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FASTBACK®

Hands-On Science in the Elementary School

James R. LeBuffe

PHI DELTA KAPPA EDUCATIONAL FOUNDATION

JAMES R. LEBUFFE

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LeBuffe has written about many topics, including improving student writing, strategic planning, science programs for elementary students, and the mainstreaming of special education students. His professional articles have appeared in numerous publications, including *The Science Teacher*, *Teaching Exceptional Children*, *Texas Elementary Principals and Supervisors Association Journal*, *The Texas Coach*, and *Perspectives for Teachers of the Hearing Impaired*. LeBuffe also has presented papers at numerous professional education conferences.

LeBuffe wishes to thank Donna Jablecki for reading this work and making helpful suggestions. He dedicates this fastback to his wife Susan, son Alex, and daughter Stephanie, who have kindled his interest in hands-on science.

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by
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Introduction

Hands-on science is not a new idea. It has been implemented successfully in many districts. But it is far from universal in American elementary schools. Several problems must be overcome in order to implement a successful hands-on science program.

Typically, elementary science instruction is textbook-driven and centers on the memorization of key "science" vocabulary words and concepts, often learned out of context. Students are given few, if any, hands-on or laboratory experiences. And they rarely learn to observe phenomena, record data, make hypotheses, and draw conclusions about events in the world around them.

Most elementary education majors who become teachers take only one or two required science courses. Thus it is not unusual for an elementary teacher to rely on textbooks and programmed ("hands-off") science materials. "Hands-on" work often is construed as the teacher performing an experiment or showcasing an interesting scientific phenomenon while students sit and watch. Pupils themselves seldom participate actively, and assessment is likely to be solely by pencil-and-paper tests.

Elementary science often is an isolated class, a time when the science textbook is taken out, material is "covered," and the textbook is then put away. Little interdisciplinary learning is provided that might connect science to mathematics, art, or language. It is not unusual for science to be allotted no more than three hours per week. Science often loses instructional time to other subjects.

Materials management also presents problems. Often classrooms do not have the microscopes, topsoil, batteries, electrical wire, acids, bases, seeds, larvae, or other materials that make science meaningful and fun for elementary school children. In other instances, the school may have excellent materials; but only a few teachers use them. And when the materials are used up or worn out, no one is regularly assigned to refurbish the kits or to replace missing materials. Batteries wear out, slides are not cleaned, cages for developing butterflies are not put away. A particularly energetic teacher may make the effort to restock materials; but without support for such activity, the effort may not be sustained.

Implementing a first-rate hands-on science program requires a substantial financial commitment by a school or district. It requires teacher inservice training in science instruction to supplement limited college experiences and the materials to permit students to engage actively in learning.

This fastback outlines the components of a successful hands-on science program and provides information to help professionals plan and implement hands-on science in their school.

Why Hands-On Science?

There are several strong reasons why a school or district should adopt an elementary school hands-on science program:

Hands-on science is fun. Dare we list this as a reason? Of course! Most teachers and students enjoy the active involvement in hands-on science studies. Students (and teachers) who enjoy what they are doing tend to do more, remember more, and learn more.

Hands-on science is instructionally sound. Research and anecdotal evidence say that children learn better when they can touch, feel, measure, manipulate, draw, make charts, and record data. Children learn better when they use higher-order thinking, such as analyzing information and making comparisons between events and materials, rather than using just rote memory. And students usually learn better when they find answers for themselves – that is, discovery learning – rather than being given the answer in a textbook or lecture.

Hands-on science provides opportunities for interdisciplinary learning. Hands-on science units are ideal for interdisciplinary learning. Good science is intertwined with mathematics as students record data, measure, make charts, and examine variables. Hands-on units strengthen language skills as pupils keep journals, write essays, and make oral presentations about their fast-growing plants, electrical circuits, or acids and bases. Art activities are integrated in hands-on science units as students sketch, draw, and construct models. And social studies topics include such issues as wise energy use and care for the environment, which are natural parts of hands-on science units.

Hands-on science is an excellent subject for cooperative learning. Many hands-on science units are most effective when small groups of two or three students work together to manipulate variables in an experiment, build a model, or record and chart their discoveries.

