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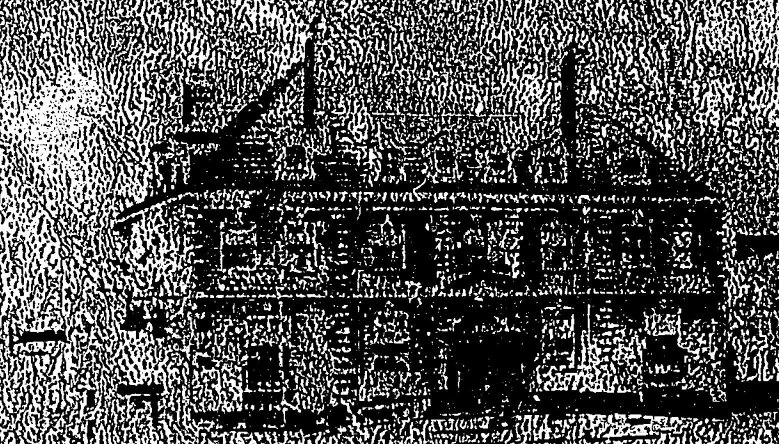
ABSTRACT

Provided are suggestions and recommendations for each item on the checklist, contained in Part A of the handbook, which was designed to help elementary school principals assess and improve science programs in their schools. Suggestions/recommendations, designed to make the checklist more meaningful and useful, are keyed by number and/or letter to specific questions presented in the four major sections of the checklist. These sections deal with areas that have a great impact on science programs. The first section focuses on administrative aspects, considering the school science curriculum plan, provisions for science in the budget, the principal's leadership role, and staff development practices. The second section focuses on science texts and/or written curriculum materials, discussing science content, process, and several related areas. The third section focuses on observations of teacher and student behavior during science classes, considering observation techniques, questioning strategies, student attitudes, and other areas. Science resources and facilities are examined in the final section, looking for evidence of these resources/facilities in and beyond the classroom, and determining how resources are acquired. (JN)

HANDBOOK III

CHARACTERISTICS OF A GOOD ELEMENTARY SCIENCE PROGRAM

Part B: Elaboration of the Principal's Checklist of Characteristics



Project for Promoting Science Among Elementary School Principals

National Science Teachers Association
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KENNETH R. MECHLING and DONNA L. OLIVER

HANDBOOK III

CHARACTERISTICS OF A GOOD ELEMENTARY SCIENCE PROGRAM

Part B: Elaboration of the Principal's Checklist of Characteristics of a Good Elementary Science Program

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There is a Chinese proverb: one generation plants the trees...another gets the shade. During this project, trees were planted with the help of many people. It is our hope that elementary school children all over the United States will benefit from the shade.

The project, Promoting Science Among Elementary School Principals, began as an idea at the meeting of the board of directors of the National Science Teachers Association (NSTA), held in Dayton, Ohio in 1980. It was conceived as a joint effort of NSTA and the Council for Elementary Science International (CESI). We are grateful for the foresight, encouragement, and leadership of Don McCurdy, then president of NSTA.

Many people shared in the development of the project. Their efforts and ideas deserve our sincere appreciation. They include:

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PREFACE

If good elementary science programs were easy to come by, most schools would have one. Needless to say, it isn't easy and most schools don't. Problems abound with science programs; teachers often lack preparation in science, they don't feel confident about teaching it, time is cramped, supplies and equipment are lacking, leadership for science is difficult to find. The list could go on and on. Your school is probably faced with one or more of these problems.

Fortunately, there are many good science programs: programs that get kids excited, programs that teachers enjoy and do a good job of teaching, programs that have the support of the school community, and programs in which children learn science processes, concepts, and attitudes valuable to their lives now and in the future. We can learn from those programs. Through our own observations, through what others have written, and through research we know the characteristics of good elementary science programs. The purpose of this Handbook is to help you to identify some of the characteristics and use them to assess the effectiveness of your own science curriculum.

