under which the teaching and learning are to take place.

This chapter presents—nonsystematically and with no claim of completeness—some principles of learning and teaching that characterize the approach of such teachers. Many of those principles apply to learning and teaching in general, but clearly some are especially important in science, mathematics, and technology education. For convenience, learning and teaching are presented here in separate sections, even though they are closely interrelated.

PRINCIPLES OF LEARNING

Learning Is Not Necessarily an Outcome of Teaching

Cognitive research is revealing that even with what is taken to be good instruction, many students, including academically talented ones, understand less than we think they do. With determination, students taking an examination are commonly able to identify what they have been told or what they have read; careful probing, however, often shows that their understanding is limited or distorted, if not altogether wrong. This finding suggests that parsimony is essential in setting out educational goals: Schools should pick the most important concepts and skills to emphasize so that they can concentrate on the quality of understanding rather than on the quantity of information presented.

What Students Learn Is Influenced by Their Existing Ideas

People have to construct their own meaning regardless of how clearly teachers or books tell them things. Mostly, a person does this by connecting new information and concepts to what he or she already believes. Concepts—the essential units of human thought—that do not have multiple links with how a student thinks about the world are not likely to be remembered or useful. Or, if they do remain in memory, they will be tucked away in a drawer labeled, say, "biology course, 1995," and will not be available to affect thoughts about any other aspect of the world. Concepts are learned best when they are encountered in a variety of contexts and expressed in a variety of ways, for that ensures that there are more opportunities for them to become imbedded in a student's knowledge system.

But effective learning often requires more than just making multiple connections of new ideas to old ones; it sometimes requires that people restructure their thinking radically. That is, to incorporate some new idea, learners must change the connections among the things they already know, or even discard some long-held beliefs about the world. The alternatives to the necessary restructuring are to distort the new information to fit their old ideas or to reject the new information entirely. Students come to school with their own ideas, some correct and some not, about almost every topic they are likely to encounter. If their intuition and misconceptions are ignored or dismissed out of hand, their original beliefs are likely to win out in the long run, even though they may give the test answers their teachers want. Mere contradiction is not sufficient; students must be encouraged to develop new views by seeing how such views help them make better sense of the world.

Progression in Learning Is Usually From the Concrete to the Abstract

Young people can learn most readily about things that are tangible and directly accessible to their senses—visual, auditory, tactile, and kinesthetic. With experience, they grow in their ability to understand abstract concepts, manipulate symbols, reason logically, and generalize. These skills develop slowly, however, and the dependence of most people on concrete examples of new ideas persists throughout life. Concrete experiences are most effective in learning when they occur in the context of some relevant conceptual structure. The difficulties many students have in grasping abstractions are often masked by their ability to remember and recite technical terms that they do not understand. As a result, teachers—from kindergarten through college—sometimes overestimate the ability of their students to handle abstractions, and they take the students' use of the right words as evidence of understanding.

People Learn to Do Well Only What They Practice Doing

If students are expected to apply ideas in novel situations, then they must practice applying them in novel situations. If they practice only calculating answers to predictable exercises or unrealistic "word problems," then that is all they are likely to learn. Similarly, students cannot learn to think critically, analyze information, communicate scientific ideas, make logical arguments, work as part of a team, and acquire other desirable skills unless they are permitted and encouraged to do those things over and over in many contexts.

Effective Learning by Students Requires Feedback

The mere repetition of tasks by students—whether manual or intellectual—is unlikely to lead to improved skills or keener insights. Learning often takes place best when students have opportunities to express ideas and get feedback from their peers. But for feedback to be most helpful to learners, it must consist of more than the provision of correct answers. Feedback ought to be analytical, to be suggestive, and to come at a time when students are interested in it. And then there must be time for students to reflect on the feedback they receive, to make adjustments and to try again—a requirement that is neglected, it is worth noting, by most examinations—especially finals.

Expectations Affect Performance

Students respond to their own expectations of what they can and cannot learn. If they believe they are able to learn something, whether solving equations or riding a bicycle, they usually make headway. But when they lack confidence, learning eludes them. Students grow in self-confidence as they experience success in learning, just as they lose confidence in the face of repeated failure. Thus, teachers need to provide students with challenging but attainable learning tasks and help them succeed.

What is more, students are quick to pick up the expectations of success or failure that others have for them. The positive and negative expectations shown by parents, counselors, principals, peers, and—more generally—by the media affect students' expectations and hence their learning behavior. When, for instance, a teacher signals his or her lack of confidence in the ability of students to understand certain subjects, the students may lose confidence in their ability and may perform more poorly than they otherwise might. If this apparent failure reinforces the teacher's original judgment, a disheartening spiral of decreasing confidence and performance can result.

TEACHING SCIENCE, MATHEMATICS, AND TECHNOLOGY

Teaching Should Be Consistent With the Nature of Scientific Inquiry

Science, mathematics, and technology are defined as much by what they do and how they do it as they are by the results they achieve. To understand them as ways of thinking and doing, as well as bodies of knowledge, requires that students have some experience with the kinds of thought and action that are typical of those fields. Teachers, therefore, should do the following:

Start With Questions About Nature. Sound teaching usually begins with questions and phenomena that are interesting and familiar to students, not with abstractions or phenomena outside their range of perception, understanding, or knowledge. Students need to get acquainted with the things around them—including devices, organisms, materials, shapes, and numbers—and to observe them, collect them, handle them, describe them, become puzzled by them, ask questions about them, argue about them, and then to try to find answers to their questions.

Engage Students Actively. Students need to have many and varied opportunities for collecting, sorting and cataloging; observing, note taking and sketching; interviewing, polling, and surveying; and using hand lenses, microscopes, thermometers, cameras, and other common instruments. They should dissect; measure, count, graph, and compute; explore the chemical properties of common substances; plant and cultivate; and systematically observe the social behavior of humans and other animals. Among these activities, none is more important than measurement, in that figuring out what to measure, what instruments to use, how to check the correctness of measurements, and how to configure and make sense out of the results are at the heart of much of science and engineering.

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Concentrate on the Collection and Use of Evidence. Students should be given problems—at levels appropriate to their maturity—that require them to decide what evidence is relevant and to offer their own interpretations of what the evidence means. This puts a premium, just as science does, on careful observation and thoughtful analysis. Students need guidance, encouragement, and practice in collecting, sorting, and analyzing evidence, and in building arguments based on it. However, if such activities are not to be destructively boring, they must lead to some intellectually satisfying payoff that students care about.

Provide Historical Perspectives. During their school years, students should encounter many scientific ideas presented in historical context. It matters less which particular episodes teachers select (in addition to the few key episodes presented in Chapter 10) than that the selection represent the scope and diversity of the scientific enterprise. Students can develop a sense of how science really happens by learning something of the growth of scientific ideas, of the twists and turns on the way to our current understanding of such ideas, of the roles played by different investigators and commentators, and of the interplay between evidence and theory over time.

History is important for the effective teaching. of science, mathematics, and technology also because it can lead to social perspectives—the influence of society on the development of science and technology, and the impact of science and technology on society. It is important, for example, for students to become aware that women and minorities have made significant contributions in spite of the barriers put in their way by society; that the roots of science, mathematics, and technology go back to the early Egyptian, Greek, Arabic, and Chinese cultures; and that scientists bring to their work the values and prejudices of the cultures in which they live.

Insist on Clear Expression. Effective oral and written communication is so important in every facet of life that teachers of every subject and at every level should place a high priority on it for all students. In addition, science teachers should emphasize clear expression, because the role of evidence and the unambiguous replication of evidence cannot be understood without some struggle to express one's own procedures, findings, and ideas rigorously, and to decode the accounts of others.

Use a Team Approach. The collaborative nature of scientific and technological work should be strongly reinforced by frequent group activity in the classroom. Scientists and engineers work mostly in groups and less often as isolated investigators. Similarly, students should gain experience sharing responsibility for learning with each other. In the process of coming to common understandings, students in a group must frequently inform each other about procedures and meanings, argue over findings, and assess how the task is progressing. In the context of team responsibility, feedback and communication become more realistic and of a character very different from the usual individualistic textbook homework-recitation approach.

Do Not Separate Knowing From Finding Out. In science, conclusions and the methods that lead to them are tightly coupled. The nature of inquiry depends on what is being investigated, and what is learned depends on the methods used. Science teaching that attempts solely to impart to students the accumulated knowledge of a field leads to very little understanding and certainly not to the development of intellectual independence and facility. But then, to teach scientific reasoning as a set of procedures separate from any particular substance—"the scientific method," for instance—is equally futile. Science teachers should help students to acquire both scientific knowledge of the world and scientific habits of mind at the same time.

Deemphasize the Memorization of Technical Vocabulary. Understanding rather than vocabulary should be the main purpose of science teaching. However, unambiguous terminology is also important in scientific communication and—ultimately—for understanding. Some technical terms are therefore helpful for everyone, but the number of essential ones is relatively small. If teachers introduce technical terms only as needed to clarify thinking and promote effective communication, then students will gradually build a functional vocabulary that will survive beyond the next test. For teachers to concentrate on vocabulary, however, is to detract from science as a process, to put learning for understanding in jeopardy, and to risk being misled about what students have learned.

HANDOUT

RESEARCH...SCIENCE, MATH and GENDER

by Laurie Hart Reyes and Michael J. Padilla

WHEN GIRLS SUCCEED IN SCIENCE, THEY CREDIT LUCK.

WHEN BOYS DO WELL, THEY CREDIT ABILITY. WHY?

Many girls simply have not been keeping pace with boys in secondary science. High school girls are less likely to study science and are not as confident as boys about their abilities in science [6]. They become more discouraged than boys about low science grades [2]. The data about girls and science accumulates, but data is not enough. We must analyze this new information and what it tells us about how we can improve. We must change the way we teach if we want to see more women in science careers in the coming decades.

So let's examine some recent data on the topic of sex-related differences in science and math achievement. Why math as well? Because math and science are learned together. In order to consider science as a career, women must have adequate math preparation; and that brings us back to our consideration of sex-related differences in achievement.

A recent meta-analysis of almost 300 studies sheds more light on gender differences in science. In those studies boys achieved better than girls in science and had more positive attitudes toward science. In elementary school, the analysis showed, boys did just a bit better than girls in science, with an effect size of 0.04 [5]. (An effect size is a difference stated in standard deviation units. A difference of 0.04 is very small.) By middle school the effect size had risen to 0.32 in favor of boys.

In another meta-analysis, researchers described several findings [10]:

.. Girls say they believe strongly that science is not just for boys. However, girls are less likely than boys to identify with science, to select science as a career, or to choose science-related activities.

.. Girls prefer life sciences, boys physical sciences. Girls like chemistry better than boys do, however.

.. During the last 6 years the gap between boys' and girls' motivation toward science has increased. Both groups show more interest in science, but boys' motivation has increased more than girls'.

A familiar source of information, the National Assessment of Educational Progress-Science (NAEP-S), has yielded two new insights. A recent reinterpretation of the assessment results attributed differences between boys' and girls' science knowledge

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to traditional gender roles [11}. Men seem to know more about technology, applied science, and other topics traditionally associated with men. Women seem to know more about such traditionally female topics as health, child development, and nutrition.

Girls are reluctant to guess on tests, and that made a difference in the NAEP-S results, according to another reanalysis [1}. Girls chose the response "I don't know" more often than boys did. That could mean that females avoid taking risks in science. "Not guessing avoids being right or wrong. Females, more than males, in this culture seem to be afraid of being wrong," the researchers suggested.

Sex-related differences in mathematics and science achievement develop over years, through the student's interaction with family, school, and society. We need much more research before we can know the causes of the differences. We cannot ignore the influences of family and society, but students learn mathematics and science mainly in school. On what should we concentrate if we want to have an impact on the way girls learn science?

Variable in space

The only important cognitive variable that may affect sex-related differences is spatial visualization, the menial manipulation of three-dimensional objects. We usually measure spatial visualization by tasks such as matching a picture of a cube with the correct two-dimensional drawing of the unfolded cube. Two pieces of evidence lead us to believe that this variable contributes to sex-related differences in math and science begin to appear. Second, it seems likely, although unconfirmed by research, that topics such as geometry, physical science, and graphing require spatial visualization skills.

Affective variables, such as students' attitudes about science, about the study of science, and about themselves as learners, may also be related to sex differences in mathematics and science performance. Students who are sure they can learn advances material are more likely to attemps to learn it; and the more they attempt, the more likely students are to learn. Several studies have confirmed the link between achievement and confidence. One study found that in every case where there was a significant difference between the mathematics achievement levels of girls and boys that favored boys, the boys also expressed more confidence in their ability to learn mathematics [3, 4}. Even then girls and boys achieved at the same level, the girls expressed less confidence in their ability to learn mathematics. Girls' confidence levels started dropping in 6th grade and continued to drop relative to boys' until 12th grade. Confidence in 8th grade proved the strongest predictor of 11th grade math achievement for boys and girls [8}. Math confidence can also predict future enrollment in math courses [9}. In science, we've already seen that girls are reluctant to guess at answers - an example of low confidence.

Another affective factor in the differences between girls' and boys' science and math performance may be whether or nor student think the subject is useful. In one study, when sex differences in perceived usefulness of math existed, a sex difference in math achievement also existed [3, 4}. If students don't see science as part of their career or life, they probably won't perform as well as they would if they saw science as pertinent. Students who do not think science important probably will not even opt to take science courses in high school. As early as middle school, more boys than girls rate mathematics as useful.

Stereotypes that label science and math as male may also affect performance. These stereotypes, including media images that show only men as users of science, influence parents' expectations for their children and students' expectations for themselves.