Hands-on science facilitates curriculum alignment. Hands-on science is not an "either-or" choice of following a district-adopted science textbook or exclusively using laboratory science kits. Carefully chosen and field-tested hands-on science units can support and strengthen a traditional science curriculum by extending textbook information.

Hands-on science emphasizes "real-world" activities. Whether connecting electrical circuits to light a bulb, watching a chrysalis become a butterfly, or examining newsprint under a microscope, hands-on science units involve the tangible phenomena of everyday life. Use of such real-world activities makes science vivid, meaningful, and fun for most children.

Hands-on science can increase parent involvement. Hands-on science units often are so interesting and exciting to students that they will talk about the units at home. Parents hear about what students are learning, see their children's journals and drawings, and share their children's excitement. When teachers capitalize on this enthusiasm, they can encourage parents to become more involved in their children's education. Some schools organize "Science Nights" during which students share and demonstrate science experiences with visiting parents, guardians, aunts, uncles, and grandparents.

Elements of an Effective Hands-On Science Program

An effective hands-on science program is marked by several characteristics:

- The school administration is committed to hands-on science.
- The program is based on a long-range plan that is updated annually.

- Key personnel – administrators, teachers, paraprofessionals – are involved in planning, implementing, and assessing the hands-on program.
- The curriculum is age-appropriate, and materials are provided and regularly refurbished.
- Integration of science with other subjects is built into the hands-on program.
- Teachers receive ongoing inservice training.
- The program is explained to the public and community support is generated.

Planning the Hands-On Science Program

Effective planning consists of four key elements: 1) administrative commitment, 2) collaboration among key personnel, 3) a written long-range plan, and 4) community support.

Support for the Program

It is crucial that the superintendent and other administrators philosophically agree with the concept of hands-on science and express that agreement in tangible ways, such as developing schedules and budgets that will facilitate the program. This commitment needs to be secured as a first step in the planning effort.

In addition to administrative support, the involvement of other key players is essential. These individuals primarily are the teachers and paraprofessionals who will work with the hands-on program, but other personnel also are important in successful planning. Some districts form a "hands-on science steering committee" with six to eight members, including an elementary principal, several teachers, the district science supervisor, other key administrators, an interested parent, and a scientist from a local firm that supports the improvement of school science instruction.

A critical requirement for the success of any hands-on science program is thorough, ongoing staff development. Without such staff development, much of the effort and expense of implementing a hands-on science program will be wasted. Thus the superintendent and other administrators must be committed to providing the time and funding necessary to train each teacher who will use the hands-on science units.

A thorough staff development session will take about three to four hours for each unit. It is recommended that these inservice programs also use a hands-on approach, with teachers performing the same tasks that they will be helping their students to perform.

The most effective teachers for these staff development sessions will be fellow teachers who have used the hands-on science units. Also, many companies will provide free staff development sessions for schools that have purchased their kits.

Long-Range Plan

The long-range plan need not be lengthy. It can be as brief as an outline, but it must be a written record of the concept and its intended implementation. "Long-range" means at least three years and preferably four or five years. A phase-in plan, carried out over several years, may be more successful than trying to implement a total program in a single year. Here is a possible sequence for phasing in a new districtwide hands-on science program:

Year 1: Enlist support for hands-on science and develop an initial plan.
Year 2: Introduce the first hands-on unit in each grade.
Year 3: Introduce a second unit in each grade.
Year 4: Introduce a third unit in each grade.
Year 5 and thereafter: Maintain the system.

Districts may opt for more or fewer districtwide core units, and individual schools or teachers may develop independent units. Such flexibility will allow teachers who embrace the hands-on concept to implement a more complete hands-on program earlier, while less confident teachers gradually ease into hands-on science.

The written plan also must include cost estimates for major program components, such as:

- purchasing and refurbishing materials,
- establishing and maintaining a materials center,
- providing ongoing staff development,
- providing additional staff if needed, and
- assessing program effectiveness and student learning.

The plan also should articulate any cooperative arrangements, such as a partnership with another school, a nearby district, or a local business.

Community Support

An "Introduction to Hands-On Science" evening is a good way to inform the community about the new elementary school program. Parents, leaders of local scientific and engineering firms, and school employees should be invited. Local newspaper, radio, and television reporters also should be invited.

