HAWAII NATURE STUDY PROGRAM

FOR ELEMENTARY SCHOOL CHILDREN

PROGRAM MANUAL

A project of

CURRICULUM RESEARCH AND DEVELOPMENT GROUP
University Laboratory School
UNIVERSITY OF HAWAII
1776 University Avenue
Honolulu, Hawaii 96822

HISTORY AND SPONSORHSIP

Between the years 1955 and 1962, the Catholic School Department of the Diocese of Honolulu developed and published a series of booklets on nature study entitled EXPLORING NATURE IN HAWAII. These booklets, illustrated in color for elementary children, continue to be used in both public and non-public schools throughout the State of Hawaii.

In 1959, the Hawaiian Academy of Science became an associate in the development. Since then and continuing to the present, all drafts of the nature study materials are reviewed by appropriately chosen members of the Hawaiian Academy of Science for critique and correction.

The current Hawaii Nature Study Project took form in 1973 at the Curriculum Research and Development Group of the University of Hawaii. With University support, program materials are being designed, written, and tested.

The Catholic School Department retains ownership and management of the EXPLORING NATURE IN HAWAII series. The Academy of Science handles the revolving funds for the HAWAII NATURE STUDY publications. Financial assistance toward the publication of the first three Hawaii Nature Study units (PARTS OF PLANTS, INSECTS, SPIDERS) was provided by grants from the Atherton Foundation, the McInerny Foundation, and the Castle Trust. Sea Grant sponsored part of the REEF AND SHORE unit produced in cooperation with the Waikiki Aquarium. The Office of Environmental Quality Control has also assisted with production.

Project philosophy and goals have been shaped by generous input of ideas from the members of the Steering Committee who have been associated with the project throughout its history. Current members of the Steering Committee are listed here with the year in which they first became associated with the Hawaii Nature Study effort.

- *Msgr. Daniel J. Dever, Superintendent of Catholic Schools in Hawaii. 1953.*
- *Dr. Doak Cox, Director, Environmental Center, University of Hawaii. 1959.*
- *Saul Price, National Oceanographic and Atmospheric Administration, Hawaii. 1961.*
- *Dr. Francis M. Pottenger, III, Chairman, Science Dept., University Laboratory School. 1967.*
- *Dr. Arthur R. King, Director, Curriculum Research and Development Group, University of Hawaii. 1973.*

Inestimable assistance in refining the materials has been offered by the many teachers who piloted the rough drafts in varied classroom situations in both public and non-public schools. Of particular help have been practical suggestions made through two years of classroom testing by Dorothy Buddemier, Mary Magdalene Cambra, Cathy Chock, Dennis Kawamoto, Luetta Kuhns, Sister Joyce Marie, Carlene Toda, and Yvonne Toma. Equally appreciated are pilot teachers who have joined the project more recently. Of great value to the overall production are the illustrations by Sayo Nakagawa, and the critiques and support given by colleagues, especially Barbara Klemm in the Curriculum Research and Development Group.

PROGRAM MANUAL

FOR THE

HAWAII NATURE STUDY PROJECT

by the

CURRICULUM RESEARCH AND DEVELOPMENT GROUP
UNIVERSITY OF HAWAII

Assisted by the HAWAIIAN ACADEMY OF SCIENCE
and other friends of the Project

THE HAWAII NATURE STUDY PROGRAM for elementary school children is in the design stage in the Curriculum Research and Development Group, University of Hawaii. The decision to move to full developmental status will be made in 1976.

Address correspondence to the Project Director, Sister Edna L. Demanche, Ph.D., at the University of Hawaii. Address on front cover. Phone (808) 948-7793.

August 15, 1975

THE HAWAII NATURE STUDY PROGRAM MANUAL

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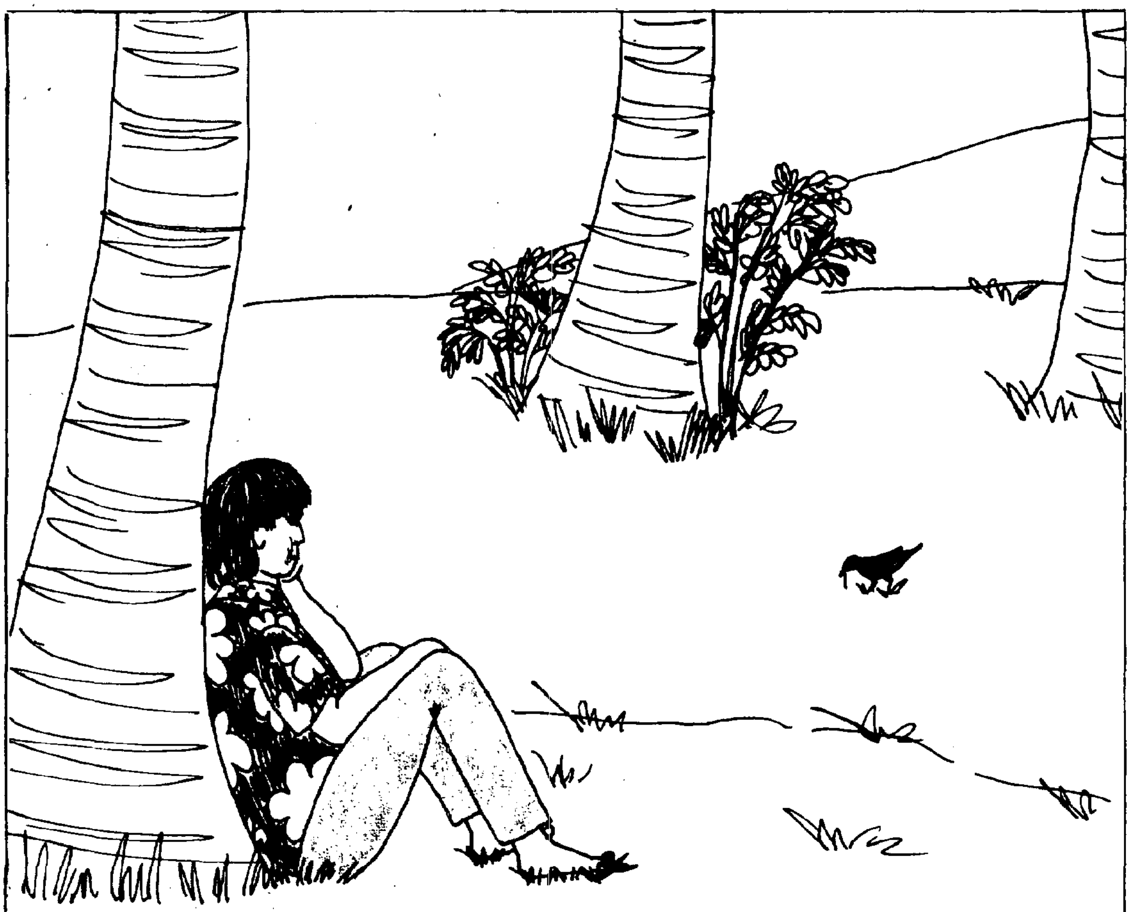
I. THE HAWAII NATURE STUDY PROGRAM

The Hawaii Nature Study Program is a laboratory- and field-oriented program for elementary students. The focus of study is the plant and animal life and the physical components of the Hawaiian environment, and their ecological relationships. The program stresses student on-site observations, experimentation, discussion, and learning by experience.

The Hawaii Nature Study Program is designed to fit within the science curriculum but it correlates with other subject areas in school as well as with local community interests. It promotes awareness, appreciation, knowledge, and understanding of the environment. The specific skills it developes prepares students for science courses in the intermediate school.



The Hawaii Nature Study Program for elementary children is comprised of out-of-door, campus-centered, problem-solving, observations and investigations.

Books of the Hawaii Nature Project.

The written materials of the Hawaii Nature Study Project consist of a PROGRAM MANUAL and a series of TEACHER'S GUIDES, each bound separately and titled according to subject matter. The PROGRAM MANUAL and the TEACHER'S GUIDES, can be purchased in paperback at cost price through the project office. See front cover for address.

The PROGRAM MANUAL describes the program, the rationale, and goals. It provides teachers with procedures and strategies useful for conducting classroom and campus investigations. It suggests methods for instructing students in the basic skills needed for experimentation and scientific reporting. Issued September 1975.

TEACHER'S GUIDES include the following:

PARTS OF PLANTS consists of observations and investigations for Kindergarten through sixth grade (Grades K-6) on plant structures using whatever plants are available in campus and home neighborhoods. Issued September 1974. Revised edition, September 1975.

INSECTS is a series of investigations for Grades K-6 utilizing insects found in most local school neighborhoods. Issued September 1975.

