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GUIDELINES FOR THE DEVELOPMENT OF ELEMENTARY SCIENCE CURRICULUM K-6.

BY- HOLMAN, JAN L.

KANSAS STATE DEPT. OF PUBLIC INSTR., TOPEKA

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GUIDELINES FOR USE BY TEACHERS AND ADMINISTRATORS IN THE DEVELOPMENT OF A K-6 SCIENCE PROGRAM ARE PRESENTED. SECTIONS OF THE MANUAL INCLUDE INFORMATION RELATED TO--(1) RECENT CHANGES IN THE PHILOSOPHY AND TECHNIQUES OF SCIENCE TEACHING, (2) THE NATURE AND NEEDS OF THE LEARNER, (3) EDUCATIONAL OBJECTIVES, (4) THE INTEGRATION OF EXISTING SUBJECT AREAS OF SCIENCE WITH MATHEMATICS AND OTHER SUBJECTS IN THE CURRICULUM, AND (5) FACTORS THAT INFLUENCE SCIENCE TEACHING. RECOMMENDATIONS CONCERNING LABORATORY SAFETY, EQUIPMENT AND FACILITIES, AND AUDIOVISUAL AIDS ARE INCLUDED. (AG)

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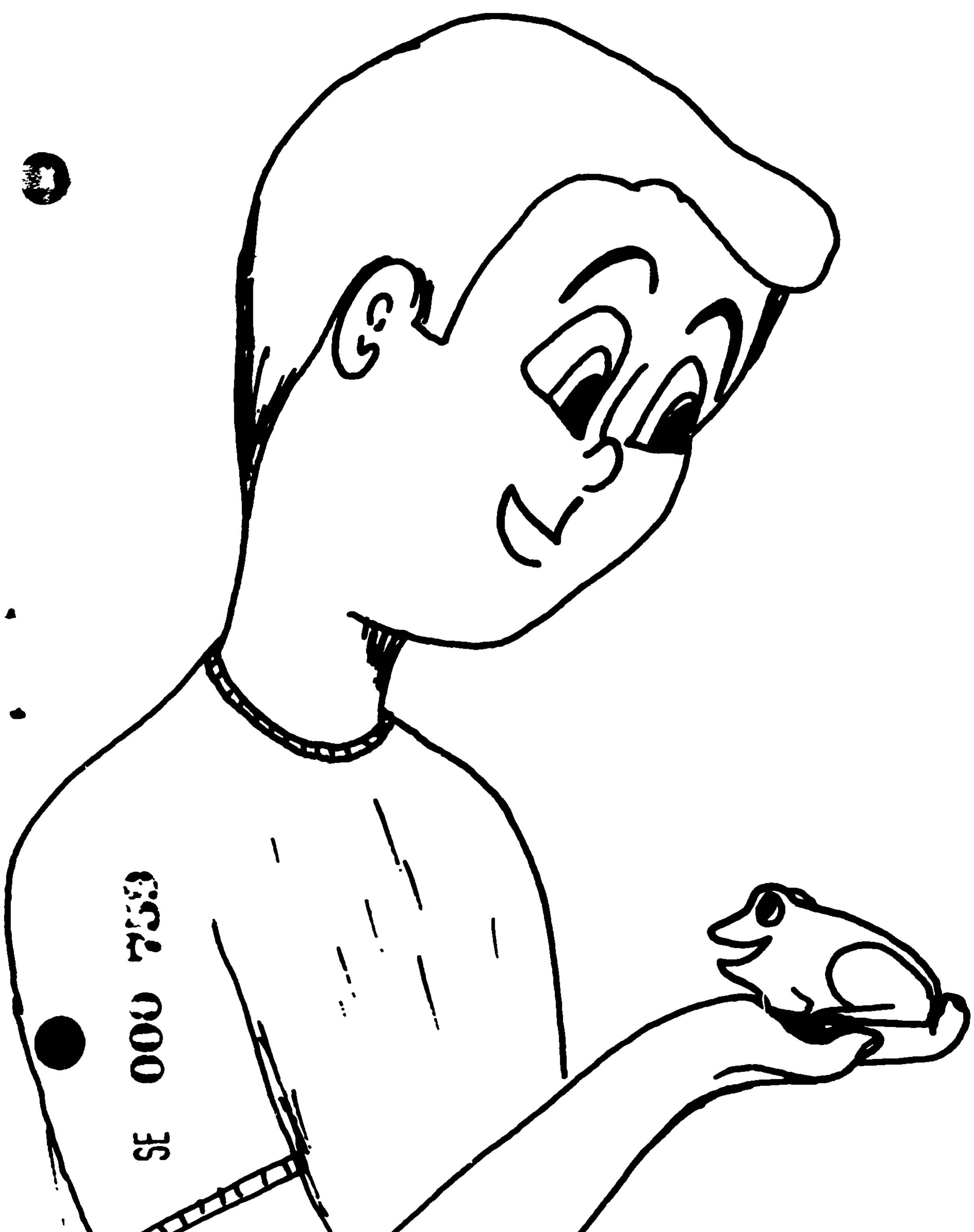