The last of the affective factors sets u pa no-win situation for women. Women more often attribute success to effort and luck, while men attribute success to their ability. On the other hand, women attribute their failures to lack of ability, while men attribute their failures to other causes. What does this mean? If a student thinks she has failed because of lack of ability, she is less likely to work harder to improve than will a student who believes he has failed because he didn't try hard enough. Conversely, when a student does succeed, if she attributes her success to luck, she is not encouraged by the success.

What about Teachers?

We have considered characteristics of the students - cognitive and affective variables. But what characteristics of schools, classrooms and teachers might contribute to sex differences?

One study found sex differences in math achievement only in some schools [3, 4}. The differences did not seem to be related to the socioeconomic status of the students. The researchers hypothesized that the cause of the differences might lie partly within individual schools.

Within schools the most important influence on science and math learning in the teacher. Teachers can influence students' attitudes about themselves and about science and mathematics. On researcher noted that teachers interacted more with high-achieving boys than with high-achieving girls in a class of seventh graders. This was true of interactions teachers initiated and ones students indicated. [7}

Middle grade teachers must realize the pivotal role these grades play. The middle years are often the last during which all students are required to take mathematics and science courses. So we need to examine critically what and how we teach. Middle grade teachers must remember how important confidence is and plan lessons so that the self-fulfilling prophecies of failure are broken.

We must evaluate closely what we expect from out male and female students and try to eradicate the myth that males are naturally better than females in math and science. Any we must convince out female students that science is useful. Studying real-life problems such as environmental concerns or energy issues can help, as well as examining the science of everyday living - bicycles, cooking, athletics. Enthusiastic teachers who examine and reexamine their attitudes and expectations of male and female students, and who take special care to encourage girls, can help make sure that science becomes an equal opportunity employer.

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Science Teaching Should Reflect Scientific Values

Science is more than a body of knowledge and a way of accumulating and validating that knowledge. It is also a social activity that incorporates certain human values. Holding curiosity, creativity, imagination, and beauty in high esteem is certainly not confined to science, mathematics, and engineering—any more than skepticism and a distaste for dogmatism are. However, they are all highly characteristic of the scientific endeavor. In learning science, students should encounter such values as part of their experience, not as empty claims. This suggests that teachers should strive to do the following:

Welcome Curiosity. Science, mathematics, and technology do not create curiosity. They accept it, foster it, incorporate it, reward it, and discipline it—and so does good science teaching. Thus, science teachers should encourage students to raise questions about the material being studied, help them learn to frame their questions clearly enough to begin to search for answers, suggest to them productive ways for finding answers, and reward those who raise and then pursue unusual but relevant questions. In the science classroom, wondering should be as highly valued as knowing.

Reward Creativity. Scientists, mathematicians, and engineers prize the creative use of imagination. The science classroom ought to be a place where creativity and invention—as qualities distinct from academic excellence—are recognized and encouraged. Indeed, teachers can express their own creativity by inventing activities in which students' creativity and imagination will pay off.

Encourage a Spirit of Healthy Questioning. Science, mathematics, and engineering prosper because of the institutionalized skepticism of their practitioners. Their central tenet is that one's evidence, logic, and claims will be questioned, and one's experiments will be subjected to replication. In science classrooms, it should be the normal practice for teachers to raise such questions as: How do we know? What is the evidence? What is the argument that interprets the evidence? Are there alternative explanations or other ways of solving the problem that could be better? The aim should be to get students

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into the habit of posing such questions and framing answers.

Avoid Dogmatism. Students should experience science as a process for extending understanding, not as unalterable truth. This means that teachers must take care not to convey the impression that they themselves or the textbooks are absolute authorities whose conclusions are always correct. By dealing with the credibility of scientific claims, the overturn of accepted scientific beliefs, and what to make out of disagreements among scientists, science teachers can help students to balance the necessity for accepting a great deal of science on faith against the importance of keeping an open mind.

Promote Aesthetic Responses. Many people regard science as cold and uninteresting. However, a scientific understanding of, say, the formation of stars, the blue of the sky, or the construction of the human heart need not displace the romantic and spiritual meanings of such phenomena. Moreover, scientific knowledge makes additional aesthetic responses possible—such as to the diffracted pattern of street lights seen through a curtain, the pulse of life in a microscopic organism, the cantilevered sweep of a bridge, the efficiency of combustion in living cells, the history in a rock or a tree, an elegant mathematical proof. Teachers of science, mathematics, and technology should establish a learning environment in which students are able to broaden and deepen their response to the beauty of ideas, methods, tools, structures, objects, and living organisms.

Science Teaching Should Aim to Counteract Learning Anxieties

Teachers should recognize that for many students, the learning of mathematics and science involves feelings of severe anxiety and fear of failure. No doubt this results partly from what is taught and the way it is taught, and partly from attitudes picked up incidentally very early in schooling from parents and teachers who are themselves ill at ease with science and mathematics. Far from dismissing math and science anxiety as groundless, though, teachers should assure students that they understand the problem and will work with them to overcome it. Teachers can take such measures as the following:

Build on Success. Teachers should make sure that students have some sense of success in learning science and mathematics, and they should deemphasize getting all the right answers as being the main criterion of success. After all, science itself, as Alfred North Whitehead said, is never quite right. Understanding anything is never absolute, and it takes many forms. Accordingly, teachers should strive to make all students—particularly the less-confident ones—aware of their progress and should encourage them to continue studying.

Provide Abundant Experience in Using Tools. Many students are fearful of using laboratory instruments and other tools. This fear may result primarily from the lack of opportunity many of them have to become familiar with tools in safe circumstances. Girls in particular suffer from the mistaken notion that boys are naturally more adept at using tools. Starting in the earliest grades, all students should gradually gain familiarity with tools and the proper use of tools. By the time they finish school, all students should have had supervised experience with common hand tools, soldering irons, electrical meters, drafting tools, optical and sound equipment, calculators, and computers.

Support the Roles of Girls and Minorities in Science. Because the scientific and engineering professions have been predominantly male and white, female and minority students could easily get the impression that these fields are beyond them or are otherwise unsuited to them. This debilitating perception—all too often reinforced by the environment outside the school—will persist unless teachers actively work to turn it around. Teachers should select learning materials that illustrate the contributions of women and minorities, bring in role models, and make it clear to female and minority students that they are expected to study the same subjects at the same level as everyone else and to perform as well.

Emphasize Group Learning. A group approach has motivational value apart from the need to use team learning (as noted earlier) to promote an understanding of how science and engineering work. Overemphasis on competition among students for high grades distorts what ought to be the prime motive for studying science: to find things out. Competition among students in the science classroom may also result in many of them developing a dislike of science and losing their confidence in their ability to learn science. Group approaches, the norm in science, have many advantages in education; for instance, they help youngsters see that everyone can contribute to the attainment of common goals and that progress does not depend on everyone's having the same abilities.

Lost Talent

The Underparticipation of Women, Minorities, and Disabled Persons in Science

Jeannie Oakes

SUMMARY

As the nation's economic base shifts increasingly toward technology, U.S. students' participation and achievement in science and mathematics become increasingly important. The current explosion of technology suggests a future economy based increasingly on the size and quality of the technological workforce. Yet even as this sector of the workforce is increasing, the proportion of the U.S. population involved in science and engineering has slipped, compared with Japan, West Germany, France, and the United Kingdom.

Demographic projections add to the concern, for the traditional pool from which scientific workers have been drawn in this country is shrinking. As a result of overall declines in the birthrate since 1964, the pool of 18- to 24-year-olds—the cohort preparing for careers and entering the workforce—will shrink by 23 percent by 1995. The composition of the pool will also change. The number of whites will decline markedly, while the number of minorities will increase. Higher birthrates and immigration will cause the number of minorities in the 18- to 24-year-old group to grow by 20 to 27 percent by 1998. In addition, women will continue making headway in the workforce; they will represent 47 percent of the total workforce and half of those pursuing professional careers. The U.S. Department of Labor estimates that women, minorities, and immigrants will constitute 80 percent of the net additions to the labor force between 1987 and 2000.

The composition of this projected workforce causes great concern for the scientific community. Currently, only 15 percent of employed scientists, mathematicians, and engineers are women; blacks (who constitute 10 percent of all employed workers and 7 percent of professional workers) and Hispanics (5 percent of all workers and 3 percent of professionals) each constitute about 2 percent of the scientific workforce. In addition, women, blacks, and Hispanics are underrepresented among those *preparing* for careers in science. Although women have made great strides in the past decade, they earn only 38 percent of the scientific bachelor's degrees, 30 percent of the master's degrees, and 26 percent of the doctorates awarded in the United States, and most of these are in psychology and the social sciences. Blacks and Hispanics have made little progress: Blacks earn 5 percent of the scientific bachelor's degrees and 2 percent of the doctorates; Hispanics earn 3 percent of the bachelor's degrees and 2 percent of the doctorates. Like women, blacks and Hispanics who earn degrees in science tend to major in

psychology and the social sciences; their percentages have not changed substantially in 10 years.

If the United States is to function effectively in a technology-based economy, it cannot afford to underutilize its workforce so drastically. If the nation continues to rely on decreasing numbers of white and Asian males for scientific talent, the quantity—and quality—of the workforce will be substantially lower than it would be if all groups were included. In addition, as technology becomes increasingly central to work and national life, lack of attainment in science and mathematics will affect the ability of women and minorities to compete for employment, wages, and leadership in any professional field. In a society grounded in the long-standing policy of the fair distribution of economic and social opportunities, such a situation is untenable.

This study explores reasons why women, minorities, and physically handicapped people hold fewer professional jobs in science and technology than white and Asian males, and it suggests potential solutions to the problem.

Schooling rests at the heart of the issue. Careers in science and technology result from students passing through a long educational "pipeline." Doing so successfully involves three critical factors: *opportunities* to learn science and mathematics, *achievement* in these subjects, and students' *decisions to pursue* them. Women and minorities lose ground on all three factors, but in different ways and at different points in time. Very little is known about the movement of physically handicapped people through the pipeline.

The pool of scientific/mathematical workers moves into the pipeline during elementary school and reaches its maximum size before 9th grade. During high school, some additional students enter the flow, but considerably more leave. Following high school, the movement is almost entirely outward. In elementary school, students' early achievement in mathematics appears related to their interest in science and math, and to the science-related experiences they have both in and out of school. In many schools, the students with the highest interest and achievement have enhanced opportunities to learn science and mathematics through being placed in special enrichment programs.

As students move into middle schools and junior high schools, those with high interest and/or high scores on basic-skills tests move into advanced classes that prepare them for high school mathematics. In contrast, students who lack interest and/or have low test scores are often assigned to remedial, review, or practical classes, where they are not prepared for advanced senior high school science and mathematics courses. Such students leave the scientific pipeline at this juncture.

In senior high school, students' achievement and curricular choices influence their subsequent opportunities. Typically, high-achieving students who plan to attend college enroll in programs that require a greater number of mathematics and science courses. Lower-achieving students enroll in vocational or general programs that require fewer such courses. Those who enroll in mathematics and science courses beyond the program requirements are those with both high interest and high achievement. On the whole, these are the students who choose mathematics and science majors in college, the next major juncture in the pipeline.

Once a student is in college, persistence in a scientific major becomes crucial to emerging from the pipeline into a scientific career. At this stage, persistence seems to be related to high school achievement (as measured by SAT scores), high school grades, high school class rank, and grades earned in college.

While women and minorities drop out of the pipeline at various stages, women tend to leave primarily during senior high school and college, while blacks and Hispanics leave much earlier. Furthermore, women leave because they *choose* not to pursue scientific careers, while blacks and Hispanics leave principally due to low achievement in mathematics during the precollege years. Gender differences in mathematics achievement are nearly nonexistent in both elementary and junior high school; by senior high school, though, achievement differences become evident. At the same time, elementary school girls show less positive attitudes toward science and science careers than do boys, and the gap widens in junior high; by senior high school, girls exhibit a more negative attitude, pursue fewer mathematics and science opportunities, and score considerably less well than boys on measures of mathematics and science achievement. In contrast to women, blacks and Hispanics consistently demonstrate high interest in mathematics and science, but their lower achievement often places them in remedial programs from elementary school on, thus limiting their opportunities for science-related experiences. By the time blacks and Hispanics reach senior high school, the achievement gap between them and whites has widened, effectively blocking them from mathematics and science opportunities beyond high school.

If the situation is to be remedied, it will be necessary to intervene at those junctures in the pipeline where students drop out, and the interventions must be appropriate to each group. Although many intervention programs exist and evaluation data have been collected and reported on their effects, few programs have been subjected to systematic inquiry. Nor has much empirical work been done on the causes of underparticipation or on ways to address those causes. The available research suggests that altering the way science and mathematics are taught can promote girls' achievement and the likelihood of girls choosing to study these subjects. Likewise, minority achievement can be increased by providing additional, positive science and mathematics experiences both in and out of school, as well as providing altered instruction, career information, and contact with role models.

Much remains to be done, however. First, it is essential to monitor more closely the overall trends in the status of women and minorities in science and mathematics and to translate the data collected into useful "indicators" for policymakers and educators. Presently, for example, the data available are inadequate to permit studies of racial and ethnic subpopulations; typically, Mexican-Americans, Central Americans, Puerto Ricans, and Cubans are lumped together as Hispanics, while the Asian category includes such diverse groups as Chinese, Vietnamese, Japanese, and Filipinos. Second, we must know much more about how schooling relates to minority students' learning opportunities, achievement, and decisions about their future careers, especially at the elementary school level. Finally, it is necessary to explore how individual and social factors interact with girls' attitudes about science and mathematics and how that interaction affects girls' choices not to participate in scientific careers.

BREAK

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Break Period

The trainer should announce a 15 minute break at this point. During the break the trainer will need to set up the work stations. There are probably more work station suggestions than will be needed. The trainer should select in advance those that will best the needs of the group, whether there are elementary and/or secondary teachers and the group size. The printed descriptions of the work stations that are not set up should be made available as a handout. The research and reference material included in this section are considered a required work station.