SPIDERS AND OTHER ANIMALS OF THE SCHOOL NEIGHBORHOOD contains investigations for Grades K-6 involving spiders, birds, lizards, sowbugs, and similar small animals (other than insects) found in most school neighborhoods. Available January 1976.

REEF AND SHORE, for Grades K-6, is observations and investigations which can be carried out in the classroom (with the aid of salt water aquaria) and during visits to the reef, the beach, and the Waikiki Aquarium. Available September 1976.

SOIL, WATER, AIR for Grades K-6 emphasizes the local physical environment. Available post-1976.

MORE PLANTS is a follow-up on PARTS OF PLANTS for Grades K-6. It presents plant classification, some simple plant physiology, and other plant relationships. Available post-1976.

Later TEACHER'S GUIDES in the series will involve phenomena special to Hawaii but beyond walking distance of most school campuses, such as the active volcanos, bogs, rain forests, forest birds and animals, and other special environmental phenomena.

Eventually the Hawaii Nature Study Program will have teacher and student reference aids, slides, pictures, and printed student materials. Meanwhile this role is served by EXPLORING NATURE IN HAWAII, available in Volumes 1 through 8 from the Catholic School Department of Hawaii, Box 1247, Kaneohe, Hawaii 96744; $13.75 per set of 8 volumes.

Equipment and Supply Needs.

In addition to the PROGRAM MANUAL and the TEACHER'S GUIDES, the program needs are minimal. The students need notebooks. The "laboratory" supplies are nearly all of the kitchen and dime store variety.

Grade Levels.

Hawaii Nature Study activities and investigations are designed for use in Kindergarten through Grade 6. Each topic is presented at three BANDS or levels of difficulty. Teachers are encouraged to choose whichever BAND materials seem best suited for their given grade or situation.

BAND 1 activities and procedures are for very young and inexperienced pre-readers and pre-writers. BAND 1 materials are useful in primary classes but could be used or adapted for older children with learning disabilities.

BAND 2 activities are suitable for young students who are beginning to read and write independently, such as average 3rd and 4th graders, precocious youngsters in earlier classes, or inexperienced older groups.

BAND 3 activities and procedures make demands on students (5th and 6th graders) who are expected to think through and carry out investigations at a young scholarly level.

TYPES OF ACTIVITIES	GRADE LEVELS						
	K	1	2	3	4	5	6
Simple Observations		BAND ONE					
Simple Investigations				BAND TWO			
Upper Elementary Work						BAND THREE	

Further description of the TEACHER'S GUIDES together with suggested teaching strategies is given in Section II of this PROGRAM MANUAL.

The Nature of Nature Study.

Nature Study, in centuries-old tradition, carries a connotation of appreciation and knowledge of "Mother Nature" springing from contemplation of the flowers of the field, the animals of the forest, the stately trees, the babbling brooks, the eternal hills. Nature Study, circa the 1970's, retains this valuable and nostalgic view but adds further dimensions.

Nature Study in modern guise addresses the total environment using all available media. Old-fashioned contemplation and the making of artistic line drawings or wood cuts is augmented in modern times both by formal studies using investigative, problem-solving strategies, and by informal use of art, storytelling, music, participative recreation, crafts, and whatever engages the senses, the mind, the whole person. The goal of Nature Study today is the achievement of awareness, appreciation, knowledge, and attitudes of personal responsibility toward the total environment, both natural and manmade.

Modern Nature Study, as defined above, is synonymous with some definitions of environmental studies. The words environment, environmental, and environmentalist have in many locales in Hawaii become charged with antagonistic emotional biases. To excape this burden of negative feelings, this program, which is devoted to unbiased educative goals toward the environment, is called by the older name, Nature Study, but with the term redefined and expanded to include an approach through multiple avenues to the total milieu.

Hawaii Nature Study in the School Curriculum.

The focus of study in the Hawaii Nature Study Program is the out-of-door, local Hawaiian environment, particularly that which is immediately accessible within the school and home neighborhood.

Most of the single activities fit within the span of one class period. This is appropriate to the short interest span of small children. This also allows the out-of-door activities to be accomplished without the need of chartering a bus or rearranging the school schedule to accommodate a field trip. This ease of management permits frequent, even daily, observations of changes and collection of data in the environment just outside the classroom door.

Student activities described in the TEACHER'S GUIDES can constitute a complete program in themselves about Hawaii's unique environment, should such a course be desired.

A more common usage of the Nature Study activities is to incorporate them into the elementary science course. Hawaii Nature Study by itself is not a complete science course. It omits universal topics such as electricity, gravity, photosynthesis, and similar topics which can be obtained adequately from standard elementary science texts. However, the Nature Study program does include instruction in the basic science skills such as observation, data logging, and reporting, learned through usage of the local environment.

Hawaii Nature Study materials are easily incorporated into art, music, social studies, language (storytelling, writing, reading, spelling, vocabulary), arithmetic, and crafts. Many teachers find it useful to keep all the TEACHER'S GUIDES available and select topics or groups of topics, as local opportunities and interest indicate.

The Hawaii Nature Study Program can be affiliated with the other school subjects, particularly with science.

Nature Study	Science	Math	Social Studies	Language Arts	Art	Music	Practical Arts/Crafts	Recreation

Rationale and Goals.

It is the aim of the Hawaii Nature Study Program to help teachers to create an exciting exposure to the world at our doorstep, to foster the acquisition of some basic learning skills, and to encourage the intellectual and humanistic growth that can flourish in such a setting. If this program succeeds, young students will leave elementary school ready to grapple, with some vigor, with the fundamentals presented in intermediate and high school courses and to move into larger life contexts with senses attuned to a living and changing environment.

The prime task of the Hawaii Nature Study Program is to sensitize the young to their environment, to make children alive to and reflective of the realities around them. Fortunately, young children are born-learners, born-seekers, born-enthusiasts. The challenge to the ingenuity of the elementary teacher is to keep alive and feed those natal instincts. Interest motivates learning. If enjoyment and well-ordered pleasure surround the presentation of materials to young children, learning will not only occur, it cannot be prevented. With but little encouragement, the appetite to learn grows and expands. It reaches into and out beyond books, beyond school, beyond graduation. Enjoyment and knowledge of the natural and man-made world can ripen into expressions of responsibility and concern, an environmental ethic. The growth is self-enhancing. Just as initial awareness and interest motivates study and understanding, so the knowledge acquired enhances enjoyment and deepens interest.

Based on this rationale, the Hawaii Nature Study Program aims to achieve in students:

A. ATTITUDES

1. Increased interest in their environment, particularly their immediate environment.

2. Growth in awareness, appreciation, love, and respect for the natural world, beginning with their everyday world.

3. Sensitivity to the relationships between themselves and the here and now of their natural and human environment.

4. Feelings of enjoyment, pleasure, and happiness while observing and working in the natural and manmade world.

5. A willingness to share both joys and hard work; a team spirit in the approach to problems, successes, and failures; a social ease in communicating ideas and hunches.

B. SKILLS

6. Improved skills in observing, in noticing things, in paying attention to realities outside themselves.

7. Heightened use of imagination and creativity as demonstrated by the expression of originality and inventiveness in trying to solve problems, or plan investigations.

8. Some beginning of intellectual skills such as logical analysis of data, judgments about adequacy of evidence, drawing of valid conclusions.

9. Programming skills such as setting up of data tables assembling and delivering oral and written reports, engaging in discussion and critique sessions.

10. Manual skills such as using standard simple equipment, taking measurements, building insect cages, caring for plants and animals.

C. CONCEPTS

11. Recognition of some names, terms, facts, commonly held theories.

12. Some understanding of causes, effects, dependencies, relationships.

13. Retention of terms and ideas which seem to the student to be important or interesting enough to remember.

D. VALUES

14. A sense of reverance, of respect, of gratitide, of personal involvement out of love for all the things of man and nature.

    This last goal cannot be directly aimed for in teaching. It can only be hoped for. It may be prepared for, and achieved almost unwittingly, insofar as personal values come through to students from the inner being of those who instruct them. This personal dynamic is the seed bed of response and responsibility.

. . . .

In the primary grades, the attitudinal goals, Numbers 1 to 5, receive greater attention. Achievement of skills and concepts are touched upon very lightly with the very young. Content receives increasing attention in the middle grades.