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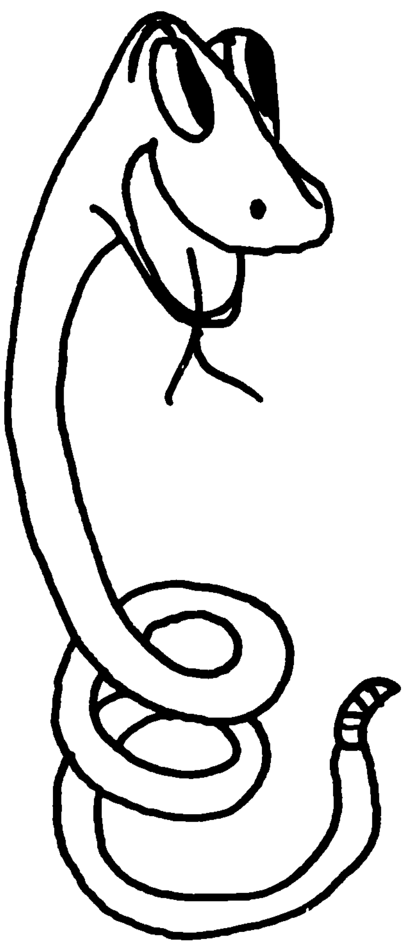

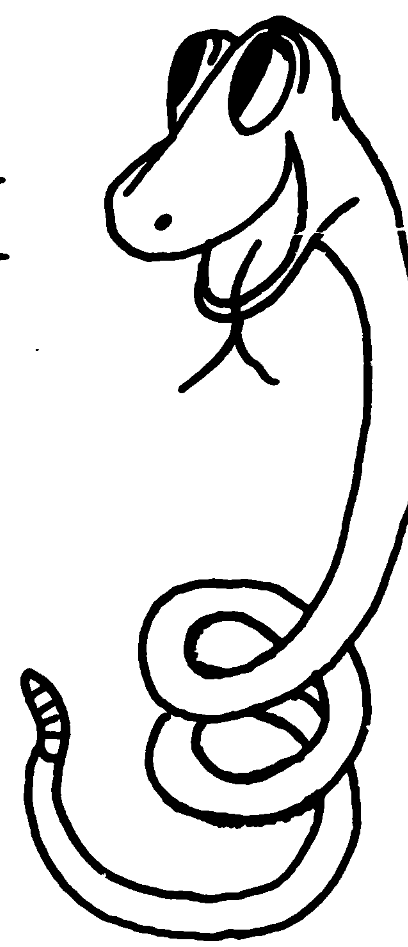

K-6

1966

Division of Instructional Services
George L. Cleland, Director

Curriculum Section
C. C. Rice, Director

prepared by
Jan L. Helman, Consultant in Science

FOREWORD

Knowledge in science doubles every ten years. Since the elementary grades set the foundation for future scientific achievements, the teaching of science must be constantly improving to meet this ever present challenge.

This publication is designed to aid the teacher in formulating fundamental science concepts and improving the science program in the classroom. Few teachers will be able to incorporate all suggestions found herein but everyone should use some of the principles, ideas, methods, and philosophies. This will take a genuine effort by the teachers and the pupils.

H. C. Kampschroeder

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Guidelines for the Development of
Elementary SCIENCE Curriculum

This guide is designed to aid curriculum workers, teachers and administrators. It sets forth ideas in science teaching, promising practices in science teaching, some philosophies of science and the pitfalls in present day curricula. It is not designed to be a fixed, inflexible approach to the teaching of elementary science. It attempts to provide a definition of the structure and nature of science. It describes the processes of scientific inquiry. And finally, it will provide in broad terms an organizational plan for the science curriculum.

AN APPROACH TO SCIENCE TEACHING

There is a two-fold responsibility in teaching science. The teacher must meet the needs of the child by employing the best known learning methods and impart knowledge of the nature of science.

The guide published in 1958 by the State Department of Public Instruction is in many respects very well written and contains many significant points. It fails, however, to express the new revolution in science teaching, which is of primary importance in the techniques used to approach the study of science. These techniques are exploration, investigation, and discovery. Science programs in the past have for the most part been a memorization of facts, significant data, and theories. Some attention has been given to the laboratory and the field, but these areas have been greatly under-emphasized. The approach has been toward knowing important natural phenomena. The focus has now changed. It has shifted from the knowledge itself to how knowledge is acquired.

Science is not so much a bushel of facts as it is a process of solving a problem concerning a natural phenomenon. It is a process of rational inquiry used in search of understanding nature. This understanding is not confined to knowledge of biology, aerospace, geology, physics, chemistry and geography but rather encompasses all learning in all disciplines since it is merely a method to obtain more complete understanding of the individual and the worl in which he lives.