WORK 6 STATIONS

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Work Stations

ELEMENTARY AND SECONDARY SCIENCE ACTIVITIES FOR CLASSROOM USE

OBJECTIVE: To offer demonstrations and examples of hands-on science lessons to use in both elementary and secondary classrooms.

GROUP SIZE: Small groups to fit the number of work stations used. Depending on size and grade level, not all work stationsmay be needed. Select the work stations which best fit interests of participants. It's possible that 3 or 4 work station activities including resources as a work station, may be sufficient. An alternative is to set up a work station as a demonstration.

TIME: 45 minutes.

MATERIALS: Materials for investigations are listed on the first page of each work station lesson plan. Each work station needs specific supplies. They are all listed on the Module Content page at the front of this module. Have enough copies of each activity for all participants. These handouts are written as lesson plans for the classroom teacher.

PROCEDURE:

1. Trainer sets up the work stations during the preceding break.
2. Trainer makes a general explanation of the workstations by stating their objectives. Use the "Teaching Strategies" overhead to explain why hands-on science lesson activities are more likely to increase girl's success in science.
3. Explain the appropriateness of gender equity to promote quality science education for all students. (See Handout 5-A, Carol Klein article for suggested strategies such as increasing direct experience in the classroom, taking the bias out of assessment tests, changing the perception of science as masculine, correcting the disparity in spatial abilities, making up for lack of role models, and adjusting the classroom approach.)
4. Trainer clarifies that Resource Materials are a work station appropriate for elementary and secondary teachers.
5. Organize participants in teams or small groups according to the grade level they teach.
6. Trainer allows time for activities to take place. Once a small group has finished their activity they may move to or join another small group at a work station. Some activities don't take very long.
7. Trainer tells participants when there are only a few minutes work time left.

8. Trainer asks participants to briefly share what happened with each investigation.

Use the "Work Station Questions" transparency (or write the questions on newsprint) to pose questions relevant to each work station activity.

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Work Station Questions

1. Were there any surprises or "Ah ha's?"
2. What other ways have you done these investigations?
3. What would you change in the investigation?
4. What problems did you have with these activities?
5. How could you gear it up or down for your grade level?
6. What extensions could be added?
7. What learning log ideas could be added?
8. Did any interdisciplinary connections come to mind?

Teaching Strategies to Improve Interest, Achievement and Attitudes of Girls Toward Science

Increase direct experience in the classroom.

Use a team approach to instruction.

Before using new equipment, allow students to become familiar with it (e.g. batteries and bulbs).

Implement programs to improve spatial abilities.

Focus on inquiry skill development, especially in the elementary school.

Incorporate single-sex laboratory groups.

Progress from the concrete to the abstract in instruction.

Balance the use of traditionally boy's and girl's activities for examples in your lessons and tests.

Evaluate text and curriculum material for sex bias in illustrations and narrative.

Allow students to pra :tice skills and analysis of information and making logical arguments.

Set equal expectations for girls' and boys' performance in science education.

*(Source: **Science and Children**, October 1989 and Science for All America)*

ALL LEVELS WORK STATION #1

Resource Material

ACTIVITIES FOR GRADES 1 - 6

1. Introduce students to biographies of women in science. Each student in turn can then develop a diorama, decorate a cake, make a mask, puppet or costume for one woman who especially captures her/his interest and do an explanatory presentation to the class. The entire assemblage can form the base for a school "women's history museum" in the classroom or library, with other classes invited to the opening ceremony and student-conducted tours. One class may do women in science, while another does women in math, etc.

2. Arrange for a storyteller or parent to dress in appropriate costume to circulate in your school telling stories about real American women in science, past or present. As a language arts exercise, the students might ask her questions about the stories, transcribing her responses for a class report.

3. Invite a woman working a non-traditional science job to share her experiences with your class. In advance, have the students prepare interview questions to ask her about the training her work required, what got her interested in this work initially, what she especially likes about the work she does, what its drawbacks are for her, and what her future plans are for her working life. A guessing game to determine just what her work is in the first place can be such, such as "Twenty Questions" or "What's My Line?"

4. Start a collection of pictures and articles from magazines, newspapers and advertisements depicting women in traditional and non-traditional science activities. Which are easier to locate? What are the adult women in your students' lives doing that the images represent? Create a mural telling the story of these lives and images to hang outside of your classroom for visitors and other students to see and consider.

5. Observe the birthdays of our foremothers in science throughout the year as you do our forefathers - special bulletin boards, classroom lessons, art projects, films, stories, skits. Birthday cakes decorated by the students to represent the life work of the birthday woman add to the impact and sense of importance, of course!

6. Announce a shoe box float contest and miniature parade on a selected theme dealing with women in United States science. A student committee can design, make and present ribbons to all participants, and announce each float during the parade.

7. "Piece" a quilt of construction paper collage squares, each depicting a scene from the life of a particular woman in science. Display these together on a dark background for maximum effect.

ALL LEVELS WORK STATION #1

Resource Material

BOOKS FOR YOUNGER READERS

FOUR WOMEN OF COURAGE, Bennett Wayne, editor
True grit is what made Jacqueline Cochran, Dorothea Dix, Helen Keller, and Linda Richards famous. Young people who need encouragement to read will be inspired by their bravery. Photos. Grades 3-8. 168 pages, cloth, ISBN 0-8116-4911-3. $9.95

FIRST WOMEN OF THE SKIES, Kitty A. Crowley
Brief, interesting looks at the lives of five women pioneers in aviation: Bessie Coleman, Mathilda Moisant, Harriet Quimby, Valentina Tereshkoba and Emily Warner. Grades 3 and up. 48 pages, cloth, ISBN 0-89547-063-2, $10.95

WOMEN WHO DARED TO BE DIFFERENT, Bennett Wayne, editor
Easy-to-read detailed life stories of daring women from earlier times: Nelly Bly, reporter; Amelia Earhart, pilot; Maria Mitchell, astronomer; and Annie Oakley, sharpshooter. Photographs. Grades 3-8. 168 pages, cloth, ISBN 0-8116-4902-4, $9.95

WOMEN WITH A CAUSE, Bennett Wayne, editor
The lives of Susan B. Anthony, Anne Hutchinson, Lucretia Mott, Eleanor Roosevelt, and the causes they championed are the subjects of this easy-to-read volume. Photos. Grades 3-8. 168 pages, cloth, ISBN 0-8116-4914-8, $9.95

TATTERHOOD AND OTHER TALES, Ethel Johnston Phelps, editor
All the central characters in these 25 international folk tales are spirited females - decisive heroines of courage, wit and achievement who set out to determine their own fate. Includes details about their sources. Illustration. Grades 1-6. 166 pages, paper, ISBN 0-912670-50-9, $6.95

RACHEL CARSON: WHO LOVED THE SEA, Jean Lee Latham
Carson's love for the ocean and biology led her to become a scientist, while her clear writing helped awaken the world to the destructiveness of pesticides. Photos. Grades 2-5. 80 pages, cloth, ISBN 8116-6312-4, $8.95

LILIUOKALANI, Mary Malone
This biography of Hawaii's last sovereign, Queen Liliuokalani, gives young readers a full picture of her life as an educator and her short, stormy career as a monarch. Illustrations. Grades 2-5. 80 pages, cloth, ISBN 0-8116-6320-5, $8.95

ELIZABETH BLACKWELL: PIONEER WOMAN DOCTOR, Jean Lee Latham
In 1849 Blackwell became one of the first women allowed to earn a medical degree in the U.S. She went on to work as a physician and to found a hospital and medical college for women in New York. Illustrated. Grades 2-5. 80 pages, cloth, ISBN 0-8116-6319-1, $8.95

EMBERS, Ruth Meyers and Beryle Banfield, editors
Lively fiction, biography, poetry and oral histories portray people who in various ways overcame traditional barriers of race, sex and disability. Illustrations. Grades 3-7. 175 pages, paper, ISBN 0-9300040-47-3, $8.95

EMBERS, TEACHER EDITION, Ruth Meyers and Beryle Banfield, editors
Provides a teacher/learning plan for each selection in the reader. Activities will assist students in exploring concepts of justice, equality, family culture and tradition as well as developing reading and language arts proficiency. Grades 3-7. 142 pages, spiral bound. ISBN 0-9300040-46-5, $18.95

WOMEN, NUMBERS AND DREAMS, Teri Hoch Perl and Joan M. Manning
Math puzzles, activities and illustrations accompany each of the thirteen biographical sketches of women mathematicians. Multicultural and marvelous! Who's included? Lenore Blu, Mary Everett Boole, Jean Darling, Kathi Dwelle, Evelyn Boyd Granville, Sally Handy-Zarnstorff, Sonya Kovalevskaya, Ada Lovelace, Fanya S. Montalvo, Emmy Noether, Edna Lee Paisano, Mary Somerville and Grace L. Yang. A separate 21 page teacher's manual accompanies the book. Grades 3-6. 257 pages, paper, $12.95 set

MYSELF AND WOMEN HEROES IN MY WORLD: A CURRICULUM UNIT FOR KINDERGARTEN,
National Women's History Project, Illustrated by Mary Crawford
Marvelous flannel board figures accompany each of the six lively biographies, as do recall and discussion questions, specifically related activities, a teacher bibliography and culminating unit activity. In all, these materials will bring to life the six women of this unit for young children: Queen Liliuokalani, the last reigning Monarch of Hawaii; Maria Tallchief, world famous prima ballerina; Harriet Tubman, slave liberator of the Underground Railroad; Amelia Earhart, adventuresome pilot; Sonia Manzano, stage and television personality; Sojourner Truth, fearless speaker for human rights. A personal history activity concludes the unit, drawing connections between the life choices of the child and the lives of these six remarkable women. 68 pages, paper, $7.50

WOMEN'S HISTORY CURRICULUM UNITS FOR GRADES 1, 2 and 3
National Women's History Project, Illustrated by Mary Crawford
Specially designed in accordance with social studies guidelines, these units each include 6 biographies and illustrations of women representing the 5 major ethnic groups and disabled persons, plus classroom and individual activities, language and math exercises, and oral history kits.

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ALL LEVELS WORK STATION #1

Resource Material

RELATED PUBLICATIONS

HANDBOOK 1 SCIENCE TEACHES BASIC SKILLS
HANDBOOK 2 THE PRINCIPAL'S ROLE IN ELEMENTARY SCHOOL SCIENCE
HANDBOOK 3 CHARACTERISTICS OF A GOOD ELEMENTARY SCIENCE PROGRAM
HANDBOOK 4 WHAT RESEARCH SAYS ABOUT ELEMENTARY SCHOOL SCIENCE

Kenneth R. Mechling and Donna L. Oliver, National Science Teachers Association, 1742 Connecticut Avenue, NW, Washington, DC 20009.

SCHOOL SCIENCE AND MATHEMATICS, Volume LXXIX, #4, April 1979

SCIENCE AND MATHEMATICS IN THE SCHOOLS: REPORT OF A CONVOCATION, National Academy of Sciences and Engineering

Yager, Robert E., ***WHAT RESEARCH SAYS TO THE SCIENCE TEACHER***, N.S.T.A., University of Iowa, Iowa City, IA 52242, 1982

SCIENCE EDUCATION FOR THE 1980S, California State Department of Education, 1982

IMPROVING MATH AND SCIENCE EDUCATION, American Association of School Administrators, 1985

EDUCATING AMERICANS FOR THE 21ST CENTURY, National Science board, 1983

Science Educational Society: ***A GUIDE TO INTERACTION AND INFLUENCE***, Abraham, Michael, University of Oklahoma, 1979

WOMEN OF ACHIEVEMENT, Susan Raven and Alison Weir, Harmony Books, New York, 1981

STUDIES IN SCIENCE EDUCATION, Volume 4, 1977, Layton, David, Centre for Studies in Science Education, University of Leeds

Black, P. J., ***PUPILS' ATTITUDES TO SCIENCE***, N.F.E.R. Publishing Co. Ltd., 2 Jennings Buildings, Thames Avenue, Windsor, Berkshire, England, $3.50

SCIENCE EDUCATION DATA BANK, Directorate for Science Education, Office of Program Integration, Buccino, Alphonse

HANDOUT 6-11C
Johnson, Liz, Comp., and Hall, Roberta M. Comp., "Selected Activities Using 'The Classroom Climate: A Chilly One for Women?,'" Association of American Colleges, New York, NY 1984

WOMEN'S HISTORY CURRICULUM GUIDE AND 1985-86 RESOURCE CATALOG ($1.00) National Women's History Project, P.O. Box 3716, Santa Rosa, CA 95402

RESOURCES FOR EDUCATIONAL EQUITY, WOMEN'S EDUCATIONAL EQUITY ACT PROGRAM, U.S. Department of Education

RESOURCES TO COUNTER RACISM, SEXISM AND OTHER FORMS OF BIAS IN SCHOOL AND SOCIETY 1986 CATALOG, Council on Interracial Books for Children, Inc.