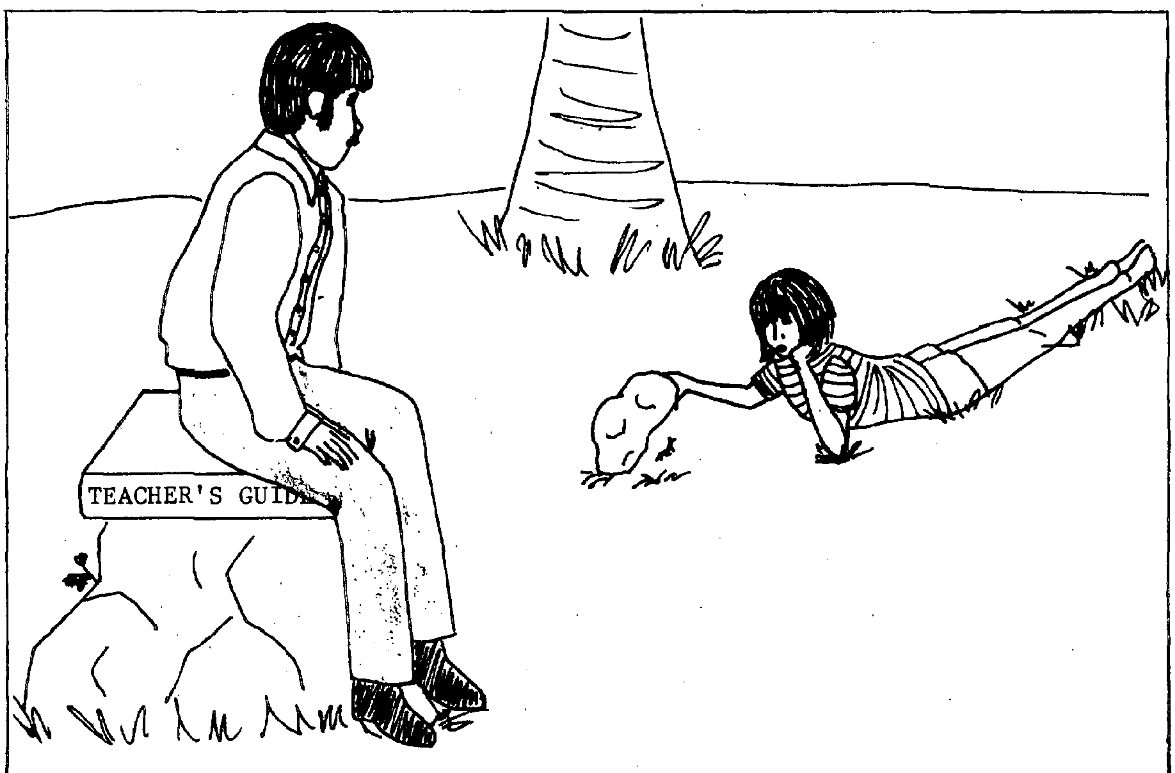
Which specific pieces of knowledge are focused on at any given moment is left to the elementary teacher to decide. The TEACHER'S GUIDES supply material from which each teacher can select whatever kind and amount seems appropriate to the given grade level and student capacity. If only 10% of the given content is learned and retained by the students, they are 10% ahead of where they were. In certain classes, 10% may be enough. More can be added later.

With upper elementary classes or with abler students, it may be desirable to push for learning a higher percentage of the materials presented. This is done by first concentrating on improving the attitudes listed as the first five goals, then exposing the students to additional materials which they can discover, explore, and investigate. Their increase in interest, love, enjoyment, and ease in communication is the determinant of how much additional knowledge they will acquire.

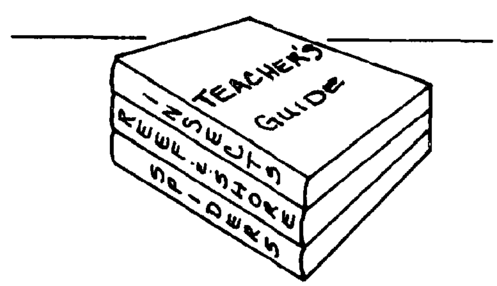
II. THE HAWAII NATURE STUDY TEACHER'S GUIDES

The Hawaii Nature Study TEACHER'S GUIDES are reference books for teachers. They describe activities which can be done and suggest ways to guide students in doing them.

The content and format of the TEACHER'S GUIDES have been shaped in response to practical comments and suggestions from pilot teachers who tested the first drafts. Heed was taken of comments by teachers who had classes and classrooms with the advantages and the handicaps commonly encountered in elementary schools.



Students may believe, if they wish, that Nature Study teachers invent interesting problems and challenges spontaneously.



The Format of the TEACHER'S GUIDES.

Each TEACHER'S GUIDE is a book devoted to one subject. For example, there is a TEACHER'S GUIDE on INSECTS, a TEACHER'S GUIDE about REEF AND SHORE, and so on.

Within each guide are topics. Topics are numbered in sequence within each book. For example, the first few topics in the SPIDERS TEACHER'S GUIDE are called:

1. Operation Spider Hunt

2. Caging and Care of Spiders

3. Spider Food

4. etc.

Each topic provides one or more activities which the students may do. Some activities are simple observations; some are "how to" skills; most are problem statements to initiate investigations. Each activity is labeled as suitable for BAND 1, BAND 2, or BAND 3. For example:

Name of TEACHER'S GUIDE	Topic Number	Title of Topic	Recommended Band Level	Numbers and Types of Activities found under the given Topic Heading
PARTS OF PLANTS	2	Stems	Band 1	One activity on observation of stem shapes and colors
PARTS OF PLANTS	2	Stems	Band 2	Two investigations about qualities and sizes of stems
INSECTS	4	Monarch Butterflies	Band 1	Two observational activities on caterpillars and adults
INSECTS	4	Monarch Butterflies	Band 2	Eight problem investigations about larvae, chrysalides, and adults
INSECTS	4	Monarch Butterflies	Band 3	Five problem investigations about feeding and mating of Monarchs

Placing the activities for all three BAND levels concerning one topic near together makes it easy for a teacher to choose BAND 1, 2, or 3 according to whichever level of activity seems suitable for the class. It also is possible to use two or all three levels simultaneously in the same class, giving BAND 1 observations to some children while challenging others in the class with the more sophisticated investigations of BAND 2 or BAND 3.

The style of presentation for each topic in the TEACHER'S GUIDES varies somewhat, dictated by convenience and the nature of the activity. In general, the presentation adheres, more or less, to the following style:

Under each topic heading, an Introduction briefly states the immediate objectives of the activity and other points of concern to teachers.

A Time Frame indicates a ball park estimate of how many class periods a teacher might expect to use for the activity.

Materials needed for the activity, such as glue, wire, poster paper, are listed in a column to serve as a convenient check list for the teacher in preparing the lesson.

Problem statements which initiate each investigation are outlined in black boxes. If desired, the boxes can be cut out, pasted onto 6x8 cards, and made available to the students.

In addition to the problems which make up the main body of a topic, Further Investigations or Additional Problems are often added as optional activities. These can be given to classes, to small groups, or to individual students who show an interest or an ability to carry an investigation further. These added tasks are also useful for brighter students to pursue while the majority of the class are finishing the original problem.

Procedures for carrying out each activity are suggested. Procedures are usually listed twice; first in brief outline, then with considerable detail.

Procedures-in-Brief is an outline, or a digest, or an overview of the activity. Some innovative teachers read only the Procedures-in-Brief and go from these in whichever direction their own and their students' creative ideas take them.

Procedures-in-Detail is a development, point by point, of the Procedures-in-Brief. Teachers may read Procedures-in-Detail a day or so before the lesson as an assist in planning and preparing. The details can be followed as written, giving teachers inexperienced in out-of-door nature study work some assurance of managing the activity in an acceptable manner. Many teachers follow the Procedures-in-Detail the first time they do the activity. Thereafter they have the confidence to make adjustments and changes to fit their particular class needs and neighborhood opportunities.

Some topics have an extensive technical vocabulary associated with them. For these, a vocabulary list with definitions is added into such topics for the teacher to refer to and use according to student ability and interest.

Experience has shown that vocabulary lists are best not taught as such. The teacher's inclusion of technical words as part of his or her classroom conversation serves as the best stimulus and means of learning the words.

Teacher Background Information is added for those topics which are based on scientific information which the teacher needs in order to direct the investigation or lead the discussion effectively. Such information is given briefly to preclude the need of the teacher to go to the library to look it up.

Teaching Strategies.

Nature Study is an observational and investigative learning experience for the student. The teacher is the facilitator, the challenger, the helper, the resource person, the leader-from-the-rear. The Nature Study teacher stimulates and challenges students to go out and do their own work. Teaching strategies which are specific to an activity are suggested for that activity in the TEACHER'S GUIDE.

In general, in BAND 1 activities, the teacher is largely the stimulator of enjoyment and appreciation. BAND 1 activities are frequently simple exposures to out-of-door phenomena accompanied by enjoyable experiences, stories, art, music, questions, and discussion to create a positive and enduring memory.