When a child is asked his impression of a scientist, he might think of a hermit in some deep, dark laboratory, or a sophisticated looking man in a white coat working a maze of glassware, but rarely, if ever, will he say that he, the child, is a scientist. In actuality, he is the best picture of the true scientist known. He asks "Why?" incessantly. Ideally, a scientist concerns himself with answering this question. Too often the child becomes the listener and the teacher becomes the asker. Or what is worse, the teacher may give direct answers to any question the child might ask. This may squelch the child's initiative and sense of inquiry. He will lean more and more on the teacher as a walking encyclopedia. No person is an encyclopedia nor should anyone act as if he were. Giving answers would be more likely to feed the vanity of the teacher than to teach the child. Students would probably conclude that the storage of facts is characteristic of a well-educated person. The sign of a good teacher is not what he can teach the children but whan he can get children to teach him. This again should not be done by asking the children to tell him, but by stimulating the children in various ways to volunteer something.

Certainly it is necessary to set up guidelines for the child to follow. It would be sheer idiocy to expect any individual to acquire, without guidance, all of the knowledge man has accumulated throughout history. The child has neither the background nor the lifetime to do this sort of thing. Scientists are usually trusting. They accept most of the information scientists set down for them as being truth as long as there is no reason to reject it. Such acceptance is necessary to progress. This is not meant to imply that scientists do not question, but reliability is one of the basic demands of scientists. Discoveries are almost always based on existing knowledge since the amount of time necessary to prove all of this fundamental knowledge would be well beyond the time available.

For this reason there are some fundamental procedures that should be followed in attempting to solve any problem. These are flexible and, if possible, should be derived by the children in the classroom activities rather than outlined in steps by the teacher. If these procedures, or procedures which can accomplish the same end, are followed, they will lead the child from the solving of a simple problem to the development of concepts which will help him to understand the world around him.

In later paragraphs there is a list of procedures which might be followed in problem solving. Children in the early elementary grades may not be able to utilize all of the procedures listed, but it is the responsibility of the intermediate grades to extend the use of the procedures to achieve a greater understanding of the natural phenomena touched upon in the early years. Knowledge is the sum total of the students' experiences, and experiences never fail to increase. Therefore, understanding the concepts of nature should become more and more sophisticated. Broad, straight-trunked generalizations may become many branched with exceptions and supplementary concepts.

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THE CHILD

In order to teach science or any other subject well, it is preferable to understand as fully as possible the nature of the children being taught. The nature of children has always been a baffling area of knowledge. Even though everyone was once a child, when the age of pre-adolescence is concluded it is very difficult to remember back to one's successful learning habits. Generally accepted, however, are several attributes which are exhibited externally and easily observable. Basically, the child is an explorer. He is a problem solver. He is one who searches for self and world. He is a social being. He is active. He has a keen sense of responsibility. A good science program will be directed toward all of these qualities.

Based on these characteristics of the child the following needs have been established as directionary goals for the teacher to meet. The child in the primary grades needs

Activity
Exercise (doing things to exercise large muscles)
Opportunity to do things for himself
Freedom to develop powers
Praise, patience, encouragement
Direct participation
Flexible standards
Logical thinking for only short periods of time
Practice developing small muscle skills (hand-eye coordination)
Contact with real animals and plants (not just pictures)
Collection and display of work
Informal classroom atmosphere with some direction.

The child in the intermediate grades needs

Definite responsibility
Individuality
Initiative at science study and planning
Much discussion
Little or no pressure
Opportunity to make decisions
Affection
A sense of humor in adults

Recognition
Manipulation of instruments (thermometers, barometers, etc.)
Experiments for observation over long periods
Quantities of resource materials
Self evaluation
Understanding of the significance of a wrong answer (It is important if one can profit by it.)
Informal classroom atmosphere.

The needs of the child may be fulfilled in many ways. It is imperative that the approach should vary. Nothing will wither the sense of inquiry more surely than too much repetition and resultant boredom. Some of the better approaches include

Observing and drawing inferences using the senses of touch, vision, smell, hearing, and taste.
Questioning and making intelligent guesses
Exploring and individual research
Experimenting
Measuring and classifying
Concluding and testing
Predicting
Communicating

Teachers should encourage each child to follow all of these approaches as much as possible, thereby stimulating enthusiasm for learning. This enthusiasm must continue throughout the child's schooling. Science itself depends on this enthusiasm.

PURPOSES OF SCIENCE STUDY

There are four major purposes in the teaching of science. These are (1) to help the children acquire a knowledge and understanding of natural phenomena and a familiarity with the physical and biological environments in terms of fundamental concepts; (2) to help the children acquire an under tanding and appreciation of the nature of science as a study of natural phenomena based on observation, investigation, and the discovery of relationships; (3) to help them acquire the ability to use and develop rational powers of the mind; and (4) to help them acquire an understanding and appreciation of the relation of science to the accivity of man.*1

There are several steps in the procedures to fulfill these purposes. These procedural steps are by no means the only possible way to accomplish these purposes. They are simply one suggestion. They are

To study data of a natural phenomenon,
To challenge the validity of data (source, amount of sample, relevance, etc.),
To interpret data in terms of understood vocabulary,
To organize interpretations and formulate or identify relationships,
To formulate hypotheses based on these interpretations,
To outline experiments which will validate the hypotheses,
To experiment to determine the validity of these hypotheses based on solving the problem,
To draw conclusions based on the experiments.