WOMEN, MATH AND SCIENCE; A RESOURCE MANUAL, Center for Sex Equity in Schools, University of Michigan, 1984

Vetter, Betty. ***"WOMEN IN THE NATURAL SCIENCES."*** Signs 1, Part 1 (Spring 1976) 713-720

EXPANDING YOUR HORIZONS IN SCIENCE AND MATHEMATICS: A HANDBOOK FOR PLANNERS IS A PROGRAM TO HELP EDUCATORS AND PARENTS ENCOURAGE YOUNG WOMEN TO CONSIDER CAREERS IN SCIENCE AND TECHNOLOGY. The handbook describes how to plan, conduct, and evaluate conferences for young women. "The Math-Science Connection" presents four exemplary programs for girls and women considering scientific or technical study. "Sandra, Zella, Dee, and Claire" takes a look at the scientific careers of four women - an astronomer, a veterinarian, a laser physicist, and an engineer. For middle and secondary school students. 0078 (50 pp.) $2.50

HOW HIGH THE SKY? HOW FAR THE MOON? An Educational Program for Girls and Women in Math and Science. Sure to pique students' interest, this program shows you how to teach science, and equity at the same time. The annotated list of materials for each grade will save you valuable planning time. If you're a math or science teacher, counselor, media specialist, librarian, or administrator, you and your students will find this an exciting addition to your curriculum. For grades K-12. 0103 "How High the Sky? How Far the Moon? (132 pp.) with "Women Scientist Today," four audiotape cassettes and guide. $14.50

SPATIAL ENCOUNTERS is a classroom manual enabling fun and learning to come together. With these materials boys and girls enjoy visual-spatial games such as remembering patterns or completing and rotating figures. The exercises contain easy directions for classroom and self-directed use. They show how various visual-spatial skills have applications in the real world of scientific occupations - math, geography, acoustics, landscape architecture, and telecommunications. Particularly helpful for girls and women whose skills in these areas are often blunted by socialization and stereotyping. For grades K-12 and adults. 0434 "Spatial Encounters" (338 pp.). $14.00

ALL LEVELS WORK STATION #1

Resource Material

GENDER RESEARCH SUMMARY

RESEARCH—INTEREST AND ATTITUDE:

"Interest in science is related to achievement"
Bloom (1976)

"Increasing the interest and participation of women and racial minorities in mathematics and science majors and careers continues to be an issue of national concern." (National Science Foundation, 1984)

"Students who have a high level of interest in mathematics and science are more likely to pursue mathematics and science majors and to persist in these fields than are students who have lower interest levels." (Maines, 1983; Thomas 1984)

"Race and sex differences in students' interest in, and affinity for, mathematics and science have been reported in a number of studies (Fox, 1976; Berryman, 1983; Chipman and Thomas, 1984). The findings from these studies indicate that Black and female students express lower levels of interest and affinity for mathematics and science than white and male students." (Thomas, Gail E.)

"Students acquire a dislike for science courses early. By the end of the third grade, almost 1/2 of all students feel they would not like to take science; by the end of the eighth grade, only 1/5 have a positive attitude toward science." (Science and Mathematics in the Schools)

"Elementary school girls like science and math as much as boys do. Female students begin to lose their interest in science and math in their early teens." (Adding a Woman's Touch, p. 25)

RESEARCH - ABILITY:

When girls succeed in science, they credit luck. When boys do well, they credit ability. Why?"

"Women attribute their failure to their lack of ability, while men attribute their failures to other causes." (Reyes, Laurie Hart and Padilla, Michael J., **Science, Math and Gender, the Science Teacher**, p. 48, September 1985)

"It has been reported that the extent to which students like math and science and pursue college majors and careers in these fields is largely a function of the academic ability and mastery that students exhibit in these fields." (Werts, 1966, Astin and Panos, 1969, Benbow and Stanley, 1980)

RESEARCH - PEERS:

"Picou and Carter (1976) found that peer modeling and peer encouragement have a significant effect on educational aspirations of students. Peer influence has also been found to have an effect on school outcomes in science. Howe and Durr (1982) reported that planned peer interactions during chemistry laboratories increased student understanding of abstract concepts. Keevos found that attitudes toward science were strongly influenced by friends who participated in math and science activities. He concluded that the peer group with which a student spends his or her leisure time would be expected to influence personal attitudes toward science and math. Attitude toward science is contagious...both in a positive, as well as in a negative manner." (Talton and Simpson)

RESEARCH - PRAISE AND ENCOURAGEMENT:

"The extent and nature of teacher praise affects students' attitudes towards mathematics and science. For example, Kaminski (1976) reported that teachers readily assume that girls like reading and dislike math and science. Teachers subsequently encourage girls and boys differently based on this assumption." (Thomas)

RESEARCH - ADULT ROLE MODELS:

"Having early exposure to and access to relevant role models and receiving adequate encouragement from 'significant others' (i.e., parents, teachers, counselors, and peers) also have been reported as important factors that influence students' interest and attitudes towards mathematics and science. Malcom, Hall and Brown (1976) and Young and Young (1974) found that exposure to, and interaction with, professional role models in the natural and technical sciences are critical for recruiting and retraining students' interest and participation in mathematics and science." (Thomas, p.32)

"Positive family attitudes and encouragement also have been reported as important factors for recruiting and retaining students' interest and participation in math and science. For example, Fox (1976) found that at a very early age, girls, but not boys, are told that having children is a responsibility that will interfere with their occupational careers. Thomas (1984) and Malcolm (1976) also reported that Blacks and females receive less encouragement to pursue college majors and careers in mathematics and science than do whites and males." (Thomas)

RESEARCH - SCIENCE CLUB PARTICIPATION:

"Providing students with greater access to informal mathematics, science education, and extracurricular activities has been identified as an additional strategy for increasing their interest in math and science." (Fox, 1982; Fisher, 1983; Kahle, 1983) This could be accomplished through informal interaction with parents and older siblings, attending museums, participating in math games and math and science clubs.

RESEARCH - HOBBIES:

"It has been reported that having an affinity for mathematics and science hobbies and engaging in such hobbies during childhood are positively related to students' subsequent interest in mathematics and science education and careers. (Kahle, 1983) Also, students with high educational and occupational expectations have been reported as having favorable attitudes toward mathematics and science than students with low educational and occupational expectations. Young (1983) and Steel (1978) also noted that female and Black students are socialized very early in their educational development to be more 'affective' and 'service oriented' and less 'analytical' and 'quantitative' in their career interests and aspirations. As a result, these students express less competitive and lower occupational expectations than do males and whites. Young and Young (1974), Thomas and Gordon (1983) and Gottfredson (1977) However, females and Blacks express comparable and sometimes higher educational expectations than do males and whites." Thomas, Alexander and Eckland, (1979), Thomas (1979), (Thomas, p.34)

The results from Thomas show that having an interest in science hobbies has the strongest positive relationship to interest in high school science for males and females.

For females, the next two most important factors are:

1. having received encouragement to major in science, and
2. performance on standardized tests.

For males they are:

1. childhood aspirations of being a scientist, and
2. high school grades.

RESEARCH - BENEFITS OF SCIENCE EDUCATION:

"Ruth Wellman cites 18 studies which found that direct first-hand manipulative experiences in science enhanced the development of process skills in young children in kindergarten to third grade and had a positive correlation with their success in beginning language and reading achievement."

"Wellman cites a dozen studies which point to benefits children can derive from science instruction. Included are vocabulary enrichment, increased verbal fluency, increased ability to think logically, and improved concept formation and communication skills." (p. 7)

"Barafaldi and Swift note that the deficit in science teaching in the elementary school is often the consequence of teachers' sincere, but misguided, notion that they are too busy teaching more important things, such as reading and language arts. If they knew that the results of research indicate a positive relationship between children's participation in activity-centered science programs and the development of oral language skills and reading readiness, perhaps science would get greater share of their attention." (Mechling, Oliver)

RESEARCH - TEACHERS CAN HELP:

"Within schools, the most important influence on science and math learning is the teacher. Teachers can influence students' attitudes about themselves and about science and mathematics." (Reyes, Laurie Hart and Padilla, Michael J., **Science, Math and Gender, The Science Teacher**, p. 48, September 1985.)

"Teachers interacted more with high-achieving boys than with high-achieving girls in a class of seventh graders." (Reyes, L. H. Classroom Processes, Sex of Student, 1981)

Confidence is crucial and we must plan lessons so that the self-fulfilling prophecies of failure are broken!

We must evaluate closely what we expect from our male and female students and try to eradicate the myth that males are naturally better than females in math and science.

We must convince our female students that science is useful.

Study real-life problems such as environmental concerns or energy issues. Examine the science of everyday living...bicycles, cooking, athletics.

"The extent and nature of teacher praise affects students' attitudes towards mathematics and science. For example, Kaminski (1976) reported that teachers readily assume that girls like reading and dislike math and science. Teachers subsequently encourage girls and boys differently based on this assumption." (Thomas)

"The nature of science, the tool we use to describe and order our environment, requires that we teach it through concrete, hands-on experiences." (What Research Says, p.50)

Subtle behaviors which occur; try to avoid:

- Interrupting girls more frequently than boys or allowing them to be disproportionately interrupted by others in class.
- Calling directly on boys more often than girls.
- Asking questions followed by eye contact with male students only, as if only boys were expected to respond.
- Addressing the class as if no females were present, or using classroom examples in which the professional is always "he," the client or patient always "she."
- Overlooking women when, for example, talking informally with students, nominating students for awards or prizes.

RESEARCH — WOMEN IN SCIENCE: A LONG ROAD

Consider:

- Less than 14% of all math and science Ph.D.'s are women.
- Only 6% of all professional engineers are women.
- Less than 3% of the nearly 1,400 members of the National Academy of Sciences are women.

Statistics indicate that women are not adequately represented in the math and science fields, and, according to a recent study by Teresa G. Monger of the Department of Petroleum Engineering at Louisiana State University, they will continue to be underrepresented. "Women who go into the male-dominated engineering field experience a lot of stress, and maybe that's why the numbers aren't growing more rapidly," speculates Monger. "Maybe we should be discussing why engineering isn't attractive or worth the struggle for some women."

Monger, who based her study on statistics from a salary survey of 250 engineering schools and freshman college enrollment figures, suggests that better information campaigns are needed to reach girls in grade school and high school.

A few schools and institutions have made some strides: Mount Mary College in Milwaukee sponsors a program to enable high school girls to learn about career opportunities in math and science, for example; and IBM awards grants to several pre-college and college programs geared toward women who want to enter the field. But for the most part, institutions have been slow to provide encouragement.

It doesn't get easier once a woman is in the field either, says Vivian Gornick, author of Women in Science: Portraits from a World in Transition (Simon and Schuster, 1983). Once women get to the top scientific positions, Gornick told a Rutgers University lecture audience recently, they don't get the same raises men do. And in 1980, twice as many women were unemployed in the field as men. There's a little hope, though. In the earliest days of female scientists, women were not allowed to express differences in style or personality. That, Gornick says, is starting to ease up.

RESEARCH...GIRLS AND SCIENCE: THE GAP REMAINS

All those textbook pictures of girls performing science experiments, the women's movement and a general push to improve education have not erased the difference in boys' and girls' achievement in science, according to the second International Science Study. The study measured U.S. students' knowledge of science in grades five, nine and 12, and is comparing it with that of students in 24 other nations, as well as with the performance of U.S. pupils in 1970. The international comparisons will not be available until 1986.

On the domestic front, however, today's students showed a modest improvement over their 1970 counterparts. Of particular note was their improvement on questions requiring so-called "process skills," as distinct from simple recall of facts. This shift matches a change in the emphasis in commercial science-education programs, which have been paying much more attention to "higher-order thinking skills."

But the difference in performance between girls and boys, which was significant in 1970, is still significant today. Moreover, the difference between boys' and girls' scores increased as they moved through their school years. The differences were greatest in the physical sciences. In the fifth grade, for example, boys did better on items dealing with the correct placement of batteries in a flashlight and the reason a thrown ball comes back to the ground.

This kind of finding, which persisted and intensified up through the grades, suggests that girls could profit from more experience with physical materials, according to Willard J. Jacobson of Columbia University's Teachers College and Rodney L Doran of the State University of New York at Buffalo. Jacobson and Doran are coordinating the U.S. part of the study.

—Susan Walton

ALL LEVELS WORK STATION #1

Resource Material

RECOMMENDED SCIENCE INSTRUCTIONAL BOOKS

HANDS-ON NATURE: INFORMATION AND ACTIVITIES FOR EXPLORING ENVIRONMENT WITH CHILDREN
Jenepher Lingelbach, 1972, Vermont Institute of Natural Science, distributed by Sewall Company, Lincoln, MA

THE SEASIDE NATURALIST
Deborah A Coulombe, 1984, Prentice Hall Press, New York, NY

SHARING NATURE WITH CHILDREN
Joseph Bharat Cornell, 1979, Dawn Publications, Nevada City, CA

SHARING THE JOY OF NATURE
Joseph Cornell, 1989, Dawn Publications, Nevada City, CA

RANGER RICK'S NEWSLETTER
National Wildlife Federation, Washington, D.C. (Examples of issues are: Incredible Insects, Digging for Dinosaurs, Wild about Weather)

KEEPERS OF THE EARTH
Michael J Caduto and Joseph Bruchac, 1989, Fulcrum Inc., Golden, CO

CESI—Council for Elementary Science, International; Clearinghouse for Science, Mathematics, and Environmental Education, Ohio State University, 1200 Chambers Road, Third Floor, Columbus, OH 43212

AIMS NEWSLETTER, Aims Education Foundation, P.O. Box 8120, Fresno, CA (activities that integrate math and science)

PROJECT WILD: ELEMENTARY ACTIVITY GUIDE, Project WILD Aquatic (K-12), 1987, Western Regional Environmental Education Council, Saling Star Route, Boulder, CO

INVITATIONS TO SCIENCE INQUIRY
Tik L. Liem, Ginn Custom Publishing, Lexington, MA

ENVIRONMENTAL SCIENCE SERIES, 1978, Western Education Development Group, University of British Columbia, (examples are the Snow Book, the Estuary Book)

LEARNING SCIENCE PROCESS SKILLS
H. James Funk and others, 1979, Kendall/Hunt Publishing Company

SCIENCE THROUGH CHILDREN'S LITERATURE: AN INTEGRATED APPROACH
1989, Teacher Idea Press, Englewood, CO