BAND 2 and BAND 3 activities engage the intellect more prominently. Students are encouraged to find their own answers by investigating the flora, fauna, and environmental conditions around their campus and home neighborhoods. The teacher in BAND 2 and BAND 3 activities, while not neglecting the stimulating and interest elements of the lesson, is predominantly the challenger who supplies problems without "answers". The "answer" is given by the data which are collected. The teacher, with his or her professional background information, guides the investigation by strategically placed questions to keep student pursuit on course and validly founded.

An effective strategy is to verbalize or paraphrase problem statements and discussion questions found in the TEACHER'S GUIDES. A problem becomes more interesting if it is not read to the student from a book but rather spoken in a tone of voice which indicates wonderment or curiosity. For example: If the TEACHER'S GUIDE states

> Problem:
>
> What foods do spiders eat?

the teacher, with the book well out of sight, might say to the class,

"I wonder what spiders eat?"

For special assistance in teaching strategies, a 22-page booklet entitled FACILITATING GROUP INVOLVEMENT AND DISCUSSION is put out by the Foundational Approaches in Science Teaching project. A copy of this valuable paper may be obtained for 50¢ from the office of the Director of the FAST Project, University Laboratory School, 1776 University Avenue, Honolulu, Hawaii 96822.

Selecting a Problem for Study.

The teacher is the architect of the Nature Study enterprise on which a class embarks. Deciding which Nature Study activities to pursue with the class and identifying problems for investigation can be done in many ways.

a. Relevant action occurs when both teacher and students are alert to opportunities in the neighborhood, such as a bird nest, a certain type of tree or grass, a sudden rain storm. A problem statement which makes use of the situation can often be found among the range of topics in the several TEACHER'S GUIDES.

   In INSECTS and in SPIDERS AND OTHER ANIMALS OF THE SCHOOL NEIGHBORHOOD the activities are dependent on what specimens are available. It might be useful in these two cases to list on the board the topics from the tables of contents and briefly outline the possible activities for the class. The students can then assist in looking for insects and other animals in the neighborhood which go with the list of possible activities. As an opportunity is found by the teacher or by one of the students, the activity can be pursued.

b. A method of pursuing Nature Study topics which gives a sequential coverage is for the teacher to select any one of the TEACHER'S GUIDES, begin with Topic 1, and follow through with succeeding topics until the class shows the onset of fatigue (usually 1 to 3 weeks). Then switch to a different TEACHER'S GUIDE and pursue that set of topics for a while.

c. A study topic can be found by latching onto a question raised by a student, if it is a question within the ability of the student to explore.

   For example, if a student says, "Miss Wong, why does my stink bug always sit in the same corner of my cage?", don't answer the question. Instead, say, "That's a good observation. How could you find out?". Then help the student, if necessary, to design an experiment on changing the light, humidity, location of food, temperature, presence of other stink bugs, in search of an explanation.

d. An investigation can grow from a class discussion. Listen for comments by students which take for granted something which should be based on evidence. Challenge the student to demonstrate the validity of the claim. For example, when Johnnie proclaims, "My hermit crabs are bigger than Lani's because I got mine from Makapuu.", ask, "John, are Makapuu hermit crabs really bigger than those from other beaches?" Then lead on to setting up ways to test this hypothesis.

e. A useful way to tie in Nature Study topics with other school subjects is to note what is being done at the time in social studies or arithmetic or some other class. Pick out a Nature Study topic which can be associated with it. For example when the history lesson focuses on the voyages of Columbus, take the topic in PARTS OF PLANTS which considers spices. The study of spider webs fits well into an art class. Nature Study can provide innumerable points of contact with the English class in story writing and reading. Even sports such as surfing, hiking, and fishing can have a Nature Study component.

Besides the problems posed in the Hawaii Nature Study TEACHER'S GUIDES, ideas for Nature Study investigations may be gleaned from other books, other programs, newspapers, conversation, or the teacher's personal background experience.

Planning the Investigation.

After a problem has been identified for study, plans must be made for pursuing its solution.

Elementary students cannot usually plan a valid experiment and carry it through from beginning to end without help. If they could, they would be graduate students instead of 2nd, 4th, or 6th graders. However the intelligence of elementary students should not be underestimated. It is amazing how much good thinking and organizing children can do when responsibilities are laid upon them gently bit by bit.

The Procedures in the TEACHER'S GUIDES suggest some ways by which each of the problems listed there may be handled. These ready-made plans are convenient to have at hand on days when originality is in short supply. But on many occasions students can share in planning their own experiments. Below are a few ways to nourish student decision-making and planning skills.

a. Experience in planning and leadership can be given to students by appointing a small group to take over the management of an investigation which will be carried out by the entire class. For example, suppose the topic to be considered is "How to Mount a Spider Web?". A select group of three or four students might be given the TEACHER'S GUIDE with the suggestion that they use the ideas there plus further ideas of their own. They need to be given a few days to practice the technique themselves and plan how they will present their demonstration to the class. They may even be capable of taking over the direction of the class when the class is carrying out the web mounting process.

b. One way to help a class to plan together is to list the problem on the board. Then list the main divisions of labor needed to achieve end results. Assign groups to work out the details of each listed task. The following is an example of how this might work.

Suppose the class has already learned a technique for distinguishing soil types. The problem now presented is, "What different kinds of soil can be found on our school campus?". The teacher writes the problem on the board and asks the class what actions would be needed to solve this problem. The class might respond, "Take soil samples", "Make tests", etc. The teacher lists these, as well as other tasks which the teacher knows are needed, on the board and assigns a small group to work out the plans for each task. The list might look like this:

- From where on the campus shall the soil samples be taken? (Planning Group 1)
- How many samples shall be taken from each site? (Planning Group 2)
- What kind and how much equipment will be needed to make tests? (Planning Group 3)
- How shall the class be divided into teams for doing the tests? (Planning Group 4)
- Set up a blank data table for receiving data. (Planning Group 5)
- Set up rules for cleaning hands and equipment after the tests are completed. (Planning Group 6)
- (List other planning groups as needed).

The groups are given a brief time to do the planning assigned to them. Each group reports its plan to the class. The whole class then works together to implement the plans. With practice, the teacher can gradually do less, while the students gradually take over more of the planning for each experiment.

c. Another way to provide for class planning is to divide the class into groups, giving each group either the same small investigation or completely different small problems. Each group has the task of planning its own experiment from beginning to end. The teacher can circulate among the groups during the planning to see how things are going, asking strategic questions here and there.

Students need to be taught, and then constantly helped to incorporate into their planning, the basic requirements for validity in testing, especially data logging, use of controls, need of replications, setting of standards. These items are discussed in the last section of this PROGRAM MANUAL.

Monitoring Student Investigations.

Students need special support and encouragement for those portions of their class and field work in which lapses of interest or discouragement are likely to occur. The following critical points are often in need of teacher influence and guidance.

a. Materials in long-term experiments.

Outdoor study sites of on-going experiments need frequent visiting. Caged classroom animals need daily student care and feeding. Plants need regular watering.

Students should see their teacher looking at their plants and into their cages every day. This daily show of personal interest accompanied by a question or comment from time to time helps students to persevere in their responsibilities, and keeps student interest alive and on course.

b. Data keeping in long-term experiments.

Student notebooks and records need to be kept up to date as work proceeds. The constant temptation is to wait until the investigation is complete and then try to recall what happened and on which day.

c. Plans and procedures in long-term experiments.

A check should be made from time to time as to whether the original experimental plans for controls, replications, and data logging are being carried out and whether they are in need of revamping.

d. Foundering experiments.

Foundering experiments should be brought to an early conclusion.

Investigations which seem to be lagging or not working should be talked about and either improved or terminated. Experiments which are allowed to drag on or gradually peter out to nothing leave students with a feeling of failure and a sense of distaste. An unsuccessful or failing experiment can be assessed for whatever learning value it has yielded to that point and then brought to a satisfactory close or shifted into something else.

e. Reports on individual and small group projects.

The activities of individuals and small groups need to be kept tied to class interests and vice versa. Small groups or individual workers should be asked to report periodically to the class on how their work is going, and at its conclusion make a full oral report. Periodic reporting helps to maintain a momentum of interest within the small group, and keeps the class consolidated by mutual interest bonds.

Reporting small group projects has other important educational values. It exercises the reporters in making themselves clear on a topic with which the rest of the class is not acquainted, and exercises the class in the techniques of listening and asking questions.

f. Reports on class projects.

Besides reports by small groups, investigations done by the class as a whole need to be reported orally and/or in writing. Directions for making notebook reports are in the last section of this PROGRAM MANUAL.

Maintaining a Class File.

An accumulation of reports from year to year can help succeeding classes, either as examples or as points of departure, for continuing the same or similar investigations at further depths.

Carefully reading what classes have done in previous years can give the students a flavor and practice of doing what research scientists do, namely, search the literature before moving ahead blindly to "reinvent the wheel."

