Best of General Science from

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Best of General Science
from
Science Teacher's Workshop

SCIENCE TEACHER'S WORKSHOP

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West Nyack, New York

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About This Book

This book presents a broad selection of innovative yet highly practical activities and demonstrations for teaching general science. It includes materials for teaching all areas of the diverse general science curriculum—basic chemistry, life science, introductory physics, and earth and space science. In addition, it offers a variety of special exercises for introducing basic techniques, mathematics and measurement, electricity, and meteorology.

Each selection has been carefully chosen from articles submitted by outstanding science teachers to *Science Teacher's Workshop,* a monthly teaching service for secondary school science teachers across the country. It represents a successful and workable technique for involving students more meaningfully in the basic concepts and processes of science.

Practicability as well as effectiveness has been an important criterion in the selection of activities. Few of them require expensive or elaborate apparatus. Most are the product of the science teacher's efforts to make the best use possible of the resources at hand in devising new and better ways of teaching and learning science.

As an aid in using activities, each includes all of the details and directions you will need for its immediate use or adaption in your own classroom or laboratory.

- Objectives are clearly stated to pinpoint the specific purposes of the activity.
- Materials for carrying out procedures and constructing any needed apparatus are presented in convenient checklist fashion.
- Source notes are provided for obtaining items not normally found in the general science classroom or laboratory.
- Procedures are complete and organized in a clear, step-by-step manner.
- Caution notes are included where appropriate to protect the teacher and his students in working with materials requiring special handling.

- Analyses of results are provided in many cases to serve as guidelines to working out exercises.
- Examples of student work are included where useful to furnish a concrete idea of what to expect.
- Illustrations of apparatus and procedures are abundant and functional.
- Follow-up ideas are presented to help the teacher stimulate and guide students to further investigation.

This book offers you dozens of practical and tested ways to enrich, reinforce, or replace different parts of your regular teaching program. Each one represents a further opportunity to give students a richer, more rewarding science experience and, at the same time, a means to save valuable preparation and teaching time.

We hope it will help to make general science a more challenging and enjoyable experience for both you and your students.

The Board of Editors
Science Teacher's Workshop

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1 Basic Techniques for General Science

"Discovering" the Laws of Science

by Charles L. Roberts
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It is true that most basic laws of science can be "told" to the student, reinforced by some examples, and the task of "teaching" is done. The student will remember these laws—but! He experiences no practice in problem-solving, no opportunity to test conclusions, and no satisfaction of accomplishment or development of determination. In short, "telling" the student enables him to clear the first hurdle—learning the law—but fails to give him the skills needed to solve the more complex problems that may follow.

> **Note: To acquire these skills and a working understanding of the basic laws of science, the student cannot simply be told. He must be given the opportunity to become more actively involved with what he is learning.**

One method of accomplishing this involvement is to challenge students to "discover" these laws themselves. The "discovery method" of learning has been shown to be very effective in science teaching, and even in classes of 30 or more, using simple household items to overcome cost factors, it is possible to give each student the chance to "discover" many of the basic laws of science.

DISCOVERING A "LAW OF LEVERS"

In the following example of the discovery method, paper clips, common pins, and soda straws are used to allow each student to develop his own "law of levers." Throughout the whole experience, the student is *not told* what he should find. He is only encouraged to look for some relationship in his data.

Procedure

To begin, have students construct the simple apparatus shown in Fig. 1, as follows:

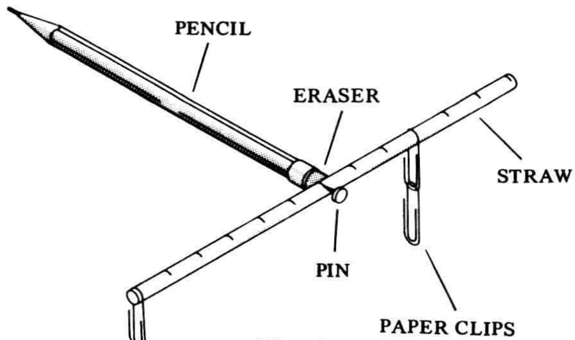

Fig. 1

1. Group students in pairs and provide each station with a straw, ruler, common pin, and a handful of paper clips. Instruct students to locate and mark the center of the straw, then mark even units in both directions from the center. Next, have them punch the pin through the straw's center and into an eraser on the end of a pencil. The straw should be turned on the pin several times so that it is loose.

2. When the straws have been fastened, have students make several balancings by placing paper clips in single chains on both sides until the straw stays horizontal. Each balancing should be a different combination of forces (F—paper clips) and distances from the center (L—length). Instruct students to keep a chart of their trials.

Some possibilities are shown in the accompanying sample charts (any choice of letters will do):

F_l (clips)	F_r (clips)	L_l (units)	L_r (units)
2	4	4	2
6	4	2	3
6	6	2	2
3	1	2	6
3	6	2	1

C_l (clips)	U_l (units)	C_r (clips)	U_r (units)
2	4	4	2
6	2	4	3
6	2	6	2
3	2	1	6
3	2	6	1

3. After students have made and recorded data for five or six trials, instruct them to find some "rule" to their data. Several examples of students' work are:

$$\frac{F_l}{F_r} = \frac{L_r}{L_l} \qquad \frac{C_l U_l}{C_r U_r} = \text{one}$$

$$F_l L_l = F_r L_r \qquad \frac{F_l L_l}{F_r} = L_r$$

Such a variety of insights clearly indicates that students are doing their own work.