FAMILY SCIENCE
1988, Northwest Equals, Portland, OR

ALASKA SEA WEEK CURRICULUM SERIES
University of Alaska Fairbanks, 138 Irving, Fairbanks, AK 99775-5040, (907) 474-7086

TEACH ABOUT GEESE
U.S. Fish & Wildlife Service, Office of Public Use and Information, Environmental Education, 1011 Tudor Road, Anchorage, AK 99503, (907) 786-3351

ALASKA WILDLIFE WEEK
Alaska Department of Fish & Game, Division of Wildlife Conservation, Nongame Wildlife Program, P.O. Box 20, Douglas, AK 99824, (907) 465-4265

PROJECT LEARNING TREE
American Forest Institute, 1250 Connecticut Avenue N.W., Washington, D.C. 20036

CLEARING
Environmental Learning Center, 19600 S. Molalla Avenue, Oregon City, OR 97045Alaska Department of Education

Resource Material

RECOMMENDED SCIENCE VIDEOS

1. The following videos are available through the **Office of Educational Program Support.** For further information on these videos please contact **Brita Rice at (907) 465-2835.**

ABOUT SCIENCE

40 programs/10 minutes each on a series of short, single concept units for students at the intermediate and junior/senior high levels. Programs include:

Preparation of Oxygen
Physical Properties of Oxygen
Chemical Properties of Oxygen
Preparation of Carbon Dioxide
Properties of Carbon Dioxide
Dry Ice
A Flame Test
Distillation
Combustion and Weight Changes
Electroplating
Conductivity
Acids
Bases and Neutral Compounds
Mixtures and Compounds
Electrolysis
Conservation of Matter
* Mercury Barometer
Carbohydrates
Fats and Proteins
The Effects of Air Pressure
Electroscope
An Electric Current
A Series Circuit
A Paralled Circuit
Static Electricy
Understanding Magnets
Magnetic Behavior
Electromagnets
Making a Telegraph
An Electric Motor
Wet Cell
Dry Cell
Short Circuit & Fuses
Producing an Electric Current
An Electric Bell
Expansion and Contraction
Mineral Kingdom
Mass & Weight
Volume
Density

ECOSYSTEMS OF THE GREAT LAND

6 programs/15 minutes. The different ecological regions of Alaska, and the the relationships between weather, plants, animals and people withi eachsystem are the focus of this series. Programs include:

Introduction to the Ecosystems
Tundra
Taiga
Coastal Forests
Oceans
Man's Impact on the Environment

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RECOMMENDED SCIENCE VIDEOS CONTINUED

INTERACTIONS

12 programs/30 minutes each. The industrial revolution, computerized farming, gene splicing, nuclear power—solutions to society's problems often create new problems and demand new decisions. The INTERACTIONS video series is intended to equip high school students to make these important decisions knowledgeably. Programs include:

- Waste Management
- Robots
- Superconductivity
- Acid Rain
- Energy
- Food
- The Auto
- Groundwater
- Genetic Engineering
- Climate
- Water
- Wilderness

NASA TELECONFERENCE

7 programs/60 to 90 minutes each. Featured speakers in this teleconference will include NASA project personnel and specialists in the field of aerospace education. Programs include:

- Space Shuttle Flight Status
- Space Station
- Launch Vehicle Preparation
- Hubble Space Telescope
- Living in Space
- Future Exploration
- Technology and Your Classroom

A PLANET FOR THE TAKING

16 programs/30 minutes each. This series vividly illustrates that human survival is inextricable bound to a healthy environment. Programs include:

- Human nature parts 1 & 2
- Mythmakers parts 1 & 2
- Subdue the Earth parts 1 & 2
- Who needs nature parts 1 & 2
- The Ultimate Slavery parts 1&2
- Improving on Nature parts 1 & 2
- At War with Death parts 1 & 2
- The Runaway Brain parts 1 & 2

THE SEARCH FOR SOLUTIONS

9 programs/20 minutes each. The ***SEARCH FOR SOLUTIONS*** examines problems as diverse as the speed of chemical reactions, the songs of the humpback whale, and the design of minimal-surface buildings for outer space. Programs include:

- Investigations
- Evidence
- Patterns
- Adaptation
- Context
- Trial and Error
- Modeling
- Theory
- Prediction

RECOMMENDED SCIENCE VIDEOS CONTINUED

THE SECOND VOYAGE OF THE MIMI*

24 programs/15 minutes each. Using a combination of television series, print materials and microcomputer software, THE SECOND VOYAGE OF THE MIMI will integrate science and math concepts as the Mimi is charted by a team of archeologists who are studying ancient Maya civilization. Scientific techniques are used to locate and the date the discovered artifacts. Female scientists are featured throughout this series. Programs include:

A Character to the Past	If I Can Do This
A Tomb in the Jungle	Up a Tree
A Light on the Cliff	In the Canopy
The Underworld	The Incredible Shrinking Head
A Stone Puzzle	Feeling the Pressure
The Scent of a Trail	Letters From the Maya
The Quest Begins	The Ancient Farm
A Road to Discovery	Venom: A Scorpion Tale
A Friendly Village	Curandera
Discovery	Sweating It Out
Lost and Found	As The World Turns
The Fate of a King	One Stone At a Time

*For additional materials to enhance the viewing of ***THE VOYAGE OF THE MIMI*** programs write:

Sunburst Communications
Department CT 65
39 Washington Avenue
Pleasantville, NY 10570-9971

WHAT ABOUT

12 programs/15 minutes each. The process of hypothesizing, observing, inferring and experimenting are to science what water and sunshine are to plant life—without them scientific knowledge would never grow. This series helps students understand the various processes used in scientific investigation. Programs include:

Questioning	Recovering Data	Modeling
Hypothesizing	Classifying	Experimenting
Observing	Inferring	Decision-Making
Measuring	Predicting	Communicating

RECOMMENDED SCIENCE VIDEOS CONTINUED

2. These videos are available through the **Office of Adult and Vocational Education.** Contact **Barbe McClung or Carin Smolin at (907) 465-4685** for further information.

EXPLORING TECHNOLOGY EDUCATION

19/10 to 15 minute programs. Orientation program. 56 page classroom support material. Programs in this unit are:

Introduction to Technology
Overview of Technology
People, Technology, and Environment
Communication
Introduction to Communication
Designing Messages
Producing and Transmitting Messages
Evaluating Messages
Construction
Introduction to Construction
Designing and Planning a Structure
Building Safely
Finishing a Structure
Manufacturing
Introduction to Manufacturing
Manufacturing Systems
Using and Evaluating Materials
Manufacturing Process
Manufacturing Process Planning
Energy, Power and Transportation
Overview of Energy
Conversion of Energy into Power
Transmission, Control and Storage of Power
Transportation Systems

PRINCIPALS OF TECHNOLOGY

Applied Physics, Applied Mathematics, Vocational Education. 14 multimedia instructional units, with 78 video programs, 104 laboratory excercises, and 52 demonstrations. Student and Teachers guide for each unit. 15 minute informational program. Units contained in this series are:

Force
Work
Rate
Resistance
Energy
Power
Force Transformers
Momentum
Waves and Vibrations
Energy Convertors
Transducers
Radiation
Optical Systems
Time Constants

3. The following materials are available through the **Office of Instructional Delivery and Support.** For the fee schedule/registration form or additional information on these materials, please contact: **Alaska State Library, Media Services, 650 W. International Airport Road, Anchorage, AK 99518, (907) 561-1132.**

About Science Teacher Guide
Ecosystems of the Great Land Teacher Guide
A Planet for the Taking Teacher Guides
The Search for Solutions Teacher Guides
The Second Voyage of the Mimi Teacher Guides

RECOMMENDED SCIENCE VIDEOS CONTINUED

B. From Outside Sources

AIT Instructional Services

1. Videos available from **AIT.** For more information please call **AIT Instructional Services at (800)** 457-4509

WOMEN IN SCIENCE

7/30 minute programs and 1/40 minute program with an 80 page teachers quide. The programs are:

Biomedical Fields	Engineering
Chemistry	Geoscience
Computer Science	Physics and Astronomy
Dentistry	Scientific Careers for Women: Doors to the Future

TV Ontario

2. Videos available through **TV Ontario from the Department of Education.** For futher information on these videos please contact **Lois Stiegemeier at (907) 465-2644.**

TAKE A LOOK

20 programs/10 minutes each/color

TAKE A LOOK helps children discover the role science plays in their lives. In each program, they join Jeffrey, a city kid spending his summer on a farm, in the the exploration of science. Jeffrey's guide is Kate, a writer of science books for children, who takes viewers on visits to various environments to see the program subject as it fuctions in the real world. The programs are:

Plants	Boats
Flowers and Seeds	Mixtures
Growing Things	Sun and Other Stars
Insects	The Moon
Eggs	Rocks
Birds	Crystals
Flight	Fossils
Seasons	Wind
Playground Science	

RECOMMENDED SCIENCE VIDEOS CONTINUED

GOOD WORK

47 programs/5 minutes each/color

A series of short documentaries that provides useful, up-to-date information on interesting occupations for young people. Each program profiles a young person who either is undergoing an apprenticeship or has recently completed his or her training. The programs are:

- Shipmaster
- Marine Engineer Officer
- Fish and Wildlife Technician
- Microbiology Technician
- Dietician/Nutritionist
- Computer Aided Design Technician
- Microcomputer Technician
- Natural Resources Engineering Technician
- Waiter
- Robotics Technician
- Composite Materials Specialist
- Pipefitter/Steamfitter
- Stationary Engineer
- Chemical Process Operator
- Chemical Engineering Technician
- Mechanical Engineering Technician
- Appliance Repairer
- Industrial Woodworker
- Hotel Management
- Non-Destructive Test Technician
- N/C Machine Tool Programmer
- Sheet Metal Worker
- Heavy-Duty Equipment Mechanic
- Heavy Equipment Operator
- Mining Engineering Technician
- Construction Carpenter
- Avionics Technician
- X-Ray Technologist
- Critical Care Attendant
- Baker
- Metal Patternmaker
- Instrumentation Mechanic
- Auto Mechanic
- Welder/Fitter
- Small-Engine Mechanic
- Plumber
- Broadcast Electronics Technician
- Polymer Test Technician
- Computer Programmer
- Cabinet Maker
- Piping Design Draftsperson
- Tool and Die Maker
- Industrial Technician
- Mould Maker
- General Machinist
- Systems Analyst
- Electronics Technician

HANDOUT

ELEMENTARY WORK STATION #2

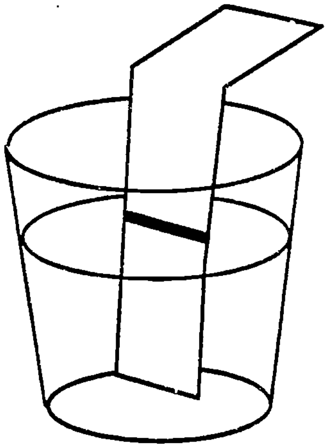
Chromotography

OBJECTIVE: To determine the color pattern of different colored felt tip markers.

MATERIALS:
1 roll plain white paper towels or coffee filters
1 set felt tip marking pens (assorted colors, non-permanent ink, including black)
Plastic glasses
Water

MATERIALS FOR EXTENSIONS:
Water
Alcohol
Food coloring
Paper towel/coffee filters
Eye dropper
White chalk

PROCEDURE:



1. Cut paper towels or coffee filters into approximately 1" wide strips.
2. Place the strip in the glass, folding it over the edge with one end touching the bottom of the glass.
3. Remove the paper and color a band with one of the markers 2" from the bottom end.
4. Fill the glass with about 1" of water.
5. At this time explain to the students the rest of the procedure and using the work sheet ask them to predict what will happen to the ink?
6. Place the strip in the glass so that the color stripe is 1" above the top of the water.
7. Have the students watch the water as it moves up the strip of paper.
8. Repeat with different colors. (Sometimes the colors show up better as it dries.)

EXTENSIONS:

1. Try food coloring, but instead of plain water, use a mixture of 1 part alcohol to 3 parts water.
2. Cut the paper towel in the shape of a circle or use round coffee filters. Use the colored marker to place a small circle in the middle. Use an eye dropper and put about10 drops of water on the color. It will then form circular bands of color.

3. Use a colored marker and draw a ring around an unused white piece of chalk. Place the chalk upright in a container of water with the band of color above the water. You may pour out the water when the color separation starts.

EXPLANATION:

The molecules of different colors vary in their attraction to water molecules. As the water travels up the strip of paper, it passes through the molecules of color. Some of the different color molecules will be strongly attracted to the water molecules and will travel with the water until the attraction to the paper molecules is stronger. At that point, the molecules of that one color will stop and form a band of color. The colors separate because each color has a different attraction to the water and paper.

ELEMENTARY WORK SHEET

Chromotography

What color felt marker is being tested?	What color(s) do you think you will see?	Actual Results

Were you surprised with the results? ____________________

Why or why not? ____________________

____

____

____

HANDOUT

ELEMENTARY WORK STATION #3

Sink or Float

OBJECTIVE: To find out which things sink and which float.
Do large objects float more easily than small ones? Does the shape of an object make a difference?

MATERIALS: Transparent glass containers (beaker, bowls)
Aluminum Foil
Various objects: eraser (not hollow), thumb tacks, paper clip, penny, wood, orange, apple, egg, plastic foam, candle, seeds, etc.

PROCEDURE:

1. Hand out "Sink or Float" work sheet. Ask: Which objects will float? Record the guesses. Then test each piece and record the findings.

	Object	Guess	Sink/Float
a.	___________	___________	___________
b.	___________	___________	___________

2. Ask: Why did some shapes sink and some float? Discuss the findings and ideas.

EXTENSIONS:

1. Use aluminum foil squares and design shapes that float. Soft modeling clay may be used instead of aluminum foil.

2. Use foil to make a boat that floats. Start adding paper clips, one by one until the boat sinks. How many paper clips will the boat hold before it sinks? This is how the Plimsoll line works on boats.