Talking with Other Teachers.

Probably the most pleasant way to become a successful Nature Study teacher is to talk shop with other Nature Study teachers. Teachers, like other professionals, deepen and broaden their own ideas and acquire new zest for moving forward when they exchange ideas and experiences with one another.

During the first two test years of this project, area meetings of pilot teachers were held about every 6 weeks. A written questionaire at the end of the two years revealed that nearly all the teachers wanted area meetings to continue because of the stimulation they received from listening to one another.

Hawaii Nature Study teachers meetings, workshops, seminars, and summer courses are announced from time to time. These serve two purposes: (1) Teachers are able to exchange new ideas and inspirations with one another; (2) Teachers report new and good ideas to the project which can be incorporated into revisions of the TEACHER'S GUIDES at the next printing.

Testing and Evaluating Techniques.

The message of the Hawaii Nature Study Project to elementary students is that serious work in the environment can be enjoyable, that originality and creativity in planning and carrying out observations and investigations are valued, and that data and evidence hold the final authority in drawing conclusions. Whenever students are tested or evaluated on their Nature Study efforts, the testing instrument must convey this same message. It is futile to spend time and effort inspiring Nature Study ideals, if the testing program ignores the idealistic goals of the program, and recognizes and rewards only the memorization of "right" and "wrong" answers to factual items.

If the Hawaii Nature Study Program is to succeed, its tests and evaluations must convey to students that education includes productive attitudes, values, responsibilities, and enjoyment, as well as skills and conceptual knowledge. Below is a partial list of some types of "tests" which teachers might add into the more formal evaluation events to help stress attitudinal and values goals.

EVALUATING ATTITUDES

1. Make a long mixed list of verbs and nouns such as TREES, SINGING, COCKROACHES, SCIENCE, SPIDERS, BASEBALL, etc. Ask the students to put a ☺ or a ☹ next to each word depending upon how they feel about that word.

2. Do students talk about or work on their nature study activities beyond the class assignment period? How much or how long?

3. If you have a self-contained classroom, ask parents what school subjects their children talk about at home with the greatest pleasure or the greatest dread. (Do not indicate which subjects or kinds of answers you are looking for.)

4. Listen to the students' free conversation for expressions of appreciation, liking, happy attitudes, fears, disinterest, of the topics they have studied.

5. Express dislike for a certain topic or activity or organism and see if the children will agree or disagree with you. If so, for what reasons?

6. Ask students to tell their "before" and "after" attitudes, e.g. after finishing the spider activities, ask how they felt about spiders before and how they feel now.

EVALUATING SKILLS

7. Make up a practical problem which draws on skills students have learned but applied to a different problem. For example: If they have taken care of cockroaches and taken data on their habits, ask them to explain how they would go about investigating Insect X which is two inches long with unknown food preferences. Another example: if they have been studying leaves by measuring them, ask them how they would go about studying the sizes of roots.

EVALUATING CONCEPTS

8. Give a written test (multiple choice, true and false, fill-in, any kind) on one or more topics the students have dealt with. Help the students to correct their own papers. Have them keep a record of

which points they know and do not know. Do not grade the papers. If the papers are collected, compile data from them showing which points were most often got right and which were most often missed. Publish the list on the bulletin board to be used as a guide for further class activity and review. With fear of grades and personal failure removed, students frequently take a keen interest in reducing their list of class errors and missed information. Ignorance becomes a challenge to be overcome rather than a stigma.

SKILLS AND CONCEPTS

9. Make a list of concepts and skills the students have had an opportunity to learn. Ask them to mark down whether they feel they have learned the material well, poorly, not at all. Make sure they realize that their replies are not to be graded. You might announce that the purpose of the test is that you are checking your own teaching and want to know which points you failed to teach very well.

10. Examine student Nature Study notebooks and reports. It is better not to give a grade or mark but rather make favorable or helpful remarks here and there in the notebook.

Longitudinal Record.

The Hawaii Nature Study Program offers a wide range of topics and activities, adaptable to classes from Kindergarten through Grade 6. With some exceptions, there is no designated sequence of topics nor necessity for a given topic to be taught at one grade level rather than another.

This flexibility allows teachers to select whichever topics from the entire project they wish to teach. It permits choice of activities which seem to correlate best with other subjects in the curriculum of the given grade. Teachers with particular talents or interests can give accent to the areas of their personal strengths.

However, such wide open choices in every grade can leave any teacher above Grade 1 at a disadvantage in not knowing what previous knowledge and experience a class has had. The Longitudinal Record is a device which assists teacher to know which topics a class has been exposed to, which ones might be further built upon, and which have never been taught.

It is recommended that Longitudinal Records, one for each class, be kept in the school file. Teachers can find them there each September, up-date them during the teaching year, and re-file them in June. A complete record for a class beginning Nature Study in Grade 1 would consist of six pages by the end of Grade 6.

A sample record page is shown below. The blank record form on the next page can be reproduced and used for record keeping.

LONGITUDINAL RECORD

The Hawaii Nature Study Project Class of 1978

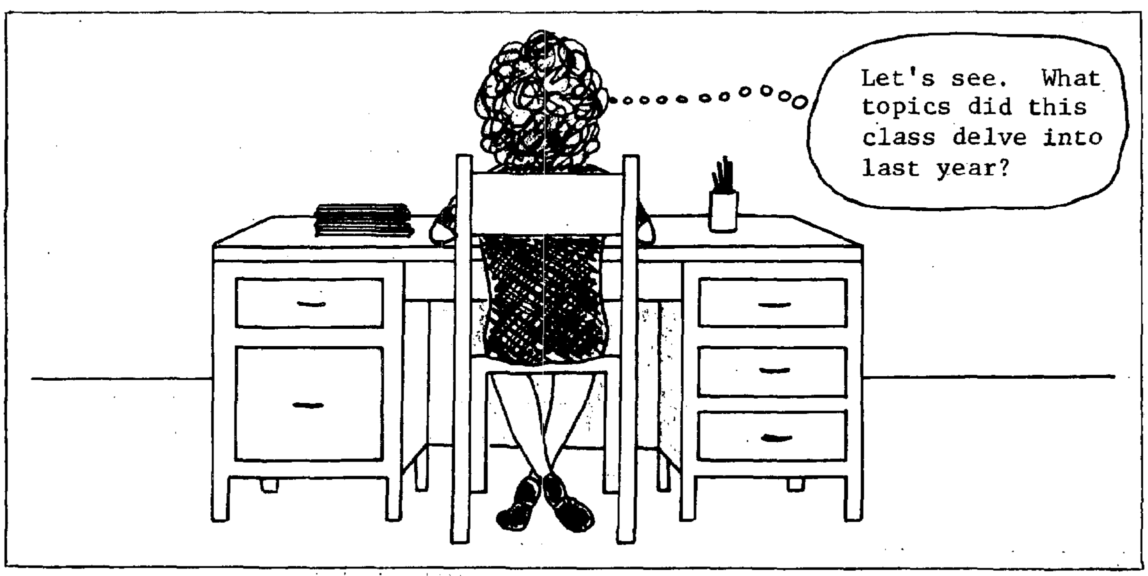
Year 75-76 Grade 4 Science Teacher Mary Jones

Number of new students added to class this year 5

Total enrollment this year 32

Topics repeated from previous years	Band Level reached this year	Comments
Parts of Plants 2-B, C, D; *Stems; Animals-Spiders 6*	*Band 2* *Band 2*	*good vocabulary coverage; good data; weak reports*

Topics taught new this year	Band Level reached this year	Comments
Names of Campus Trees & Shrubs.	*Band 2*	*They know about half of them.*
Fun in the Rain.	*Band 1*	*Many absences; not well done.*
Field trip to Foster Gardens.	*Guided tour*	*Excellent learning situation.*
Monarch Butterflies #4.	---	*Larvae died. Did not try over.*
Part of Plants - Roots.	*Band 2*	*Well done. Good records & reports for Band 2.*



LONGITUDINAL RECORD

The Hawaii Nature Study Project Class of 19___

Year__________Grade_____________Science Teacher________________________________

Number of new students added to class this year___Total enrollment this year___

Topics repeated from previous years	Band Level reached this year	Comments

Topics taught new this year	Band Level reached this year	Comments

III. THE HAWAII NATURE STUDY STUDENT MATERIALS

The Hawaii Nature Study Project provides no bound student text book. The students' first line of access to information is his own direct observation and investigation done on the school campus and in the environment of Hawaii. The student may glean additional information from formal and informal discussion with teachers, with classmates and team-mates, from the library and encyclopedias, from parents and neighbors. In other words, the "wide world" is the Hawaii Nature Study student text book. The tangible medium which holds the course together for the student is his own notebook.