The focus of the event should be explaining hands-on science and showing the program's anticipated advantages for students. Presenters should have a variety of program kits for participants to view and handle. And the organizers might present a demonstration lesson to give participants a real "hands-on" experience for themselves. The evening can be staged at an elementary school, and refreshments can be served. Such an introduction can do much to inform the public and to build community support for the new program.

Selecting Hands-On Science Units

Once a district is committed to introducing hands-on science to elementary school students, teachers and administrators should determine the instructional units to be used and develop an implementation schedule. District personnel need to decide whether to use a textbook in conjunction with the hands-on units at the beginning and to work toward eventual elimination of textbook science altogether, or to keep the textbook as a permanent feature. Many schools continue to use a science textbook as an integral part of the elementary science curriculum after hands-on units are introduced.

A key decision involves the number of hands-on units to incorporate at each grade level. A unit may require two to eight weeks, and a teacher might not use the hands-on unit every day. Thus the pace of instruction will affect the number of units to schedule. Likewise, some grades may take longer to work through a typical unit than other grades, and so it may be necessary to schedule fewer units at one level and more at another.

It also is important to identify core and optional units. Teachers will be required to teach the core units but may choose to teach the optional units, depending on student interests, available time, and other factors. School systems typically choose two, three, or four required core units at each elementary grade.

Teacher Involvement in Unit Selection

Some school districts form grade-level unit selection committees that include the science supervisor (or other administrator knowledgeable about science) and several teachers from that grade level. This committee determines which units to adopt as core, required units for the school system. Coordination among grade-level committees can be accomplished by the science supervisor or by a small representative group.

In many cases, commercially prepared units, or kits, are reviewed. All such units under consideration for adoption should be field-tested by two or three respected teachers. Factors such as the "friendliness" of the material to teachers and students, the time needed to cover material, the durability of the components, the appropriateness of the kit for the grade in question, and the quality of the teacher's guide are useful criteria to judge whether a particular kit should be adopted. Most districts use a written evaluation sheet to record teachers' perceptions about field-tested kits. These evaluations are returned to the selection committee to guide in the final selection.

Other Selection Factors

Hands-on science units must be chosen with care, as they generally are used over a number of years. Other factors to consider include:

Alignment with District Curriculum. Hands-on units should be an integral part of the curriculum, not an add-on. Thus they need to align with the district science curriculum. If the emphasis in the third-grade science curriculum is life science, the selection of a unit on fast-growing plants and pollination may be appropriate, but a unit on beginning chemistry will not fit.

Cost. As a rough estimate, commercially produced hands-on kits cost between $150 and $900, with refurbishing costs of 50¢ to $5 per student. (Such kits normally contain enough material for 30 students.) A well-designed kit and a planned refurbishment system should allow for sharing the same unit among three or four classrooms each year. It is important to remember that refurbishing costs can be 40% to 50% of the purchase price and must be paid annually to keep the kit operational.

Ease of Refurbishment. The ease or difficulty of refurbishing kits is another factor for consideration when selecting hands-on units. How much staff time will be required to refit the kits? How much expertise will be needed?

Assessment. Does the kit lend itself to current assessment techniques, or will new forms of assessment need to be developed to complement the hands-on program? Are assessment suggestions or measures included as part of the kit?

A variety of commercially developed hands-on science units are on the market. (See Sources section for a partial listing of kit producers.) Some venders will provide materials and kits for preview purposes at no charge. But districts also may design some of their own kits. Some commercial kit producers carry component supplies so that schools can create their own variations of standard kits.

Creating a Refurbishment System

The lack of a refurbishment system for hands-on science units will prevent effective implementation of the program. Thus the establishment of a system is crucial. And the development of a district refurbishment center may be the most effective way to address this need. Such a center will enable the district to minimize the need for staff time for refitting hands-on kits and to capitalize on volume discounts for replacement components. Coordinated pick-up and delivery will permit prompt turn-around of refurbished kits, so that fewer kits will serve larger numbers of students than might be possible using a school-based refurbishment system.

To facilitate refurbishment, each kit should be self-contained. Everything a teacher will need to teach the unit should be placed in a container or set of containers, and each kit should include an inventory checklist. This checklist enables the teacher to verify that the kit is complete. It also enables the refurbishment center staff to verify that nonconsumables have been correctly returned and to see which consumable items need to be replaced.