Most of these procedures can be incorporated into four fundamental principles which can then be employed as a basic method of approach to any area of learning. These principles are (1) variety and pattern, (2) continuity and change, (3) interaction and interdependence, (4) and evolutionary development.*2

Variety and pattern simply refer to the differences among various living things as well as various nonliving things and the patterns of characteristics which enable the observer to note the differences. For example, a worm, a spider, a bug, and a lizard are notably different to an observer. This denotes variety. The characteristic number of legs of each of the organisms may offer the pattern which enables the observer to distinguish them.

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*1 Fish and Nelson, Science Curriculum Development in the Elementary School, California State Department of Education, Sacramento, 1964, p.1.

Continuity and change refer to both the constancy of things yet their ability to change form. Most observers are somewhat knowledgable concerning temperature, for example. They know one can measure it on a thermometer, that it is hot in the summer and cold in the winter, that it is a measure of heat present in the atmosphere. All of these facts are constants, and points of continuity with respect to the concept of temperature. Yet temperature is in a constant state of flux. It is dynamic. This shows its compliance with the concept of change.

No piece of matter or energy is independent. It is a product and an essential part of the universe. Since it conforms to these conditions it is an interacting and interdependent member of the living and nonliving world. An understanding of the nature of this interaction and interdependence will lead to a greater insight into problem solving.

Things, by nature, change in time. If it is possible for something to change, in time it will change. The record of these changes and the relationships these changes have to the environment is again of significant value in science. These changes over a period of time, through natural processes of selection, constitute evolutionary development.

The next point to be understood is how these procedures should be employed in the curriculum. The booklet, MAKING ELEMENTARY SCIENCE MEANINGFUL, A Guide for Elementary Teachers, issued by the State Department of Public Instruction, sets down several important subject areas in science. But, more important it shows the interrelationships that the discipline of science has with the other disciplines. If there is one point that should be made in this guide it is that <u>there should be an</u>

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*2 Ibid. p. 2

interdependence of science with the other fields of learning. Science is not a distinct entity. Science is not alone in its goal of learning by logic. Science is not the only important discipline. Scientific procedures and techniques are applicable to all fields of learning and should be incorporated into all aspects of teaching the various disciplines. The booklet mentioned above shows ways in which ideas in science can be incorporated into other disciplines. There is, however, an additional concept that should be incorporated--techniques.

INTEGRATION OF SUBJECT MATTER

The first approach to integrating subject matter might be exemplified in the following way. If the area under investigation during the science class were the "Sky," the subject might be integrated into the other subject areas in the following manner: Mathmatics study might include using of the protractor to measure the angle for the sundial, or to measure the length of the rod for the sundial, thus forming concepts of inches and feet (centimeters and meters); or if we traveled toward the sun which is 93,000,000 miles away, at 250 miles an hour, how long would it take to reach the sun? Language study might include writing sentences about how the sun helps us, composing a poem about the sky, or taking notes properly from reference books. Reading study might include reading and following directions for experiments in science, oral reading of reports on the sky, or by increasing the vocabulary by learning words pertaining to the sky such as dawn, dusk, twilight. Art might include drawing an arctic scene depicting the aurora borealis in the background, or drawing pictures of a rainbow. Music might include singing songs such as "Mister Sun" and "Good Morning" from New Music Horizons (Book 2). Social Studies might include learning how the time belts affect man and how sunlight affects the growth of grains and thus the economy of man, or studying about the various regions of the earth and how their conditions are caused by the earth's movement around the sun.*3

INTEGRATION OF THE PROCESSES OF SCIENCE INTO THE OTHER DISCIPLINES

In the technique suggested above, the subject was a science topic in which the other disciplines were involved through reading about it, writing about it, singing about it and drawing pictures about it. In a second technique the subject may be chosen from social studies, history, English, foreign languages, reading, or physical education, but the procedures are characteristic of science.

As an example of this approach a topic may be picked at random and explored. The subject chosen to exemplify this is "The Pioneers." Certain basic facts are given students about pioneers. Some of these might be as follows:

> They moved westward. They made homes of sod or logs. They homesteaded on the prairies. They lived by hunting, fishing, and farming. They were, at times, at war with Indians. They suffered hardships. They found water to be scarce. They built large community protection areas callled "forts."

This is by no means a complete list of knowledge given students concerning the pioneers, but it will suffice for the purposes of this publication. These facts are often imparted to the student through films, reading, discussion, or lecture. All of these methods can be used with varying degrees of success. It is certainly impractical for students to learn

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*3 Borman, Ina, Making Elementary Science Meaningful, A Guide for Elementary Teachers, revised, State Department of Public Instruction, Topeka, 1953.

about frontier life firsthand by enduring the handships of becoming a pioneer because times, societies and conditions change. The children do not have the opportunity to go out onto the prairie as pioneers in the sense that the original pioneers did. They do not have the opportunity to spend time at the mercy of the elements and nature. They can only witness it through the various audio and visual techniques used in the classroom. With these facts, usually the study of the pioneer must stop. This is the point that must be overcome. <u>Learning should not stop with facts, it should continue through meaningful experiences</u>. The implementation of experiences is the process of science. How can this implementation of experiences be utilized? To answer this question and continue with the subject at hand, take a point of interest and develop it. Children might be interested in sod and log housing, and they can be stimulated to volunteer information about each type of abode. Such information as the following might be collected.