EXPLANATION: An object that is heavy for its size has a high ndensity. Objects that are the same size can have different densities. A brick is more dense than a piece of wood the same size. If the objects are heavy for their size, they will sink. The shape of an object controls the amount of water that it pushes out of the way or displaces.

If the amount of water that is displaced weighs more than the object, it will float. If the displaced water weighs less, it will sink.

ELEMENTAFY WORK SHEET

Sink or Float

OBJECT	GUESS	DID IT SINK? DID IT FLOAT?

WHY DO YOU THINK SOME OBJECTS FLOAT? ______________________

____

____

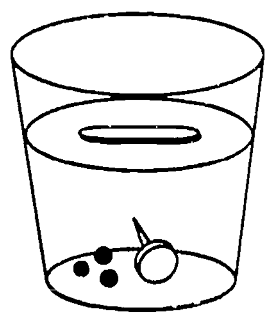
WHY DO YOU THINK SOME OBJECTS SINK?

____

____

____

____



ELEMENTARY WORK STATION #4

Gravity and Falling Objects

OBJECTIVE: To discover whether lighter or heavier objects fall the same way.

MATERIALS:

Rubber balls
Marbles
Ping-Pong balls
Tennis balls
Ruler
Table

PROCEDURE:

1. Slant a table by putting books under two legs. Put the balls at the high end of the table behind the ruler.
2. Ask: What will happen when the balls are let go? Why will the objects move? How do you know this? Tell how they will move.
3. Release the balls at least 3 times. Ask: What happened? Did the heavier objects fall faster? Why do you think the balls hit the floor at the same time? How could this experiment be improved or changed to become more accurate?

EXPLANATION: According to the laws of gravity, gravity affects all objects with the same rate of speed.

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ELEMENTARY WORK SHEET

Gravity and Falling Objects

NAME THE ROUND OBJECTS BEING USED: ______________________________

____

____

TRIAL 1. WHAT DO YOU THINK WILL HAPPEN WHEN THE RULER IS REMOVED?

____

____

____

WHAT REALLY HAPPENED?

TRIAL 1. ____

____

TRIAL 2. ____

____

TRIAL 3. ____

____

EXPLAIN WHAT HAPPENED?

ELEMENTARY WORK STATION #5

Layering of Hot and Cold Water

OBJECTIVE: To observe what happens when a jar of hot water is put in cold water or a jar of cold water is placed in hot water.

MATERIALS:
2 transparent bowls, large jars, or beakers
2 small jars or vials
Food coloring (either blue or red works well)
Hot and ice-cold water

PROCEDURE:

1. Pour hot water in one bowl. Put cold water in small jar with blue food coloring.

   Ask: What will happen when the cold water jar is put in the hot water?

   Put the small jar carefully in the large bowl keeping the jar upright.
   (The jar may be covered while being placed in the bowl.)
   Ask: What happened?

2. Pour cold water into the other bowl and hot water in the jar.

   Ask: What will happen?
   Why do you think so?

   Put the jar in the cold water. Again, keep the top upright.

   Ask: What happened?

3. Have the students draw what happened in the first and second procedure. Label hot or cold water.

EXPLANATION: Hot water is lighter than cold water so it rises and moves to the top of the bowl. As the hot water cools, it mixes evenly so the water becomes all one color.

ELEMENTARY WORK SHEET

Layering of Hot and Cold Water

1. THE SMALL JAR OF COLD WATER IS PLACED IN THE BOWL OF WARM WATER.

DRAW WHAT YOU THINK WILL HAPPEN

DRAW WHAT HAPPENED

2. THE SMALL JAR OF HOT WATER IS PLACED IN THE BOWL OF COLD WATER.

DRAW WHAT YOU THINK WILL HAPPEN

DRAW WHAT HAPPENED

EXPLAIN WHAT HAPPENED AND WHY IT HAPPENED

HANDOUT

ELEMENTARY WORK STATION #6

Sink the Paper Clips

OBJECTIVE: To observe the strength of the water's surface.

MATERIALS:
Boxes of paper clips
Plastic transparent glasses
Water

PROCEDURE: Fill the glasses to the brim with water. It should be level with the top of the glass.

Ask: How many paper clips can be added to the glass before it overflows?

Everyone guesses and records the guess before the investigation starts. Then slowly, one by one, place the paper clips in the glass until the first drop of water spills over the brim.

Ask: How many paper clips did you put in the water? Why do you think so many paper clips go into the water before it spilled?

EXTENSION: Try this with pennies or marbles.

EXPLANATION: Water has surface tension which acts as a skin on the top. This allows the water to bulge up over the top of the glass much like blowing up a balloon and stretching the surface of the balloon. Surface tension is what causes the stinging when a person does a belly flop in a swimming pool.

AIIM

Association for Information and Image Management

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ELEMENTARY WORK STATION #7

Classification of Animals

OBJECTIVE: To have students sort the animals according to similarities and then label the groups.

MATERIALS:

Classification handouts
- #1 can be used for grade 2 or 3
- #1 and #2 for grades 3 and 4

Scissors
Glue
12 x 16 paper

PROCEDURE:

1. The students cut apart the classification sheets.
2. Place the animals in groups which have similar characteristics.
3. Write the name of the group on a blank piece of paper.
4. Glue the organized groups on 12 x 16 paper.

EXPLANATION: Classification is an important science process. The teacher will learn about their student's ability to classify. Accept the students' classification. Question their reasoning.

Ask: Why did you label the group ______?
How do the animals belong to the group?
Do you need to change your groups?
Does that animal fit in two groups?
Why is that animal difficult to fit in a group?
What did you find out about some of the animals?
Would you have changed your groups if you did this again?
What are some reasons for learning to classify animals?

VARIATIONS: Have older elementary students generate their own animal examples. Have them print them on handout #3 then cut them apart and sort them.

For younger elementary students have them cut out pictures of animals then sort them or have the picture cut out prior to the lesson.

Animal Classification #1

ant	bee	rat
bat	deer	robin
bee	chicken	worm
dog	fox	squirrel
duck	goat	fly
cat	horse	turtle
cow	lion	crab
horse	mouse	crow
clam	pig	spider
rabbit	monkey	frog
goose	zebra	elephant

HANDOUT

Animal Classification #2

eagle	butterfly	alligator
clam	bear	elk
donkey	gerbil	gorilla
grouse	halibut	kangaroo
leopard	hampster	grouse
seal	owl	octopus
porcupine	mosquito	slug
whale	otter	snake
shark	salmon	parrot
koala	beaver	alligator
wolf	ape	raven

ELEMENTARY WORK STATION #8

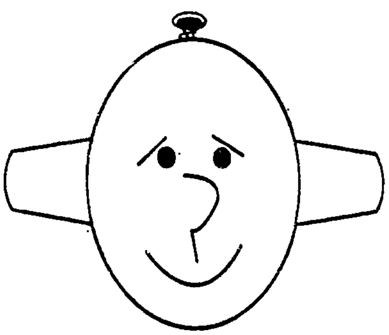
The Balloon Kid

OBJECTIVE: To observe the property of air pressure.

MATERIALS:
9" round balloons (draw face on the balloon)
2 small plastic cups
(If participants take part, each one needs a balloon and two glasses.)

PROCEDURE:

1. Tell the participants that this Balloon Kid wants the plastic cups for ears, and ask them how the ears can be attached without glue. Try their suggestions (or let them try.)



2. If the group is successful in giving a strategy, ask why the ears/plastic cups stay in place, and what you can tell about the air pressure. Where is the air pressure?

3. This is a procedure that works. Blow up the balloon about 1/3 of the way. While blowing, hold one cup in each hand against the opposite sides of the balloon. Blow until inflated.

4. How much air can be let out of the balloon before the ears fall off? Gradually let the air out. Do it again to see if the cups drop off at the same release point. What did you observe? What pressure is needed in the cups?

EXPLANATION: Because of the increase in curvature, or the actual flattening of the balloon, from small to large, the volume in the cups increased, thus causing the pressure to decrease. The air pressure inside the balloon had nothing to do with the sticking of the cups to the balloon.

ALTERNATE PROCEDURE: Warm the glasses by pouring hot water into them. Pour out the water and quickly place the glasses on the opposite sides of the inflated balloon. Hold the glasses and cool with cold tap water.

HANDOUT

ELEMENTARY WORK STATION #9

Plastic Bag in the Cup

OBJECTIVE: To observe the power of air pressure.

MATERIALS:
Thin plastic bag
Plastic cup
Rubber band

PROCEDURE:

1. Carefully put the plastic bag inside the cup and spread it against the interior sides of the cup.

2. Put a rubber band around the outside of the cup to hold the bag in place.

3. Reach into the bottom of the cup and try to remove the plastic bag. Were you surprised? Why? Why do you think the bag was hard to remove?

EXPLANATION: As the bag is lifted, the volume of space between the bag and cup increased, and this lowered the air pressure. Because the air pressure against the bag from the outside was greater, it made it too difficult to remove the bag.

A large plastic bag in a waste basket also works.

SECONDARY WORK STATION #10

Name Women Scientists

OBJECTIVE:

To provide classroom activities for focusing on women's involvement in the working world.

To provide a list of women scientists which can be used in a classroom for a research activity.

MATERIALS:

"How Many Women Scientists Do You Know" work sheet 6-1A
"Women in Science" Handout 6-1B

PROCEDURE:

1. Before handing out the listing of "Women in Science" ask participants to list the names of women scientists and their achievement on the work sheet.

   Those able to name more than two or three women scientists know more than the average person.

2. Distribute the "Women in Science" handout.

3. Ask the group questions that tie their knowledge of women scientists to gender equity in science education:

   How many more women scientists did you recognize after looking at the list?

4. Have participants suggest 3-4 ways this information can be included in the secondary science curriculum.

SECONDARY WORKSHEET

How Many Women Scientists Do You Know?

WOMEN SCIENTISTS ACHIEVEMENT

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

8. ______________________________

LIST ACTIVITIES WHICH COULD FEATURE THESE WOMEN SCIENTISTS

1. ______________________________

____

2. ______________________________

____

3. ______________________________

____

4. ______________________________

____

Resource List

WOMEN IN SCIENCE

Maria Agnesi: Italian (1718-1799)
One of the most brilliant Italians of the 18th century, she was appointed professor of mathematics at the University of Bologna. In 1748 she published An alytical Institutions for the Use of Italian Youth, a mathematics text book on algebra, analytical geometry and calculus which was widely translated.

Dr. Elizabeth Garrett Anderson: British (1836-1917)
First woman to qualify as a doctor in Britain and have a hospital named after her. (Inspired by a lecture in 1859 by Dr. Elizabeth Blackwell.)

Hertha Ayrton: British (1854-1923)
Physicist, suffragette and inventor. She invented a line-divider which is still used by architects, and also worked on the electric arc-solving problems to do with lack of stability and noise; her book on the subject, published in 1902, led to defense work for the Admiralty on search lights.

Dr. James Barry: British (1795-1865)
One of the most astonishing of all careers. Born a woman, "he" successfully disguised his sex all his life, and had a long career as a doctor with the British army.

Clara Barton: American (1821-1912)
"The angel of the battlefield," she was virtually an unpaid quartermaster to the wounded of the Civil War, and founded the American Red Cross. She was an almost exact contemporary of Florence Nightingale, and resembled her not only in her work on the battlefield, but also in her refusal to retire until her nineties despite frail health.

Ruth Benedict: American (1887-1948)
She introduced the concept of "patterns of culture" to the discipline of social anthropology. She became deaf as a child. She was 32 before she began studying anthropology.

Dr. Elizabeth Blackwell: British (1821-1910)
She was the first woman in the United States to qualify as a doctor. She was a strong advocate of common sense and preventive medicine.

Rachel Carson: American (1907-1964)
She was the marine biologist whose analysis of the harm done to the cycle of nature by pesticides led, after her death, to the banning of the use of DDT in the United States, and alerted both scientists and general public all over the world to the necessity of protecting the environment.

Edith Cavell: British (1865-1915)
A famous martyr of the First World War, she was a heroic British nurse shot by Germans for obeying the humanitarian principles of her training.

Gabrielle Emilie du Chatelet: French (1706-1749)
She was a hardworking mathematician and philosopher, who translated Newton's Pri ncipia Mathematica into French and wrote the introduction. She also introduced the mathematical ideas of the German philosopher Liebniz to France.

Evelyn Cheesman: British (1881-1969)
She was a distinguished entomologist and collector of insects and was largely self-taught.

Elena Cornaro: Italian (1646-1864)
She became Europe's first woman doctor of philosophy.

Marie Curie: Polish (1867-1934)
She was the first world-famous woman scientist and discovered the element radium. She twice won a Nobel Prize, first with her husband and Henri Becquerel in Physics, then alone in Chemistry. Her work led directly to the treatment of cancer with radium.

Rosalind Franklin: British (1920-1958)
She was the crystallographer whose x-ray photographs of the molecular structure of DNA - the protein-building "brick" from which living cells are built up - were a principal clue in the unravelling of DNA's famous "double helix" in 1953 for which several scientists won the Nobel Prize for Medicine in 1962.

Jane Goodall: British (1934-)
She is virtually the founding mother of ethology, the scientific study of the behavior of animals in the wild.

Catherine Greene: American (1731-1793?)
Eli Whitney is always given sole credit for the invention of the cotton gin. In fact, the idea for the machine was given to him by Catherine Greene when he was staying in her house. Women were not then allowed to apply for patents!

Caroline Herschel: German (1750-1848)
She was the astronomer who discovered three nebulae and 18 comets.