The refurbishment center needs to be located in a facility that is large enough to house all of the kits owned by a district, since there will be times – during summer vacation, for example – when all the kits may be in the center. The district's student enrollment and the number of kits in use at each grade level will affect the center's space requirements. A district with fewer than 5,000 elementary students will need a refurbishing center at least the size of a classroom (about 750 square feet). A district of 5,000 to 10,000 elementary students will require an area at least the size of two classrooms (about 1,500 square feet).

A refurbishment center will require heat and air conditioning in order to maintain adequate storage temperatures to ensure that sensitive science supplies do not deteriorate on the shelf. The district probably will need to supply a refrigerator for some components. The center also will need to be equipped with a sink for cleaning materials and with work tables for sorting and packing. Sturdy shelving will be needed, as some items may be heavy. A loading area away from student traffic is advisable. Districts also may want to install a security system to reduce the chances of costly break-ins or vandalism in the center.

Ordering Refurbishing Materials

When kits are returned to the refurbishment center, they will need to be restocked with materials as diverse as wires, batteries, and topsoil. Many of the companies that sell hands-on science kits also sell refurbishing supplies. However, a district may realize appreciable savings by ordering replacement materials from a variety of local vendors, such as hardware stores, discount stores, and electronic or building supply stores.

A useful resource for ordering wholesale materials is the *Thomas Register*.

Scheduling Kit Delivery

The most manageable system for scheduling kits in a district is to deliver a core kit for an entire grade at a particular school at the same time. However, some districts allow teachers to choose when to receive the core units. Giving teachers a choice of when to teach certain units allows for more flexible implementation of the science curriculum; but it also makes refurbishment and delivery more complex, and the district usually will need to have more kits on hand than if all grades receive the same kits at the same time. Following are some points to bear in mind when scheduling hands-on units if a districtwide system will be used:

- Schedule early in the school year or before school opens, so that teachers know which hands-on unit will be in their classroom at any given time. Avoid the first and last weeks of the school year, as teachers usually prefer not to be involved in hands-on units during these periods.
- Do not forget holidays and major testing dates in planning the schedule. There may need to be some "blackout" days when kits will not be in service for various reasons.
- Pay attention to kit composition. Kits with live specimens can not be left unattended over long weekends or during vacation periods.
- Emphasize the importance of returning kits promptly, so that they can be refurbished and sent out on schedule to the next user. Most kits will be used three or four times over the course of each year.

Of course, year-round schools and ungraded or multi-age classes will require atypical schedules.

Transporting Kits

Dependable transportation will be needed for pick up and delivery of hands-on kits. Most districts purchase or designate a van. Some districts even decorate the "Hands-On Science Van" with student artwork.

Staffing the Refurbishment Center

Staffing will depend on the size of the district. In addition to a designated administrator to oversee the center's operation and budget, a key employee will be the center clerk. This individual may work part time in a small district, or there may be several clerks in a larger district. A rule of thumb is that a full-time clerk will be needed for a district of 5,000 elementary students using three or four kits each year.

The duties of the refurbishment center clerk include:

- taking inventory
- ordering materials
- restocking kits
- cleaning equipment
- packing kits for transport

In smaller districts, the clerk also may transport the kits to the schools. Some districts employ a school bus driver for additional hours to transport the hands-on kits.

Supporting the Hands-On Program

It is important for teachers to receive a master schedule for the hands-on science program, so that they will know when to anticipate receiving their kits.

Since the kits are used several times each year and by various teachers, maintaining the schedule is crucial to the success of the program. Due dates must be strictly observed. Because the kits may remain in a given classroom for several weeks, it is a good idea to send the teacher a due-date reminder a week or two before the kit is scheduled to be returned to the refurbishment center.

Occasionally, a kit will arrive in a classroom with one or two items missing because of errors in refurbishment. Teachers should be able to contact the refurbishment center and receive the missing supplies promptly. The refurbishment center also may be asked to respond to special requests for materials not included in the kit that a teacher may wish to use. Therefore, it is helpful to have a policy regarding supplementary materials: what may be used and where such materials may be obtained.