THE SOD HUT

1. Would normally be built in prairie areas because sod would be available.
2. Would provide warmth in winter and coolness in the summer (insulation) because of thick walls.
3. Would be well camouflaged because it would blend with the prairie (less susceptible to Indian attack.)
4. Would be somewhat susceptible to rainstorms because of erosion.
5. Would require only a short time in construction.

THE LOG CABIN

1. Would normally be built near river basins, creek beds, or forest areas where logs were available.
2. Would not provide very good insulation but the forest areas would provide for greater protected areas from the weather.
3. Would provide camouflage because it would blend with the wooded areas.
4. Would be less susceptible to the elements simply because of the nature of wood.
5. Would take a long time in construction but the forest provided a great deal of shelter

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Once data such as these have been collected, questions begin to present themselves. Why is the sod hut better insulated than the log cabin, or, in fact, is it better insulated? A statement or hypothesis may be set up to give ideas on how to solve this problem, such as, "If the sod hut is better insulated than the log cabin, then the temperature inside the sod hut would fluctuate less with variation of temperatures outside than would that of the log cabin." Children might then set about testing the validity of this statement by building a small sod house and a small log cabin and checking the temperature change inside of each as the temperature outside is varied. Care should be taken that in construction the proportions be correct. Outside temperature may be simulated by placing the models in an oven or refrigerator. The activities and the observation of the example would provide meaningful experiences in the realm of history. Analysis of data would also be utilized. This analysis is in actuality another scientific technique. It would require interpretation of facts, and this too is scientific endeavor.

This example should point o. how scientific philosophies and techniques may be incorporated into other disciplines. Such a combining of the disciplines might be referred to as the process approach to learning. It would require investigation beyond the mere memorization of facts and it would be necessary to incorporate the scientific techniques of logical problem solving. Similar ideas could be followed through in all of the various disciplines.

In this approach to learning of all kinds, the child will begin to see relationships which will make learning and, in fact, school itself meaningful. He will not be learning packages of facts which will be of little value to him (unless he plans to specialize in them in his adult life).

The interrelationships of science make the discipline fascinating and at the same time provide its strength. Interrelationships provide the strength of the total learning pattern.

FACTORS INFLUENCING SCIENCE TEACHING

The program of material to study through any one given grade level should be based on several factors. These factors would include

The quality of scholarship in the classroom,
The background of the teacher in the field of science, although it does not require a trained scientist to teach elementary science. In fact, quite often learning with the student is a very effective method of teaching.
The climate,
The preparation of the students before field trips,
The distance to field or areas of particular scientific interests. Although field trips can be very effective, merely observing nature on the playground or around and on a sidewalk can be an effective study.
The number of businessmen and industrial leaders interested in science in the schools and their degree of interest,
The textbook used. Even though it probably sets the curriculum, it should be nothing more than a tool of stimulation toward thinking beyond the confines of verbosity.
The administrative support and interest.

The curriculum should definitely include a series of thought provoking and activity stimulating points. Some examples of this might be (1) having adequate equipment so that each member of the class can participate actively, (2) having science things around the room, (3) taking field trips, (4) bringing in animals and plants, (5) having group participation in preparing a bulletin board with a science theme, (6) teaching with excitement and genuine interest in the subject, and (7) using interesting audio-visual aids and library material.

SUMMARY

It is hoped that the reader will develop his own curriculum program. The program should, however, incorporate the "concept" philosophy of teaching science. From the material presented earlier in this booklet, we may define "concept" as ideas about related data that depend on the child's experiences and the information he accumulates as he interacts with his environment. By starting with knowledge the student possesses when he enters school and by using skills in the scientific approach, the teacher can develop in the child this knowledge to a point of scientific awareness. This awareness would include a longing to know and to understand, a questioning of all things, a search for data and their meaning, a demand for verification, a respect for logic, a consideration of premises, and a consideration of the consequences.*4 Notable exceptions might be noticed in earlier paragraphs.

The program must have a purpose. The pupils should know the purpose through directed discovery as the program is developed always from the viewpoint of these purposes.

The program must encompass some established subject matter. Even though science is a broadly interrelated discipline, there are definite areas of knowledge that should be emphasized. Five broad divisions of knowledge in the science discipline are (1) living things, (2) earth, (3) universe, (4) matter and energy, and (5) measurement, or the metric system. Each of these areas should be included in every grade level. Higher grades should extend, broaden, and deepen the

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*4 Arthur Corey, Education and the Spirit of Science, Educational Policies Commission, NEA Washington, 1966 p. 15

understanding of each area or concept developed in the lower grades.