Dorothy Hodgkin: British (1910-)
She is the x-ray crystallographer who won the Nobel Prize for Chemistry in 1964 for analyzing the structure of Vitamin B12, a vital substance in the fight against pernicious anemia.

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Karen Horney: American (1885-1952)
She was the first Freudian psychoanalyst to reject Freud's view of feminine psychology as a defective version of masculine psychology. She founded the Association for the Advancement of Psychoanalysis, the only independent school of psychoanalysis to be founded by a woman.

Hypatia: Egyptian (c.370-415)
She was one of the most popular and admired teachers of the Hellenistic world. She was a mathematician, astronomer, and philosopher, and became a professor at Alexandria, teaching the views of Plato and Aristotle.

Dr. Elsie Inglis: British (1864-1917)
She said, "I have two passions in life, suffrage and surgery." She was famous for the field hospitals she organized in France and Serbia during the First World War, having no governmental support.

Barbara Ward Jackson: British (1914-)
She was a brilliant writer on economics and a committed ecologist.

Dr. Aletta Jacobs: Dutch (1854-1929)
She was Holland's first woman physician and opened the world's first birth control clinic in Amsterdam in 1882.

Dr. Sophia Jex-Blake: British (1840-1912)
She was one of the first women doctors in Britain.

Elizabeth Kenny: Australian (1886-1962)
She pioneered physiotherapy treatment for children crippled by poliomyelitis. She opened her own hospital in South Queensland.

Dame Kathleen Kenyon: British (1906-1978)
She made history as the archaeologist who rewrote the prehistory of Middle Eastern townships by digging up Jericho and Jerusalem. In the 1930s she helped found London's Institute of Archaeology, becoming its acting director.

Melanie Klein: Austrian (1882-1960)
She was an important figure in the development of the psychoanalytic understanding of children and infants. Her great contribution was the development of a technique for analyzing young children's play as an insight into their emotional development. She wrote several books.

Dr. Dorothie Leporin: German (1715?-1762)
She was a midwife and obstetrician and wrote "On the Reasons Which Keep Women Back From Higher Education."

Dame Kathleen Lonsdale: British (1903-1971)
She was the finest x-ray crystallographer of her generation and one of the first two women to be elected to the Royal Society in 1945. She wrote "Is Peace Possible," as well as many scientific publications, and lectured all over the world.

Ada Lovelace: British (1815-1852)
She was an exceptionally gifted mathematician. She foresaw, over a century ahead of her time, how a digital computer would work.

Anna Manzolini: Italian (1716-1774?)
She was celebrated throughout Europe for the wax models she made of different organs of the body and became professor of anatomy at the University of Bologna.

Jane Marcet: Swiss (1769-1858)
She refused to believe that science was beyond the understanding of ordinary people and set an educational fashion with her "Conversations On ..." series.

Mary the Jewess: Egyptian (c.AD50)
She was one of the early alchemists who worked in Alexandria on the chemistry of metals and invented the water-bath, or bain-marie. The method ensures moist, even, gentle heat.

Margaret Mead: American (1901-1978)
The first person to make anthropology comprehensible to ordinary people. Her great contributions were to show that societies existed where adolescence was not a traumatic, rebellious phase, and that "human nature" and "sex roles" are not the same the world over, but incredibly varied.

Lise Meitner: Austrian (1878-1968)
She was an eminent physicist who pioneered the splitting of the atom, but refused to make the atom bomb.

Maria Sebylla Merian: German (1647-1717)
She was an exceptionally gifted entomologist and botanical illustrator who showed the way to the proper classification of species.

Maria Mitchell: American (1818-1889)
She was a great scientist, teacher and astronomer and the first woman to be elected to the American Academy of Arts and Sciences.

Lady Mary Wortley Montagu: British (1689-1762)
She introduced vaccination against smallpox to England.

Florence Nightingale: British (1820-1910)
She was the founder of modern nursing and the famous "Lady of the Lamp" in the Crimean War.

HANDOUT

Marguerite Perey: French (1909-1975)
She discovered the element actinium K, which she called francium in honor of her country. She was the first woman to become a member of the Academie des Sciences in 1962.

Dixie Lee Ray: American (1914-)
She is a scientist and was elected the first woman governor of Washington in 1977.

Margaret Sanger: American (1883-1966)
She was a nurse and the pioneer of birth control in the United States.

Dr. Regina von Siebold: German (1771-1859)
She was one of the first European women to be granted an academic degree in gynecology.

Mary Somerville: British (1780-1872)
She was a mathematician and astronomer of international standing. She was one of the first women to be elected to the Royal Astronomical Society in 1835.

Marie Stopes: British (1880-1958)
She received degrees in botany and zoology and became the first woman lecturer at Manchester University.

Trotula: Italian (c. AD1100)
She was the most famous of the women teachers of medicine at Europe's first university at Salerno.

Dr. Mary Walker: American (1832-1919)
She was an army surgeon and won the Congressional Medal of Honor for her care of the wounded during the American Civil War.

Chien-Shuing Wu: Chinese (1912-)
She became professor of physics at Columbia University in 1944. Her most important contribution is her experimental proof that contrary to accepted theory, similar nuclear particles do not always act similarly.

SECONDARY WORK STATION #11

Pendulum

OBJECTIVE:

To build a pendulum and find out which variables affect the time of ten swings of the pendulum.

A pendulum is a weight suspended on a string, rope, or arm that is free to pivot from an anchor point.

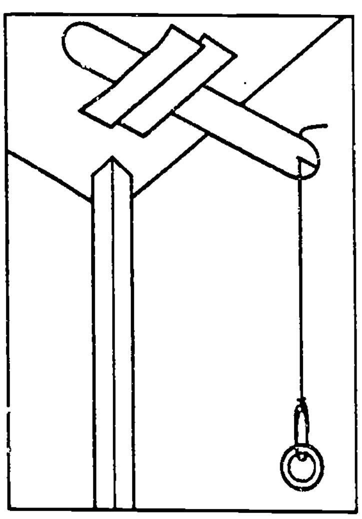
MATERIALS:

Each group receives:
70 centimeters of thread
3 paper clips
10 inches of masking tape
3 washers of light weight
3 washers of heavy weight
Tongue depressor

Recording work sheet
One per classroom or one per small group.

Use a strip of cardboard with paper clips for hooks. Place paper clips 5 centimeters apart.

PROCEDURE:



1. Hand out the materials and tell how to build the pendulum.
2. Tie the paper clip on one end of the thread.
Place the washer on the clip. Place the other end of the thread through the slit in the tongue depressor and tape on the desk so the thread swings easily. (Instead of a tongue depressor, a pencil can be taped on the desk and the end attached with a paper clip.)
3. Have participants use lengths of 10 cm, 20 cm, and 30 cm threads.
4. Have participants measure time needed for 10 swings of each length, and record information on Secondary Work sheet 6-2B
5. The participants will ask the question, "How high do we hold the washer?" Ask their ideas for giving consistency to their experiment. The pendulum should be held straight out (string parallel to the floor).
6. Participants should repeat activity with heavier washers.

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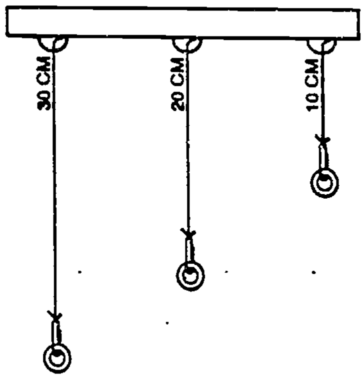

7. Hang pendulums on the recording line. What do you notice? Students will see a pattern.

8. What variables might change the time span of swings. Record on the graphs on Secondary Work Sheet 6-11A.

9. Each group agrees on and writes a concluding statement about the relationship between the variables and the speed of the pendulum's swing.

10. The conclusions are shared by a group reporter.

EXTRA:

Design a game in which a pendulum knocks over playing pieces. The pieces could be golf tees, pieces of doweling, or cuts of straws balanced on end. Put the pieces in different arrangements; like a bowling pin set-up, circle or straight line. Keep score of how many playing pieces are knocked down in so many passes.

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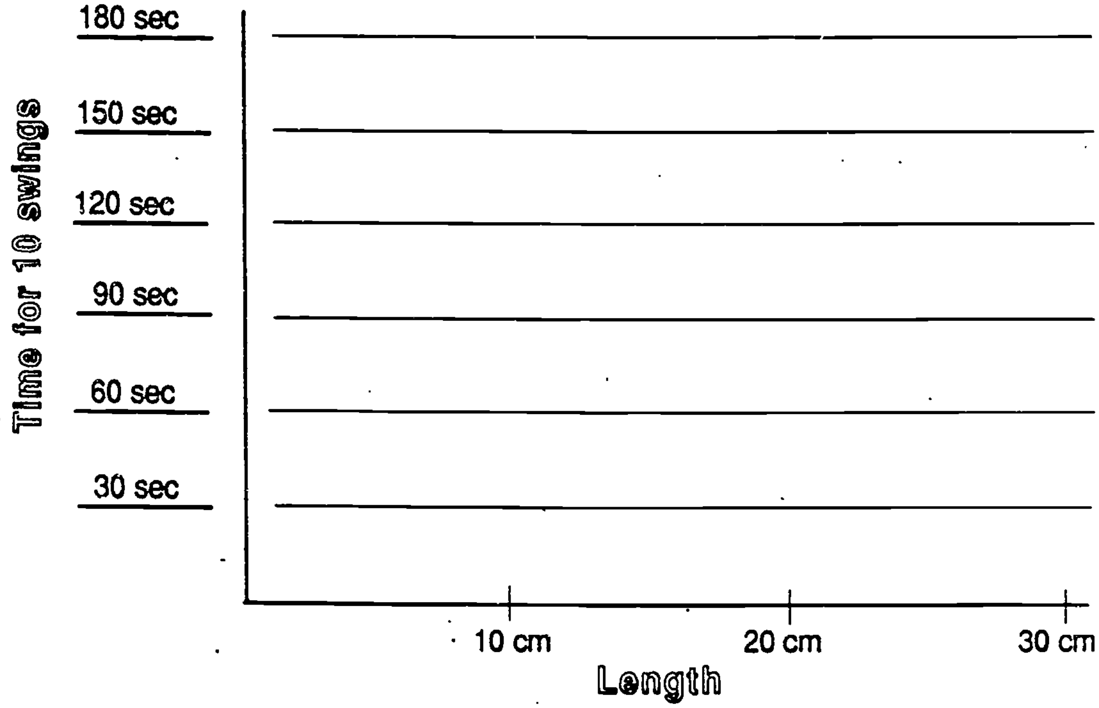
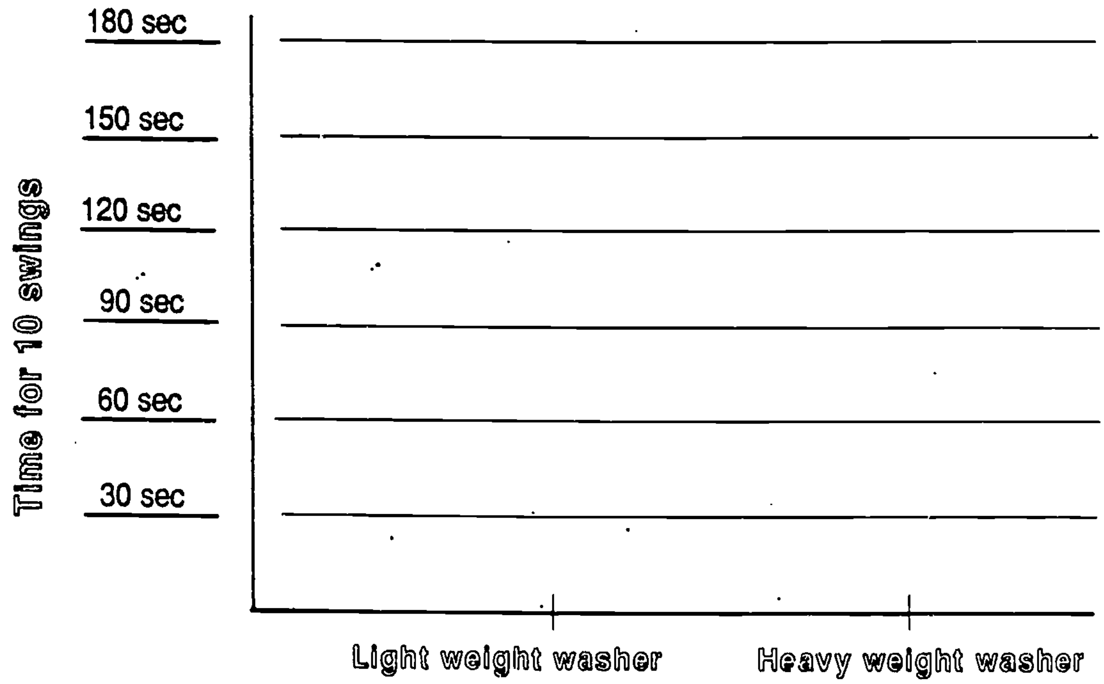
Pendulum Worksheet





SECONDARY WORK STATION #12

Classifying Vertebrate Bones in Owl Pellets

OBJECTIVE: To discover what small vertebrates are eaten by an owl.

MATERIALS:

Owl Pellet
Magnifying glass
Dissecting needle
Small metric ruler

Note: To order owl pellets call:
(206) 733-3012
3004 Pinewood
Bellingham, WA 98225

PROCEDURE:

1. Observe the outside of a pellet coughed up by an owl and record your observation.
2. Gently break the pellet into two pieces.
3. Using a dissecting needle or small spatula, separate any undigested bones and fur from the pellet. CAUTION: BE VERY CAREFUL WHEN USING A DISSECTING NEEDLE. Also remove all fur from any skulls found in the pellet.
4. Group similar bones together in a pile. For example, put all skull bones in one group. Observe the skulls. Record the length, number, shape, and color of their teeth.
5. Now try to fit together bones from the different piles to form complete skeletons.