Teachers are bound to have questions about the use of materials, how to sequence activities, the scope of the activities, how to relate the hands-on unit to other disciplines, and other questions – particularly in their initial experience with a given unit. To help teachers learn about the kits, some districts deliver the hands-on units to all teachers of a certain grade in a school at the same time. In this way, teachers can consult with each other, plan together, and compare experiences as they teach the unit. Many teacher concerns can be lessened and questions answered when several teachers of the same grade level in a school are teaching the same unit at the same time. Some schools also identify a "lead science teacher" who is available in the building to answer questions from colleagues concerning hands-on units.

The science supervisor (whether a science specialist or a designated administrator) and refurbishment center clerk should be accessible to answer questions from teachers concerning the units. "Walk-through" school visits by the science supervisor are valuable for answering questions, ensuring that the kits are in use on schedule, and general troubleshooting.

Assessing Hands-On Science

Hands-on science offers a wider variety of potential assessment strategies than does traditional, textbook science. Following are several ways to assess student learning in a hands-on science program:

Traditional objective measures. Objective tests include traditional tests of key vocabulary, fact-based matching and true-false tests, identifying scientific elements in drawings and diagrams, and so on. Such tests can be given in a pre-/post-test format to assess student learning, or the tests may be administered after individual activities or at the end of a unit.

Student-generated "learning lists." Elementary students enjoy making lists of what they already know, what they want to learn, and what they have learned from a hands-on unit. Such lists are generated through teacher-led discussions and are an effective, student-centered documentation of learning.

Drawings. Pre- and post-unit drawings are a powerful form of documented assessment. For example, a teacher might ask third-graders to draw a bee before starting a unit on plants and pollination. Then, at the end of the unit, the teacher might ask for another drawing of a bee. Comparing the two drawings will enable the teacher to assess the new information that students have incorporated into their drawing as a result of the unit. Fourth-graders might draw a diagram showing how they think a flashlight works at the start of a unit on electric circuits and then repeat the assignment after the unit.

Journals. Students should be encouraged to keep journals during each hands-on unit. Pupil journals may contain drawings, key vocabulary, recorded data, hypotheses that the students make and conclusions they reach, class notes, and handouts from the teacher. Student journals provide an excellent anecdotal means of assessing student learning.

Essays. For more mature elementary students, writing can forcefully document learning. Such documentation is especially strong if essays on the same topic are assigned at the start of a unit and at the end of a unit. The comparison of essays written just weeks apart can impressively illustrate how much learning has occurred.

Portfolios. A portfolio combines the preceding elements, allowing the teacher and the student to use various types of assessment in order to gain a complete picture of the student's learning.

Performance assessment. Can students measure, record data, attach wires, follow directions, explain a process, give a talk explaining a facet of the unit, plant a seed, or make a chart? Performance assessment allows students to demonstrate their new understanding and skill by performing "real-world" tasks under the observation of their peers and their teacher.

Hands-On Science Partnerships

Scientific and engineering firms are natural partners for schools that are attempting to improve their science programs. Such businesses need a scientifically literate citizenry and a pool of potential employees with a solid science education. When starting a local hands-on science program or when looking for support for an existing program, school leaders will find it beneficial in several ways to educate and involve local business and industry.

Involved business and industry partners can:

- Publicly support the development of hands-on science as a necessary educational program that will benefit the community, businesses, and industries in addition to helping students improve science learning.
- Contribute financial support for the purchase of hands-on science kits or refurbishing materials.
- Designate an employee to serve on the school's or district's science education steering committee.
- Advise curriculum review committees about the scientific or industrial merits of hands-on units under consideration.
- Attend science education conferences with school district employees, or sponsor teachers and administrators to attend such conferences as part of staff development.
- Serve as resource presenters, whom teachers can invite to speak to students during hands-on units.

Many firms in the United Sates actively support hands-on science initiatives in schools in their communities. The Dow Chemical Company Foundation, Du Pont, Hewlett-Packard, the Amoco Foundation, and Digital Equipment are among the better-known supporters.

Three Sample Hands-On Units

Following are three sample hands-on science units. The first two units use commercially produced kits (see address in Sources section). The third unit can be developed locally by using readily available materials.

Sample One

Unit: The Life Cycle of Butterflies
Intended grade: 2
Source: National Science Resource Center (NSRC). The teacher's guide is 124 pages, copyright 1992 by the National Academy of Sciences.

Recommended unit length: Four to six weeks, depending on the frequency of activities. It is not necessary for a class to do science activities each day.