There is no definite rule for imparting information to the child in each grade level. Although it would be a difficult task for the teacher, each student should learn at his own rate. If this is either impossible or completely impractical, the program should proceed at a rate most conducive to the best learning of the group. It is very difficult to put rigid standards on the amount of knowledge a child should have at the conclusion of each school year. Flexibility is the guideline in this case. Teachers should never have a science program so structured that they feel encroached upon by lower grade-level teachers pressing on to more intellectually challenging concepts for students that can proceed accordingly.

OTHER CONCERNS IN SCIENCE TEACHING

Safety

The new revolution in science has put a great deal of emphasis on techniques but not enough on safety. Safety must not be overlooked. Science study can be dangerous to youngsters if they do not have proper laboratory safety training. It can be equally dangerous to have the training but not have proper safety equipment in the room. Every science laboratory, even if it is a self-contained classroom, should have the following safety features:

Laboratory doors and storage room doors should be locked when not in use.

Fire equipment should be provided, such as CO_2 extinguisher.

Master control for gas, water and electricity should be conveniently located.

Permanent area or bulletin bocrd for posting safety rules, first-aid and accident procedures should be located in some prominant place.

Floor should be textured to prevent skid.

No cracked or sharp edged glassware should be used in the laboratory.

A well displayed first-aid center which contains supplies and instructions should be provided.

A wash basin with ample soap should be available in every laboratory.

Live animal storage should be humane and sanitary.

Guard rails should exist on all carts and tables used for chemicals or other substances that might be harmful if spilled or broken.

All electrical cords and plugs should have heavy rubber-covered wall plugs and heavy-duty cable to help prevent short circuits and electrical shock.

If the school plans a science center, a list of safety equipment can be obtained by contacting the science consultant of the State Department of Public Instruction.

The rules and regulations for students and teachers should include at least the following points:

The teacher should periodically check safety equipment.

Injured persons should be seated.

Students should be made aware of the hazards of handling hot glassware.

Recommended quantities should never be exceeded in any exercise involving chemicals.

Foreign substances should not be tasted in the laboratory.

Odors should be wafted toward the observer; one should never put nose directly over any unknown substance.

Horse-play should never be allowed in the laboratory.

All injuries should be reported immediately to the instructor.

Having harmful animals and plants in classrooms should be avoided.

Students should be aware of the dangerous properties of various elements and compounds normally housed in the laboratory, such as sodium, potassium, phosphorus, thermite, acids, bases, (hydroxides), mercury chlorine, bromine, hydrogen, SO_2, NO_2, etc.

Panic should be avoided in case of emergency.

Signed parental consent blanks should be secured for granting students permission to work with chemicals. These should be kept on file in the office of the principal or department head.

All containers should be properly labeled and all unlabeled materials should be discarded in the proper manner.

Special precautions should be used when using highly volatile, flammable liquids such as alcohol, ether, etc. One should open a window, keep away from open flames, and have fire-extinguishing equipment handy.

Students should be cautioned to perform only experiments which have been approved by the teacher- no unauthorized trial-and-error methods are to be used.

All students should be made aware of hazardous out-of-school activities such as

- *mixing chemicals just to see what will happen*
- *breaking fluorescent light bulbs*
- *handling television cathode-ray tubes*
- *keeping unlabeled medicine or chemical bottles*
- *keeping old medicine or poisonous materials in the reach of young children*
- *taking drugs, antibiotics or other medicine without consulting a physician.*

Students should not prepare or use any type of rocket fuel unless under the strict supervision of a person trained in the area of science.

Under no circumstances should students be allowed to take any chemicals from school laboratories for the purpose of experimenting elsewhere.

Caution should be observed in the use and handling of glass.

Caution should be observed in using the Bunsen burner, to avoid burns, fire, and explosions.

Test tubes being heated should be aimed away from any person.

Specimens preserved in formaldehyde should be thoroughly rinsed before handling.

If freshly-killed specimens must be handled, rubber gloves should be worn since the animal could have some disease which could be dangerous to the handler.

Laboratory animals should be handled with heavy rubber, canvas, or leather gloves to avoid being bitten.

There are probably several other rules and regulations that the teacher or school would like to include.

Time

The philosophy advocated in this publication is a fluid integration of disciplines with no broken sections of movement from one subject area to another. However, it is helpful for many teachers in working out their daily, weekly, and monthly programs to have an approximate monthly time allotment for each area. 10-15 percent is the suggested amount of time for science in primary grades and 15-20 in the intermediate grades. Note that this is not an increase in the amount of time suggested in the past. More time is not necessary to handle the new approach to science teaching properly.

Equipment and Facilities

A limiting factor in science teaching in elementary grades may be the equipment and facilities available. Good facilities are not essential but they certainly make teaching science by the "experiment" method more realistic. Most small equipment can be improvised but there are some things that are generally necessary to the success of science programs. The equipment and facilities can be categorized into needs for classroom facilities and needs for equipment which may be obtained from year to year. This second category would vary greatly, depending on the text and program planned by the teacher and school. However, a list of basic small equipment is enumerated following the list of general facilities. This second list does not include items which can be improvised or obtained from the children. A list of general facility needs are

The room arrangement should be flexible with no stationary furniture.