EXTENSIONS:

Examine additional pellets.
Examine pellets from other species of owls.
Try to reconstruct a skeleton.

EXPLANATION:

Owl pellets ate the undigested remains of prey ingested by an owl. The owl swallows its prey whole, and during the process of digestion, the soft parts of the prey are dissolved and passed on to the intestine for absorption. The hard, non-digestible parts (bones, teeth, fur, feathers, and chitinous remains of insects) are compressed into the gizzard and passed on to the proven triculus where the pellet remains until it is expelled. These pellets are not eliminated as feces, but are regurgitated through the mouth.

Pellets are not found exclusively within the owl families. There are many species of birds known to regurgitate pellets: hawks, eagles, falcons, and even robins are some of the more familiar ones. Out of all types of pellet ejectors, the efficiency of the process is probably as high in owls as in any other bird.

Shrew	Upper jaw has at least 18 teeth. Skull length is 23mm or less. Teeth are brown.	
House Mouse	Upper jaw has 2 biting teeth. Upper jaw extends past lower jaw. Skull length is 22mm or less.	
Meadow Vole	Upper jaw has 2 biting teeth. Upper jaw does not extend past lower jaw. Molar teeth are flat.	
Mole	Upper jaw has at least 18 teeth. Skull length is 23mm or more.	
Rat	Upper jaw has 2 biting teeth. Upper jaw extends past lower jaw. Skull length is 22mm or more.	

SECONDARY WORK STATION #13

Electromagnets

OBJECTIVE:

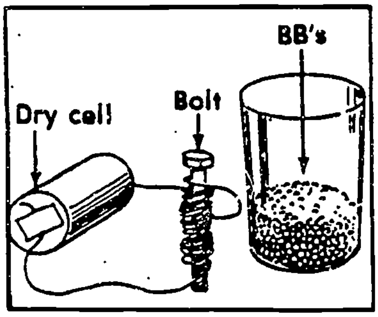
To construct several electromagnets.
To compare the magnetic force of each electromagnet.
To state the relationship between the force and the number turns of wire in t he coil of the electromagnet.

MATERIALS:

BB's (no. 8 shot), iron
4 iron bolts (at least 5 cm long)
dry cell (1.5 V)
marking pen
2 drinking cups
masking tape
insulated wire

PROCEDURE:

1. Place masking tape on the heads of the bolts. Label the bolts, "A", "B", "C", and "D".
2. Put all the BB's in one cup.
3. Test each bolt for magnetic properties by attempting to pick up some of the BB's from the cup. Record your observations on "Data Observations" Secondary Work sheet 6-4A
4. Wrap 10 full turns of wire around bolt A. Wrap 20 turns of wire bolt B, 30 turns of wire around bolt C, and 40 turns of wire around bolt D.



5. Connect the ends of the wire of bolt A to the dry cell as shown in the drawing. Carefully use your electromagnet to pick up as many BB's as possible. Hold the magnet with the BB's over the empty cup and disconnect the wire to the dry cell. Make sure all the BB's fall into the cup. Count the number of BB's in thecup. Record this value in "Data and Observations" work sheet.
6. Return all BB's to the same cup.
7. Repeat steps 5 and 6 again using bolts B, C, and D. Record the maximum number of BB's each electromagnet picked up in the "Data and Observations" work sheet.

EXTENSIONS:

Try combining additional cells to form larger (stronger) batteries.
Try more coils
Find and show ways electromagnets can do work.

EXPLANATION:

A small amount of magnetic force exists around any wire that has an electric current running through it. By coiling wire around a bolt or nail, the magnetic force will increase. This device is an electromagnet. The magnetic force can be controlled by turning the electric current on or off.

SECONDARY WORK SHEET 6-13A

Data and Observations

Observations of the magnetic properties of the bolts alone: ______________________________

Data Table 1

Electromagnet	Number of BB's picked up
A- 10 turns	
B- 20 turns	
C- 30 turns	
D- 40 turns	

Use this grid to graph your data. Determine which axis should be labeled "number of BB's" and which should be labeled "number of turns of wire".

SECONDARY WORK SHEET 6-13B

Questions and Conclusion

(optional)

1. Which electromagnet picked up the greatest number of BB's? ____________________

2. Look at your graph of the data. Is the graph nearly a straight line or a cure? ____________ What Does this mean about the relationship between the number BB's picked up and the number of turns of wire around each bolt?

4. If you made an electromagnet with the same bolt but 50 turns of wire, how many BB's would you expect to pick up? (look at your graph)

5. In what way is the force of your electromagnet different from the force of a permanent bar magnet?

6. Why would an electromagnet be used instead of a permanent bar magnet?

7. Make a general statement about the relationship between the amount of force produced by an electro magnet and the number of turns of wire\in the electromagnet.

8. A small magnetic force exists in a single uncoiled wire that has an electrical current flowing through it. Explain why coiling the wire increases the total magnetic force.

STRATEGY CHECK

Can you construct an electromagnet?
Can you compare the magnetic force in different electromagnets?
Can you state the relationship between the force and the

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SECONDARY WORK STATION #14

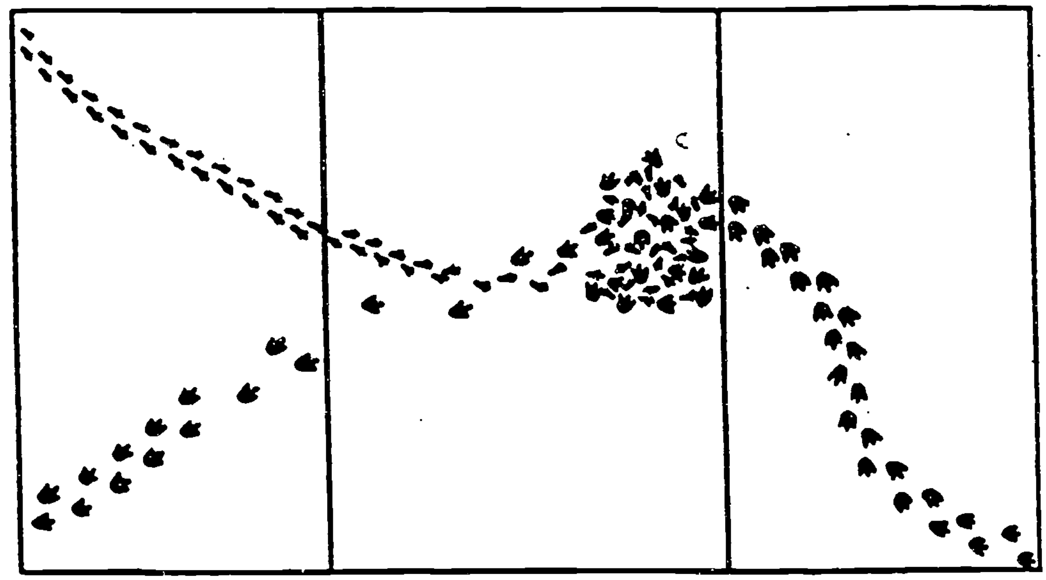
Inference

OBJECTIVE: To practice using the skills of inference and logic.

MATERIALS: Picture below

PROCEDURE:

1. Observe the tracks in the snow in the picture.
2. To help you think more logically about the picture, it has been separated into sections. Using the"Observations and Inferences" (work sheet 6-14A), makeat least two observations about each frame and for each observation write one inference that could be drawn from that observation. (More than one inference can be drawn from one observation.)



1 2 3

EXTENSION: Have students go out into the snow or moist dirt and create footprint patterns that suggest certain "happenings". One group can make prints while another can infer what has happened.

EXPLANATION: Observation and inference are ski' s that help people to be more aware of t

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SECONDARY WORK SHEET #6-14A

Observations and Inferences

OBSERVATIONS	INFERENCES
1. Example: Large footprints get farther apart.	A. The animal is stepping over stones. B. The animal is running.

SECTION 1

2. ______________________________

3. ______________________________

4. ______________________________

SECTION 2

1. ______________________________

2. ______________________________

3. ______________________________

SECTION 3

1. ______________________________

2. ______________________________

3. ______________________________

SECONDARY WORK STATION #15

Take Me To Your Lost Liter

OBJECTIVE:

To determine how much water leaks from a faulty plumbing fixture per hour, per day, and per year.

Background: It's easy to lose a liter (of water) at home. Faucets wear out and begin to drip; everyone occasionally leaves the water dripping a little after using a sink. Over time, small leaks like these add up to large amounts of wasted water.

MATERIALS:

Container to catch 1 L of water (1 L= 1000 ml)
Watch or clock with a second hand
Source of dripping water. (Use a sink, or make a multiple "leaky water source" by poking a small hole in a gallon milk jug.)
Container to catch the excess dripping water. Use a bucket or pie pan or the cut off bottom of a milk jug

PROCEDURE:

1. Start water source dripping at a good steady rate. Be sure you are getting individual drops, rather than a steady stream of water.
2. Count how many drops fall during a 10 second interval. Record your observations on the "Observations" work sheet (Secondary Work sheet 6-6A). Leave the water dripping and repeat this measurement two more times, and average the three readings. Use the average to calculate the number of drops falling in one second.
3. See how long it takes your water source to drip 1 L. First, set up your 1 L container so it will catch the dripping water. Record the time when you place the container under the dripping water, using part 2 of the work sheet.

EXTENSION:

Humans need to drink about 2.5 L of water each day to survive.
How many people could survive by drinking the water that would be wasted by your water source in one day?

_____ people

Assume that your water source will continue dripping at the same rate for one year. How much water would be wasted in one year?

_____ L

If 1000 homes in your community have water leaks that waste water at this rate, how much water does the entire community waste each year?

_____ L

EXPLANATION:

The amount of potable water on Earth is quite limited. Everyone needs to realize how much water is wasted due to dripping faucets and other leaking sources.

SECONDARY WORK SHEET #6-15A

Lost Liter

DROPS IN 10 SECONDS

Trial 1: ______ drops

Trial 2: ______ drops

Trial 3: ______ drops

Average of the three trials = _____ drops in 10 seconds.

Average drops in 10 seconds _____ divided by 10 seconds equals

_____ drops/second.

TIME TO FILL ONE LITER

Starting time: ______________

Finishing time: ______________

How much time? ______________

At that rate of dripping, how much water is wasted
per hour? __________

per day? __________

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CLOSING AND EVALUATION

7

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Closing and Evaluation

OBJECTIVE: To bring closure to the day's events, and give participants information on women in science.

To have participants fill out evaluation forms.

GROUP SIZE: All participants.

TIME REQUIRED: 5 minutes.

MATERIALS: Transparency "Women of Achievement"

PROCEDURE:

1. Trainer shows overhead "Women of Achievement".
2. Trainer asks participants to fill out evaluation forms and thanks them for their cooperation.

Women of Achievement

"Women have always practiced the arts of healing. It seems only to have been for three or four centuries, when medicine first became institutionalized, that they were virtually barred from working as doctors or surgeons. Yet there were women doctors in ancient Egypt, in classical Greece and Rome, and in the Middle Ages. In England even as late as the 16th century, women were permitted to enter the examinations which would allow them to practice medicine, and dozens are known to have passed and been licensed. However, attitudes changed and women became effectively excluded from the profession. It was not until the mid-19th century, in the face of considerable opposition, that women once again won the right to train and qualify as doctors. A similar story is true of the other sciences."

In reading the literature on famous women in science and medicine, several aspects ran through most of their lives. The first - most had a parent or significant other who was a role model for their future career choice. The second - many of those decided upon their career choice early in life. The third - many, if not having a parent whom they chose to follow, were inspired by others, via lectures or personal meetings. The fourth - most had a long, hard struggle to be accepted in a man's world.

Presenter: ______________________ Date: __________ School District: ____________________

Workshop Evaluation

I. How would you rate this workshop in the following areas?
(Please circle the most appropriate rating.)

A. Objectives were made clear.	Very clear 1	2	3	4	Not clear 5
B. Objectives were met.	To a great extent 1	2	3	4	Not met at all 5
C. Information was of practical value.	Great value 1	2	3	4	No value 5
D. Handouts/materials were relevant to my present needs.	Most relevant 1	2	3	4	Not relevant 5
E. Presentation was effective.	Highly effective 1	2	3	4	Not effective 5

II. Circle one of the following ratings which best describes your feeling about this workshop in comparison to others you have attended.

1 One of the best 2 Better than most 3 About average

4 Weaker than most 5 One of the worst

What were the strongest features of the workshop? ______________________________

____

____

What were the weakest features of the workshop? ______________________________

____

____

____

Return to:
Gender Equity Coordinator
Alaska Department of Education
P.O. Box F, Juneau, AK 99811

Trainer's Module Evaluation

TRAINER NOTE: Now that you have completed the workshop, please take a moment to complete the following evaluation. Your input will be of vital importance as the modules are refined to meet the needs of teachers.

YOUR NAME: (optional) ______________________________

NAME OF MODULE: ______________________________

WHERE PRESENTED: ______________________________

OF PARTICIPANTS: __________

I. TRAINER INSTRUCTION SHEET

A. Were training instructions clear and precise? ______ Yes ______ No

If no, please state page number and problem area: ______________________________

____

Other comments: ______________________________

____

B. Was the format of the Trainer Instruction Sheets easy to follow?

__________ Yes __________ No

II. PARTICIPANT ACTIVITIES

A. Which activity did the participants appear to enjoy the most?

____

B. Are there any activities that you feel need to be eliminated of replaced? If so, please identify.

____

____

C. Was the timing allocated for activities appropriate?

__________ Yes __________ No

Overall, do you feel this module raised the participants' awareness of sex bias?

__________ Yes __________ No

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