The text book of the Hawaii Nature Study student is the environment of Hawaii

which he captures in his mind, in his heart, and in his notebook.

The Student Notebook.

The compendium of notes on Nature Study activities and investigations is a student's sole reference for what he has studied and accomplished. Notebook keeping is a useful art for a young student to learn. It is not an easy skill. It requires care and perseverence, but it pays a high dividend in personal satisfaction and future competence.

The format in which the student casts his notebook is up to the student. Some students use hard-cover binders; others make artistically decorated covers.

Student notebooks may include notes on random observations, sketches, poems, stories, memos of book titles, or questions for future reference as well as formal scientific reports.

Some students keep a running chronology of everything that happens. Other students compartmentalize their notes, putting formal reports in one section, artistic pieces in another, references in still another, and so on.

Some activities are concerned chiefly with observations and descriptions and may be reported informally. For example, the Spider Hunt is merely a gathering of information about which spiders live in the neighborhood. Watching how sand crabs run on the beach can be reported simply as an observation of what was seen. Most of the simple observational activities of the younger children do not generate material for a full blown scientific report. These informal notes are often enhanced by pictures, drawings, comments, and stories.

Formal reports of science investigations involving procedures, data, analyses, and conclusions are bound by standard rules and format. Scientists have criteria for keeping data and making scientific reports. These are described below.

Formal Nature Study Reports.

Report making is an important skill which can be learned, at least in a beginning style, by any Nature Study student old enough to talk or to write. The merit of report making rests on the following assumptions:

1. The work of having to organize observations, investigations, data, and conclusions in a speech or in writing helps to order and clarify the thinking.

2. The struggle for accuracy, clarity, logic, and objectivity elevates the activity from being a superficial scan to being a careful and serious study.

3. Communication skills are needed in every phase of human living. Good communication needs to be practiced in every school subject.

4. Scientific reporting has a communication format special to the sciences. The science format is not likely to be learned if practice in speaking and writing is left entirely to the language courses.

The order in which science experiments are reported is essentially the same for both oral and written reports. A formal science report usually has these six parts:

1. A title -- what is this experiment about?
2. A statement of purpose -- what was I trying to find out?
3. Materials -- what did I use? how was the equipment built?
4. Procedure -- what did I do, step by step?
5. Data -- what information did I gather?
6. Conclusion -- what did I find out?

A teacher may find it useful to make a chart of these six items for the bulletin board and refer to it from time to time when students are engaged in making formal reports, either oral or written. Another idea is to have the students write these six items on the inside covers of their notebooks.

Oral Reports.

In addition to the merits listed above for reporting skills, the oral report can be an effective tool for acquainting an entire class with an activity or piece of an investigation done by only one or a few students. The oral report gives recognition to the labors of the small group and at the same time spreads whatever was learned to the class as a whole. Oral reports can promote skills in good listening as well as in good reporting.

The following instructions on how to present an oral report are a simplification of the instructions for oral reporting given in Foundational Approaches in Science Teaching (FAST 1 - Grade 7) teachers' guide. These can be further simplified to meet the needs of very young classes. Note that these formal steps need not apply to an informal "show and tell".

Instructions for a Formal Oral Science Report:

1. Speak loudly and clearly. Look at all the faces in the group.
2. State the problem. Write it on the board.
3. Tell how you investigated the problem.
4. Show a picture or a sample of the plant or animal or item. Show the equipment used and the method of using it.
5. Show the tables and graphs of your data. Put them on large charts or on the overhead projector so everyone can see.
6. Explain the meaning of the data.
7. Tell your conclusion.
8. Ask your classmates for comments and for their ideas.
9. Lead a class discussion about your experiment. Give everyone a fair chance to speak. Encourage the class to ask questions like the following:
    a. Was this a good way to do this investigation? Is there another way?
    b. Were enough tests made?
    c. Were there sufficient controls?
    d. How does the data support the conclusion?
    e. Does the conclusion claim more than the data allow?
    f. Does the conclusion answer the problem statement?

With practice, Point #9 above can generate lively class discussion. At first, the listening students have little to say. Most of the questions come from the teacher. Soon the students pick up the questioning routine and even build a spirit of examining oral reports quite critically for validity.

The FAST leaflet, FACILITATING GROUP INVOLVEMENT AND DISCUSSION, referred to earlier in this Manual, gives excellent strategies for handling such classroom discussions.

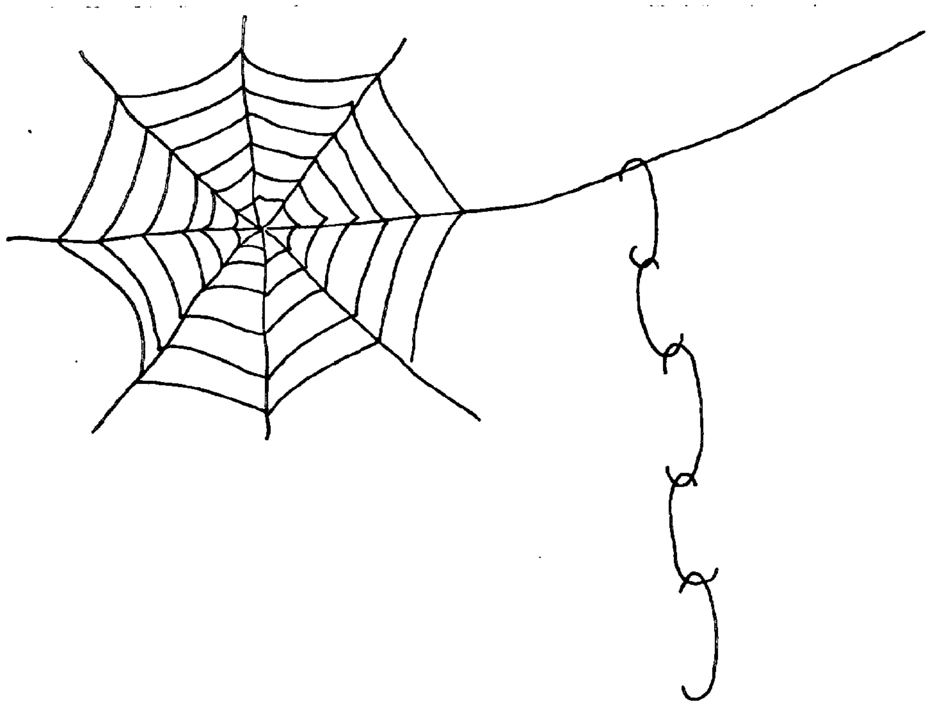
Written Reports.

Formal written science reports follow the general format indicated at the beginning of this section, namely: title, purpose, materials, procedures, data, conclusion. For elementary students, these six steps seem sufficient.

Following is a copy of a sixth grade formal report made in one of the Nature Study trial classes on the strength of a spider web. The report is reproduced here exactly as it appeared in the child's notebook without changing the English, spelling, or arrangement.

Tuesday, 12-17-74

Title	How strong is a web?
Purpose	I want to see how strong a garden spider web is.
Equipment	A web and paper clips.
Procedure	1. Find a web. 2. Put as many paper clips on as you can until the web breaks.
Data	The web stayed up even with more than ten paper clips hanging on.
Conclusion	The garden spider web is very strong.



If you were the teacher who reviewed the above student notebook, how would you remark on it? Much would depend, of course, on your personal knowledge of the child's ability, past performance, and resiliency in taking correction.

Among the good points might be noted:

-The title is well chosen.

-The English expression is accurate and clear and there is not one spelling mistake.

-The equipment is clearly stated.

-The report includes procedures, data, and gives a conclusion.

-The conclusion is consistent with the problem and the data.

Among suggestions which might be made for improvement:

-Although the diagram shows that it was a drag line which was tested and that the paper clips were hung in a chain, this is not explained verbally in the procedures.

-The data is not arranged in a table.

-The experiment was not carried to completion. Completion would be reached by hanging on more and more paper clips until the web finally broke.

-If the web were finally caused to break by the weight of paper clips, the conclusion could be made more specific, such as "A Spider web was able to support up to ___ paper clips before breaking."

-In a real web the spiral lines are not angled as shown in the student diagram nor are then evenly spaced, especially near the hub.

-Stronger evidence for the strength of spider webs would be obtained if many webs were tested and reported rather than only one.

Students (including college students) do not write perfect and complete reports the first time. Actually, the above report by a 6th grader about spider webs is very good. Only after much practice do reports become fuller and more precise.

Following is another example of formal report writing. Column 1 gives a possible style of instructing older elementary students. This example applies to Measuring Tree Trunks, which is the first activity in PARTS OF PLANTS. Adaptation of this example can be made to fit any other activity.