Materials: Included in the kit are a teacher's guide, 30 student notebooks (optional), class calendar, 30 Painted Lady butterfly larvae, eight ounces of caterpillar food, 30 one-ounce cups with lids and tissues, spoon, paint brush, two large butterfly cages, 30 hand lenses, and four feeding stations including sugar, sponge pieces, shallow jar lids, and paper cups. Not included but also needed are supplies for making caterpillar models, twigs for butterfly cages, paper towels, masking tape, egg cartons, narrow-neck bottles, lined paper, drawing paper, crayons, newsprint, markers, double-stick tape, and transparency film.

Main objective: Students will become familiar with the life cycle of the butterfly.

Secondary objectives:

- Students develop observation skills using magnifiers.
- Students observe, record, and predict changes in caterpillars, chrysalises, and butterflies.
- Students learn characteristics of living things, specifically insects, and compare the characteristics of caterpillars and butterflies.
- Students prepare materials and feed caterpillars.
- Students participate in the release of the butterflies.

Activities: During this unit, students:

- Draw pictures of caterpillars, chrysalises, and butterflies.
- Prepare food cups for caterpillars.
- Use a magnifier to observe caterpillars.
- Record observations about caterpillars, chrysalises, and butterflies.
- List or explain the characteristics of an insect.
- Feed the butterflies.
- Release the butterflies.

Evaluation:

- Pre- and post-unit lists showing students' knowledge about caterpillars and butterflies.
- Pre- and post-unit drawings of caterpillars and butterflies.
- Student participation in feeding and care of caterpillars and butterflies.
- Objective tests.
- Student journals.
- Oral reports.

Sample Two

Unit: Plant Growth and Development
Intended grade: 3
Source: National Sciences Resource Center (NSRC). The teacher's guide is 143 pages, copyright 1993 by the National Academy of Sciences.

Recommended unit length: 35 school days; however, a class does not have to work on the unit every day.

Materials: Included in the kit are a teacher's guide, 15 student activity books, 30 trays, a package of bean seeds, a package of toothpicks, 30 spoons, 15 honeybees, 6 large paper cups, 30 forceps, 30 hand lenses, 2 packages of seeds, 2 packages of potting soil, 2 packages of fertilizer, 2 packages of wooden stakes, 2 packages of plastic rings, 30 planter labels, 30 planter quads, 3 water tanks, 3 water mats, 120 wicks, 3 felt squares containing copper, a lighting system, and a bag of 500 snap-together centimeter cubes. Not included but also needed are student notebooks, drawing paper, a large jar, a newsprint pad and markers or overhead transparencies and markers, a whisk broom and dustpan, 30 scissors, glue and small glue clips, crayons, and supplies for making models of flowers and bees.

Main objectives: Students will become familiar with the life cycle of a plant and understand how and why bees pollinate some plants.

Secondary objectives:

- Students will observe and note germination of seeds and growth of plants.
- Students will record data using a bar graph.
- Students will create models of plants and bees and label their parts.

Activities: During this unit, students:

- Observe and record changes in seeds when seeds are soaked.
- Collect and organize materials for planting seeds.

- Plant seeds.
- Observe growth of plants.
- Measure the growth of plants.
- Record the growth of plants using a bar graph
- Draw plants and bees.
- Observe dried bees using a magnifying glass.
- Pollinate plants using dried bees.
- Make models of bees.

Evaluation:

- Pre- and post-unit lists showing students' knowledge about plants, bees, and pollination.
- Pre- and post-unit drawings of plants and bees.
- Essay tests.
- Objective tests of vocabulary.
- Student journals.
- Oral reports.

Sample Three

Unit: The Pillbug Project
Intended grade: 4 (This unit has been used in grades 2 through 6.)
Source: Locally developed; no commercial kit available. A teacher's guide is available: Burnett, Robin. *The Pillbug Project: A Guide to Investigation.* Illustrated by Sergey Ivanov. Washington, D.C.: National Science Teachers Association, 1992.

Recommended unit length: 10 days.

Materials: Small containers to house pillbugs, soil, pine needles or mulch, water, oatmeal, bread crumbs, crushed dry cereal, plastic spoons, paper cups, hand lenses, a small rug with a rough surface, paper, adhesive notes, several bricks, an available sink or small buckets, markers, a small shovel, student notebooks, pencils, paint brushes, and newsprint.