The teacher then plays his role by showing that all versions are actually varieties of the same "rule." Then the importance of this law and its usual version may be explained.

Law of Levers: $F_l L_l = F_r L_r$

NOTE: Through experiences such as this, the student is given more than facts. He will also become more interested in his work and perhaps even have "fun" in science class.

Provocations to Thought: Open-Ended Experiments

by George E. Pitluga

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Today's science teacher is frequently torn between two philosophies of science education. The traditional philosophy suggests that science must be primarily concerned with giving students basic facts and concepts of the discipline under study. Until these facts are mastered, it maintains, the learner is not ready for investigations on his own. This approach tends to develop lab exercises—or "experiments"—which smack of mother's cookbook, except that "add the whites of two eggs" may read "add 10cc. HCl, and shake well."

The second approach, now on the uprise, suggests that science is a method of investigating the world. It sees the so-called facts of science—while useful and important—as merely the by-product of this method of investigation. In essence, it maintains, science education is concerned with guiding the learner in the *process of practicing science.* Supporters of this approach place much emphasis on the "open-ended" experiment. The learner is presented with a problem, assisted in proposing one or more hypotheses, and guided in designing strategies for testing his hypotheses and drawing conclusions.

> **COMPROMISE: Fortunately, or unfortunately, many texts and laboratory manuals, local and state syllabi, and standardized examinations strongly encourage the first approach. However, among teachers forced into the traditional pattern by these factors, there are many who recognize the merit of the open-ended experiment. Here they will find suggestions for giving at least some students some of the time, experience in practicing the investigatory method of science.**

Using Investigations

These suggestions for open-ended experiments may be used with individual students or small groups who have completed the assigned laboratory exercises, or possibly as a substitute for a not-too-critical assigned exercise. They might also be used for extra credit activities.

Two potential advantages from using these experiments seem evident:

- For a teacher who is unsure of "newer" methods, they represent a chance to try his hand without a radical departure from "tried and true" procedures.
- For the teacher who may be forced to continue using the traditional approach, they offer a means of stimulating and encouraging the many—not all—students who really do enjoy the challenge of the open-ended experiment and the satisfaction of its solution.

PROBLEMS FOR OPEN-ENDED INVESTIGATION

The accompanying list of problems for open-ended student investigation is of course only suggestive. To this list, each teacher might add literally dozens of investigation ideas probably more pertinent to his students and the content they are studying. However, these problems do serve as useful illustrations, bearing in mind that the facts their solutions produce are not nearly so important as the methodology they require.

Experiment 1: What determines how long it takes a candle to burn out? Is it the kind of wax? Is it the length of the candle? Is it the size of the wick? Can you make one or more hypotheses? Can you devise a strategy for testing each one? Should we deal with just one variable at a time?

> **MATERIALS: Some string, waxes, cylinders, molds, and a time-keeper and beam balance may be all the equipment needed.**

Experiment 2: What determines how long it takes a pendulum to swing through one complete arc? How far out you pull it? The length of the string? The weight of the bob? or....? (The essential equipment is simple.)

> **NOTE: Even beginners can design good strategy for investigating this problem, but they must be warned to watch for one variable at a time.**

Experiment 3: Which freezes quicker—hot or cold water? (Some people insist that hot water pipes always freeze more quickly than cold water pipes.)

Experiment 4: Present students with a glass brimful of water in which an ice cube is floating. What will happen when the ice melts? Will the water overflow? or....?

> **NOTE: This problem gives students excellent practice on a very elementary level in hypothesis making.**

Experiment 5: If you live along the sea coast and teach earth science, you, yourself, may get some surprises together with the students by posing this problem: Where is the moon in reference to our meridian when it is high tide here? (Several hypotheses suggest themselves. The strategy requires careful thought, and even after the answer has been found, you may discover that, like most true experiments, this one raises more questions than it answers.)

Experiment 6: Where does the sun rise and where does it set? (This is a particularly good investigation problem for it teaches students that nature rarely gives the answer quickly—not even in a 60-minute lab period. It will help students to understand why scientists often carry on the same experiment for months, or years.)

Experiment 7: What's in the box? To acquaint students with the dilemma often faced by the true scientist, use the black box problem. Present students with a series of sealed boxes, in turn. One box may contain a piece of chalk, another a glass marble, and a third a block of wood. Challenge them to propose what is within the boxes without opening the boxes and revealing the contents. Students may be allowed to manipulate the boxes in any way they wish; however, they may not open them.

> **NOTE: Students can gain valuable insights into the nature of science with these black boxes. The teacher can supply parallel problems from the history of science itself. (I regret to say that astronomy is essentially still in the "black box" stage.)**

Experiment 8: More carefully made black boxes, such as those shown in Fig. 1, will delight and exasperate physics students. Each is sealed and has only two external binding posts. Note that electrical symbols are shown. The teacher can determine values. Of course, A.C. and D.C. current sources are essential.