Sample of Teacher Instructions:

Sample (for teacher reference) of a student notebook report made in response to the instructions in Column 1:

Each activity has a title and a time when it was done. What is the name of your activity?

Oct. 15, 1973

MEASURING TREE TRUNKS

What is the "job" or "problem" of this activity. What did you try to do or find out? What was your goal?

PROBLEM

The object of this activity was to find the sizes (distances around) all the trees in front of the Administration Bldg. of Oahu Elementary School.

What were your procedures? Tell in clear, short sentences how you carried out your investigation.

PROCECURES

Larry D., Betty R. and I measured the four trees near the driveway entrance. We measured at chest height. We used the old Hawaiian measures of ANANA, MUKU, AND IWILEI. Betty took notes on all the things we noticed about the trunks.

Scientific data are always recorded in a data table. See PROGRAM MANUAL under the heading DATA, DATA TABLES, GRAPHS.

DATA

Table 1. Distance around 4 trees near the entrance of Oahu Elem. School.

Number of tree	*Size*	*Observation*
1	*1 Iwilei*	*rough blackish bark; big long cracks in bark.*
2	*1½ Iwilei*	*same as #1. Ant nest in one big crack.*
3	*1 Anana*	*smooth gray surface, no insects.*
4	*less than 1 Iwilei*	*like #1 & #2. Bark loose on one side. Lizard eggs under loose bark. Two spiders in cracks.*

The Discussion tells what you think about the data or what you wish to point out in the tables.

> DISCUSSION
>
> *Three of the trees (1, 2, and 4) were more alike. One was larger and different. Only the smaller, rough-barked trees had insects or animals.*

Now tell your Conclusions BASED ON THE DATA.

A statement of further suggested work can be made, if desired.

A common problem for young students is drawing conclusions not supported by the data. The conclusion should ferret out all the information the data will yield, but it cannot claim more than the data supports.

> CONCLUSION
>
> *It seems to us that three trees were of the same kind and were about the same size. We do not know if this is because they are the same age or if this is the size this kind of tree grows to. The one large, smooth tree seems to be a different kind of tree.*
>
> *The insects seem to prefer the dark, rough trees with cracks.*
>
> *To find out more about our experiment we could ask the Principal when the trees were planted. We could look for more trees of the same kind and see how they compare with our three rough trees and our one smooth tree.*
>
> *We also need a better measuring system. Betty's arms are shorter than Larry's and it threw our measurements off.*

Evaluation of Reports.

Science reports are not tests and preferably are not graded.

In science it is not acceptable to do a sloppy job. Anything less than the best is not good enough and is not acceptable in the science notebook. A report which does not meet acceptance level (according to criteria for that age of student) does not get a low mark. Instead it gets done over. . .and over. . .and over. . .until it reaches acceptance (within the limits that the student can be pushed without undue hardship). There is no other way, and there is no easy way to learn to write clearly and concisely.

In formal investigations and report making, the parts which require special teaching attention are the handling of the data and the standards for validity. These are discussed next as special topics.

Data and Data Tables.

Data logging and the expression of data in graphs need to be understood and practiced by students whenever they engage in a formal science investigation.

These notes are for a teacher to translate into the language of a given grade level and ability of the students being taught. The time to explain data keeping techniques is when the students are doing an experiment which requires use of this skill.

Data are factual items. Often they are numbers.

The singular is datum. The plural is data.

In pronunciation, some people sound the a in data like the a in date or mate or fate and so that say DATA.

Some people pronounce the a as in mat or pat or cat and so they say DATA.

Still others use the a as in what or water so they say DATA. Be consistent with whichever pronunciation you choose to adopt.

When data or factual items are put together meaningfully, they convey information.

A data table is an orderly arrangement of factual items in rows and columns which facilitates analysis and comparison and speeds up communication. Scientists, especially science publishers, are very "fussy" about the format in which data tables appear in print.

Teaching the standard format for logging data in rows and columns is best done using data which the students are dealing with at the moment. The lesson may have to be repeated when the students arrive at the data collecting stage of their next experiment. Even high school and college students are often still in need of periodic reminders about table number, titles, and the indication of the unit of measurement in the column headings.

On the following page is a sample data table. This example presupposes an experiment in which caterpillars were fed on crown flower leaves which had been cut into 1-cm squares. Cutting the leaves into squares made it possible to estimate how much leaf surface each caterpillar ate each day.

Table 1. Amount of Crown Flower Leaves eaten by Five Monarch Caterpillars during five days

Date	Caterpillar#1 1-cm leaf pieces	Caterpillar#2 1-cm leaf pieces	Caterpillar#3 1-cm leaf pieces	Caterpillar#4 1-cm leaf pieces	Caterpillar#5 1-cm leaf pieces
3/12	1	1-1/4	1-1/2	1/4	1-3/4
3/13	1-1/3	1-1/2	1-1/2	1/10	2
3/14	1-1/2	1-3/4	2	none	1-1/2
3/15	1-1/2	2	2-1/4	none	1-1/2
3/16	2	2-1/2	2-3/4	dead	2-1/2

Notice the following:

- The data table has a number. The first data table for a given topic is Table 1. The next is Table 2, and so on. When starting a new set of experiments in a different problem, start with Table 1 again.

- The data table has a title. The title tells what the data show or what the table is about. The title is not a bare name. It would not be good to call this data table "Monarch Caterpillars" because that would not tell what we were doing with the caterpillars.

- The data are arranged in columns. Each column has a heading. The heading tells what kind of information is in that column. The heading also tells what units of measurement are being used. In this case, the units are 1-centimeter squares.

- "Bad" data, as well as "good" data are recorded. Caterpillar #4 died but still its data are kept in the table.

Making data tables takes considerable thought, skill, and practice. It is not as easy as it looks. Students may need help for quite a while with charting their data in tables before they are able to design a table by themselves.

Data should be recorded in notebooks, not on the backs of old envelopes or on loose bits of scrap paper.

Great difficulty in making a plan of how to get all the data in one table could be a sign that more than one variable is being considered. The experiment may need to be broken down into smaller chunks. This will simplify what goes in each table.

Graphs.

Graphs are of many kinds, those most usually seen being bar graphs, circular "pie" graphs, and line graphs. Only bar graphs will be considered in detail here.

Scientists generally use line graphs but these are often too difficult for elementary students. For teaching line graphs in a simple way, see FAST 1 (7th grade) Teacher's Guide.

"Pie" graphs are circles showing sections like pieces of pie. Pie graphs are convenient for showing percentage parts of a whole. Little percentage work is involved in elementary science.

Bar graphs are the simplest to use and the most serviceable for elementary work. The best occasion on which to teach graphing is during an experiment in which the graphing of the given data is needed in order to clarify the work at hand.

The following two examples demonstrate bar graphing techniques, using the data on caterpillars from the previous example.

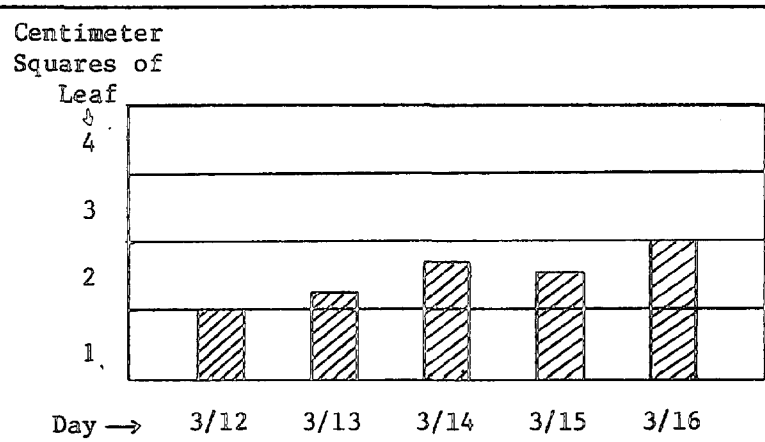


Figure 1. Amount of Crown Flower Leaves eaten by Caterpillar #1 during Five Days

Notice that:

-The bars give a visual representation of the data which makes the information quick and easy to read.