Main objective: Students will observe and learn from nature.

Secondary objectives:

- Students will learn the basic anatomy of the pillbug.
- Students will distinguish between insects and crustaceans.
- Students will find pillbugs in nature and observe and note pillbug behaviors in various settings.
- Students will work in cooperative groups.
- Students will learn how to develop and present research reports.

Activities: During this unit, students:

- Search for, find, and collect pillbugs.
- Observe different conditions where pillbugs are found.
- Observe and record behavior of pillbugs under different conditions.
- Predict behavior of pillbugs under different conditions.
- Take part in a group scientific report to class about behavior of pillbugs.
- Graph behaviors of pillbugs.
- Write accounts of pillbug behaviors.

Evaluation:

- Pre- and post-unit drawings.
- Student log books.
- Essay tests.
- Objective tests.
- Research reports, including oral presentations.

Sources for Hands-On Science

Following is a partial listing of sources of information and hands-on science kits:

Activities Integrating Math & Science (AIMS)
P.O. Box 8120
Fresno, CA 93747
(202) 291-1766

Britannica Science System
Encyclopaedia Britannica Educational Corporation
Attn: Promotion Dept.
310 South Michigan Avenue
Chicago, IL 60604-9839

Delta Science Modules
Delta Education, Inc.
P.O. Box 915
Hudson, NH 03051-0915
1-800-258-1302

Full Option Science System (FOSS)
(Developed at Lawrence Hall of Science, University of California at Berkeley)
Delta Education, Inc.
P.O. Box 915
Hudson, NH 03051-0915
1-800-258-1302

Great Explorations in Math and Science (GEMS)
(Developed at Lawrence Hall of Science, University of
California at Berkeley)
Lawrence Hall of Science
University of California
Berkeley, CA 94720
(510) 642-8718

Hands-On Science Units for the Elementary School Curriculum
(Sponsored by the Smithsonian Institution and the National Academy
of Sciences)
Carolina Biological Society Supply Company
2700 York Road
Burlington, NC 27215
1-800-334-5551
FAX: (919) 584-3399

LINX
The Science Source
P.O. Box 727
Waldoboro, ME 04272
(207) 832-6344
FAX: (207) 832-7281

NASA Johnson Space Center
Teacher Resource Center
Mail Code AP-4
Houston, TX 77058
(713) 483-8696

National Science Teachers Association
1840 Wilson Blvd.
Arlington, VA 22201-3000
1-800-722-6782

Science and Technology for Children Project
National Science Resource Center
(Sponsored by the Smithsonian Institution and the National Academy of Science)
Director of Outreach (NSRC)
Capital Gallery
600 Maryland Avenue, S.W., Suite 880
Washington, DC 20024
(202) 287-2063
FAX: (202) 287-2070

Science Curriculum Units
Mesa Public Schools
Science/Social Sciences Resource Center
143 South Alma School Road
Mesa, AZ 85210-1103
(602) 898-7815

Science Place (Primary level kits)
Scholastic Inc.
730 Broadway
New York, NY 10003
(212) 505-3000

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Phi Delta Kappa Educational Foundation

The Phi Delta Kappa Educational Foundation was established on 13 October 1966 with the signing, by Dr. George H. Reavis, of the irrevocable trust agreement creating the Phi Delta Kappa Educational Foundation Trust.

George H. Reavis (1883-1970) entered the education profession after graduating from Warrensburg Missouri State Teachers College in 1906 and the University of Missouri in 1911. He went on to earn an M.A. and a Ph.D. at Columbia University. Dr. Reavis served as assistant superintendent of schools in Maryland and dean of the College of Arts and Sciences and the School of Education at the University of Pittsburgh. In 1929 he was appointed director of instruction for the Ohio State Department of Education. But it was as assistant superintendent for curriculum and instruction in the Cincinnati public schools (1939-48) that he rose to national prominence.

Dr. Reavis' dream for the Educational Foundation was to make it possible for seasoned educators to write and publish the wisdom they had acquired over a lifetime of professional activity. He wanted educators and the general public to "better understand (1) the nature of the educative process and (2) the relation of education to human welfare."

The Phi Delta Kappa fastbacks were begun in 1972. These publications, along with monographs and books on a wide range of topics related to education, are the realization of that dream.