Desks should have flat tops so that they may be pulled together for large work areas.

Tables or benches for rough construction should be provided.

Storage space is needed for tools and materials.

Running water with sink should be placed in every classroom.

Each room should have a convenient electrical outlet for hot plates at a work counter.

Tables should have acid–resistant or at least water–resistant tops.

Resources on and near the school ground should be readily available for science experiments.

Each classroom should have a place where science materials can be placed for display and study.

Chalkboard and tackboard spaces should be provided.

Measures should be taken to provide a place to house and care for animals and plants.

Have modern equipment in good repair so as to help rather than hinder student learning.

Rooms should be readily convertible for audio–visual education and use of overhead projectors.

A list of small equipment basic to elementary science programs includes

ANIMAL AND PLANT EQUIPMENT

Animal cages
Glass aquarium tank
Insect cages
Insect killing bottle
Insect nets
Narcissus bulbs
Meal worms
Seeds
Terrarium or berbarium
Newts, Mosses, Ferns, Fish, Snails
Soil, Sand, Shells

ELECTRICAL EQUIPMENT

Bell and buzzer
Copper wire, insulated #22
Dry cells, 1½ volts
Dry cell holder for flashlight cells
Electric hot plate
Extension cord

CHEMICALS

Alcohol
Aluminum
Alum
Ammonia
Asbestos powder
Baking soda
Borax
Carbon tetrachloride
Chlorox
Cornstarch
Hydrogen peroxide (3% – 20%)
Iodine crystals
Iron filings
Lime
Lodestone
Mercurochrome
Metal scrapes of zinc, copper and aluminum
Magnesium ribbon
Manganese dioxide

ELECTRICAL EQUIPMENT – Continued

Fan with fan guard
Flashlight
Lamps for the flashlight
Motor (toy motor)
Sockets for flashlight bulbs
Sunlamp
Switches (push button, knife, toggle)
Telephone receiver or earphones
Telephone transmitter

GLASSWARE

Glass microscope slides
Glass plates
Glass rods
Glass tubing
Nursing bottles
Petri dishes
Pyrex beakers, 1 cup – 1 pint
Pyrex flask, Erlenmeyer
Test tubes (6 x ¾)
Graduated cylinder (50ml)

MEASURING DEVISES

Balance scale
Barometers (mercury and aneroid)
Compass (magnetic)
Measuring cups
Meterstick
Ruler
Spring balance
Steel tape
Stop watch
Thermometer

CHEMICALS – Continued

Mothballs (Naphthalene)
Paraffin
Petroleum jelly
Plaster of Paris
Phenolphthalein
Potassium permanganate
Turpentine
Vinegar
Sugar
Litmus paper
Camphor
Sulfur
Ammonium dichromate
Zinc metal (mossy)
Glycerine

OPTICS

Compound microscope
Lenses, demonstration set
Binocular microscope (20x to 30x)
Mirrors, concave and convex
Prisms
Reading glass
Tripod magnifiers
Microprojector
Prepared microscope slides

TOOLS AND HARDWARE

Hammer
Pliers
Tin snips
Trowel
Sandpaper
Saw
Screwdriver
Steel wire
Metal strips
Clips for batteries
Nails
Screws (assorted)

MISCELLANEOUS

Acetate sheets
Air pump
Alcohol burner or bunsen burner
Asbestos pad
Assorted pieces and sizes of wood
Building cement
Candles
Cellophane
Chalk
Cheese cloth
Collection of rocks and minerals
Corks of assorted sizes
Double boiler
First–aid cabinet
Funnel
Glue
Hard rubber rod
Knife
Labels
Magnets: U. S. bar magnets, U–magnets, or horseshoe magnets
Medicine droppers
Paper clips
Paste
Piece of fur
Pins
Plastic molding material
Pulleys
Ring stand with clamp
Rubber bands
Rubber cement
Rubber tubing 3/16 inch inside dia.
Rubber tubing ½ inch inside dia.
Scissors
Scoop
Spatula (stainless steel)
Sponge
Stoppers (solid rubber, one–holed rubber, two–holed rubber of assorted sizes
Tea kettle
Test tube brush
Test tube holder
Thumbtacks
Tongs
Tuning forks of different pitches
Tweezers or forceps
Waxed paper
Aluminum foil
Wood splints
Filter paper
Steel wool
Soda straws
String
Aluminum pan, one quart

Audio - Visual

In line with the suggestions and procedures given in the preceding discussion, the various types of audiovisual materials should be adapted to the methods of teaching suggested.