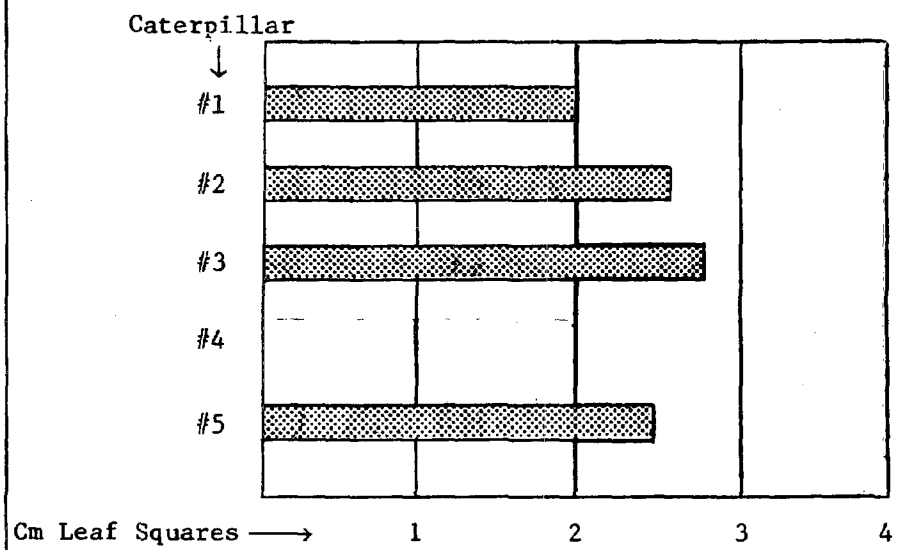
-Graphs (also all other illustrations, sketches, pictures, diagrams) are called FIGURES and are numbered in sequence beginning with #1.

-The Title is descriptive. Titles are sometimes placed under the graph instead of at the top.

-What each column and line stands for is shown along the bottom and left side of the graph.

-In this case the bars are vertical. Graphs may also be made with horizontal bars, as is shown in the next example.

Figure 2. Amount of Crown Flower Leaves eaten by Five Caterpillars on One Day (3/16)



Challenges for young students:

1. Make a bar graph showing how much Caterpillar #5 ate during the five days.

2. Make a bar graph showing how much all five caterpillars ate on the first day of the experiment.

3. How much leaf did each caterpillar eat altogether (total food intake) during the 5 days?

4. Make a bar graph showing the total amount of leaf squares eaten by all the caterpillars.

There is no single correct answer to these challenges. Any set of bars which illustrates the information correctly is correct.

Trade magazines and news magazines frequently use graphs to illustrate their articles. These might be glanced through for further discussion of different ways to arrange graphs and to label columns and bars.

Variables.

A teacher who knows and understands his or her students is the person best equipped to decide how much of this particular topic to teach, and how much demand to make on the class. Certainly younger students can be given only a simplified version. Older elementary children can sometimes do quite well with the logic of testing one variable at a time.

The preferred way to teach the material in this topic is to distribute it within the lessons taught throughout the year rather than explain it in one lecture session. Multiple variables can best be dealt with when the students arrive at an experiment involving multiple variables.

The notes given here are a reference for teachers. Besides the basic definitions, examples are given which can be used as desired or insofar as they are helpful in getting the point across.

WHAT DOES THE WORD "VARIABLE" MEAN? (Something that can change.)

Examples:
- -temperature and humidity from place to place, from time to time
- -growth, increase in heights of students, weight increases
- -speed, movement

DO VARIABLES CHANGE EVENLY? (Sometimes yes; sometimes no.)

Examples:
- -growth, temperature changes, and motions, often change unevenly
- -movement of hands around the face of a clock is an even rate of change

CAN TWO OR MORE VARIABLES GO ON AT THE SAME TIME? (Yes)

Example: -Tony is reading a book. While he is reading he is learning something (we hope) so his knowledge is changing. At the same time his eyes are getting tired and sleepy. At the same time he is getting hungry. At the same time it is beginning to rain outside.

ARE ALL VARIABLES THAT GO ON AT THE SAME TIME RELATED TO ONE ANOTHER?
(Maybe, or maybe not.)

Example: In Tony's case, perhaps the reading and the tiredness are connected. The learning in Tony's head and the rain outside are probably not connected. Are the studying and the growing hunger connected? We cannot be sure on that one.

WHEN VARIABLES HAVE NO INFLUENCE ON ONE ANOTHER, WE CALL THEM <u>INDEPENDENT</u> VARIABLES.

Example: It is raining outside and the toast in the toaster is getting brown. These two changes are not dependent on each other. In dealing with living systems, we need to be cautious about considering variables as independent. Sometimes seemingly remote conditions have an influence on living things which we do not happen to know about.

WHEN VARIABLES INFLUENCE ONE ANOTHER SO THAT ONE REGULATES THE OTHER, OR ONE DEPENDS ON THE OTHER, WE CALL THEM <u>DEPENDENT</u> VARIABLES.

Example: Susie eats a pound of chocolate every day. Every week she weighs two pounds more. When she eats less chocolate, she gains less weight. The change in her weight varies in proportion to the amount of chocolate she eats. Gain in weight for Susie is a dependent variable on the amount of chocolate eaten.

WHEN WE HAVE TWO OR MORE DEPENDENT VARIABLES, WE TEST FOR ONLY ONE VARIABLE AT A TIME.

Example: You have 10 cages of crickets to test for both food and water needs.

For validity, it will be necessary to test separately for food and for water. All ten cricket cages can be given the same food while the amounts of water are varied. Then in the next experiment, all the crickets may have ample water while different foods are tested.

Negative Example: Suppose you test for food and water needs of the 10 cages of crickets as follows: Crickets in the first 9 cages get all the water they want. No water is given to crickets in cage 10. <u>At the same time</u>, different food is put into each of the ten cages. At the end of one week, most of the cage 10 crickets are dead. Only a few crickets in cages 1 to 9 are dead. You cannot be sure it was the lack of water in cage 10 which killed the crickets. Since a different food was put in each cage, it is possible that the food in cage 10 was the cause of death.

WHEN TESTING FOR ONE VARIABLE, ALL THE OTHER ENVIRONMENTAL CONDITIONS MUST BE KEPT AT THE "BEST" LEVEL FOR THE ANIMAL OR PLANT BEING TESTED.

Example: If you wish to test beetles for effects of crowding, you need to set up many cages of beetles such that in every cage the beetles have the best possible living conditions, best food, best amounts of water. Only the number of crickets differs in each cage.

Negative Example: Suppose the sixth graders decided to test one of their members for which kind of candy he liked best. They lock him in an empty room with many different kinds of candy, but with no food, no water, no light, no bed or chair, and no radio. After 24 hours they open the door and ask which candy he liked best? Are they likely to get a correct answer? If not, why not?

When setting up tests involving living things, it helps to make a chart of all the factors which life requires. Then check the experiment against the chart to see if conditions in every cage are at an optimum level except for the one variable being tested.

As an example, using the crowding of crickets cited above, a check chart for the cages might look something like this:

Cage No.	Cage Type and Size	Location	Water	Food	Light	Temperature	No. of Crickets in Cage
1	10" square screen	lanai	wet sponge	dog biscuit	well shaded	ambient	1
2	"	"	"	"	"	"	5
3	"	"	"	"	"	"	25
4	"	"	"	"	"	"	50
5	"	"	"	"	"	"	75
6	"	"	"	"	"	"	100
7	"	"	"	"	"	"	150

Controls.

This topic is best discussed the first time the need for a control occurs in a class experiment.

In science experiments, a control is the normal situation against which to compare test cases. A control is the model or standard for comparison.

The class might find other definitions for the word "control" in the dictionary, or in their common usage of the word.

In all scientific tests involving dependent variables, a CONTROL is always set up to serve as a check and a comparison.

Example: Suppose you want to test how well cockroaches grow if they have only certain limited foods to eat. You set up many cages in which all the living conditions, water, space, etc. are at the best levels for cockroach needs. At least one cage is supplied with all the foods which cockroaches like or need. This is the CONTROL cage. In all the other cages, only foods to be tested are supplied. These are the test cages.

The advantage of using controls is that if some circumstance, other than the test condition, is influencing the experiment, this circumstance will also influence the control. If the unfavorable circumstance shows up in the test cases and there is no "control", you might think the results were due to the test instead of realizing that some other influence was at work.

Replication.

Replication means repetition, or duplication, or "lots of the same." Replication is a favorite word among scientists when they are talking about a duplication of experiments.

In an experiment, many duplicate cages or tests of the same thing need to be made. This helps to average out varying influences. The more replications, the better the chance of getting dependable results.

Examples: When drug companies test a new medicine, they make thousands of replications under many conditions before they advertise that their product is safe and effective.

In measuring or weighing things, we often make the same measurement three times (3 replications) and take the average as the true measure. Some people make the same measurement 10 times and take the average of the 10.

When a farmer wants to know if his 200 bushels of seed is good seed, he may take out one handful of seeds to plant first. If

50% of the handful grow he will consider that all the seeds are good enough and will then plant the 200 bushels. He doesn't bother to make replications of his test because for his purposes, that one test gave him sufficient information.

This completes the first edition of the PROGRAM MANUAL. As Nature Study Teachers continue to meet and give feedback on project activities, their helpful comments and suggestions will be added into this Manual and passed on to their colleagues in future editions.