Observation and experimentation, largely visual experiences, are ideally carried on by first-hand contact. This can be done in the classroom laboratory or on field trips. Where first-hand observation is impossible, vicarious experiences are necessary. Some examples of these are the movements of electric current, chemical change, internal combustion engine, and the operation of internal organs. For such as these, animation or moving models are necessary. Some items for observation are too far removed from the child by both time and space, such as the historical background of science, life-cycles, and phenomena of both living and nonliving in distant places. Various comparisons can be made with data observed first-hand. The various types of visual and audiovisual materials---films, filmstrips, slides, television, recordings, tapes--can provide substitute experiences.

It must be recognized that possibly the majority of audiovisual materials commercially available are those designed for the type of teaching earlier referred to as the memorization type. However, even these can be adapted by a resourceful teacher. The main requirement is that the teacher possess and practice the type of scientific approach expected of the child. The teacher should be able to exercise mature evaluation of the material at hand, and adapt it to a flexible learning program.

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Some suggestions for such adaptation are these: observing as many comparable views of a particular item as possible; turning off the sound track of a sound film and observing only the visual sequence with subsequent discussion, summary, and conclusions; permitting pupils to furnish their own captions for filmstrips; using homemade materials, such as 2 x 2 slides, building the class' own sequence and observations; preparing taped commentaries created by individuals or by groups; copying pupils' creative visuals of scientific observations to use on the overhead projector or drawing their own directly on the transparency; using 8 mm loop films without commentary. The list is limited only by the imagination of the teacher and the class.

Both commercially-prepared and locally-prepared materials are possible. Commercial materials, as suggested, may be evaluated and used with discretion. Local materials have the advantage of being more meaningful in their use of local resources. A teacher or pupils with photographic ability may record many observations on field trips and other situations. Teachers and pupils with scientific curiosity may develop acceptable photographic competency with presently available equipment of modest cost. These may be recorded "in season" and used later "out of season" for various types of comparisons and observations. Unusual experiences may be recorded for present and future use. Of course the graphic ability of the class should be used; however, it should be based on extended observation to illustrate accurate concepts. As a negative example, children should not develop the concept of a squirrel only as an animal sitting on his hind quarters, with his tail curling up behind, and holding a nut with his front paws. Squirrels, after all, do other things. Careful study should be given to the child's sources of information by which he makes his drawing. He should have more than one illustration in a workbook or duplicated material to color or otherwise embellish. Stereotyped illustrations are incompatible with a dynamic science program.

Scientific techniques are today part of all learning patterns. It is important for all children to be familiar with these techniques and practice them whenever possible.

BIBLIOGRAPHY

1. Blackwood, Paul E., Science Teaching in the Element :y Schools, A Survey of Practices, U. S. Department of Health, Education and Welfare, Office of Education, U. S. Government Printing Office, Washington, D. C., 1965.

2. Borman, Ina M., Chairman, Making Elementary Science Meaningful, A Guide for Elementary Teachers, Revised Kansas State Department of Public Instruction, Topeka, 1953.

3. Corey, Arthur F., Education and the Spirit of Science, Educational Policies Commission, National Education Association, Washington, D. C., 1966.

4. Fish, Alphoretta, and Nelson, Ester, Science Curriculum Development in the Elementary School, California State Department of Education, Sacramento, 1964.

5. Humphreys, Alan, What Shall be Taught?, Considerations for Process Teaching in the Activity-Oriented Classroom, Minnemath Center Reports, Winter 1965-66.

6. Johnson, Philip G., School Facilities for Science Instruction, Second Edition, National Science Teachers Association, National Education Association, Washington, D. C., 1961.

7. Piltz, Albert, Science Equipment and Materials for Elementary Schools, U. S. Department of Health, Education and Welfare, Office of Education, Washington, D. C., 1961.

8. Richardson, John S., and Williamson, Stanley E., Science Facilities for our Schools, National Science Teachers Association, National Education Association, Washington, D. C., 1963.

9. Tannenbaum, H. E., Stillman, N. and Piltz, A., Science Education for Elementary School Teachers, Allyn and Bacon, Inc., Boston, 1965.

10. Throckmorton, Adel F., Supt., A Curriculum Guide for the Elementary Schools of Kansas, Kansas State Department of Public Instruction, Revised, 1958.

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EVALUATION COMMITTEE

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Warren Bell, Director, State Department of Public Instruction
(Immediate-Past State Science Consultant)

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Dr. Bernadette Menhusen, Kansas State Teachers College, Emporia, Kansas

Pauline Gifford, Hutchinson Public Schools, Hutchinson, Kansas

Raymond D. Bell, Chanute Public Schools, Chanute, Kansas

Nona Stevens, Chanute Public Schools, Chanute, Kansas

Dorothy Hibbs, Chanute Public Schools, Chanute, Kansas

Cecilia Beuligmann, Chanute Public Schools, Chanute, Kansas

Judy Erickson, Chanute Public Schools, Chanute, Kansas

Thelma Childers, Chanute Public Schools, Chanute, Kansas

Elma Pence, Chanute Public Schools, Chanute, Kansas

Lois Caffyn, Consultant, State Department of Public Instruction, Topeka, Kansas

Harold Caldwell, Consultant, State Department of Public Instruction, Topeka, Kansa

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