There are two major, but closely related, parts to Characteristics of a Good Elementary Science Program. Part A is the "Principal's Checklist of Characteristics of a Good Elementary Science Program." It includes selected characteristics of good elementary science programs stated in the form of questions. We urge you to use the Checklist to assess your own science program. Part B, "Elaboration of the Principal's Checklist of Characteristics of a Good Elementary Science Program," is the companion document keyed by number and/or letter to each question on the Checklist. It provides suggestions and specific recommendations to make the Checklist more meaningful and useful to you. We hope you will use both as you seek to improve your science curriculum.

This Handbook is part of a National Science Teachers Association project titled "Promoting Science Among Elementary School Principals." There are four Handbooks in the series: Handbook I, titled <u>Science Teaches Basic Skills</u>; Handbook II, <u>The Principal's Role in Elementary School Science</u>; Handbook III, <u>Characteristics of a Good Elementary Science Program</u>; and Handbook IV, <u>What Research Says About Elementary School Science</u>.

Ken Mechling
Donna Oliver

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PART B

ELABORATION OF THE PRINCIPAL'S CHECKLIST FOR A GOOD ELEMENTARY SCIENCE PROGRAM

I. ADMINISTRATIVE ASPECTS

In this section we have identified administrative characteristics which can make or break a good science program. Specifically, the Handbook will help you review your science curriculum plan, focus on money for science in your school budget, help you to assess your leadership role in the science program, and consider your staff development practices.

I.A. <u>YOUR SCIENCE CURRICULUM PLAN</u>

A good elementary science program has planned science experiences for all grade levels K-6. As principal you should be sure that the science program design is clear, logical, and sequential; that there is a distinction between grade levels; and that there is a minimum of overlap between classes and grades. Children are very sensitive to boring and needless repetition. In good science programs, we don't hear kids saying, "Oh, we studied that last year."

I.A.1. A good science program is guided by statements of goals and objectives. Postman and Weingartner(1), in their book <u>Teaching as a Subversive Activity</u>, recommend that teachers

<u>am I going to do today?</u> <u>What's it good for?</u> <u>How do I know?</u> We need to ask those kinds of questions about our science programs.

What do you want the children in your school to be able to do as a result of studying science? What knowledge, skills, and attitudes should they have? What value is science to their lives? What's science good for?

Answers to questions such as these can be translated by you and your staff into statements of goals and objectives--statements that can provide direction, statements that give you targets to shoot for.

Goals are broad statements that give general direction. Here are some examples of goal statements from several school science curriculum plans:

> Science should help our children to solve everyday problems by thinking critically and creatively.

> Science should help our children to understand the environment and deal with it effectively.

Objectives more specifically identify what the children should accomplish in science. Here are some objectives:

The student will identify and name the planets.

The student will infer one or more causes in exploring an event.

The student will describe the causes of seasons, climates, weather, and day and night.

The student will record, organize, and interpret data.

The student will cite examples of the life cycles and the life processes of living things.

I.A.2. While it might be nice to have teachers do their own things in science, it simply doesn't make good sense for individual teachers to decide what their students will learn. Such a program would surely lack both continuity and sequencing and lead to sporadic and repetitious science experiences. Unfortunately, in many schools for many children, the lack of a written science curriculum plan means no science at all.

The science curriculum plan should be functional--not something that's written and allowed to gather dust on a shelf in the principal's office. It should be your plan, developed by your school community, for your school, and useful to your teachers and anyone else who needs to know where your science program is going, how you'll get there, and how you'll know when you've arrived.

I.A.3. You should examine the basic goals of education in your state to determine if your science curriculum plan is consistent with them. If you live in California, you would want to consult the Science Framework for California Public Schools. If you are in Pennsylvania, you would want to consult the Goals of Quality Education. Undoubtedly, there are some overall goals for education in your state that you can examine to see if your program plan matches the requirements.

I.A.4. The preparation of a good science curriculum plan involves everybody responsible for implementing and sustaining it. The ancient maxim "Let all approve what touches all," is certainly appropriate here. Not only will you have the benefit of the individual and collective wisdom of your staff as the plan is being developed, but they will be more likely to implement it effectively if they have had a stake in preparing it.

While it may not be possible to involve everyone in the school community in the actual preparation of the plan, advice can be sought periodically, reactions to written drafts can be requested, briefings can be presented, and everyone involved can be kept informed of progress toward its preparation. The plan should not be a surprise to anyone.

I.A.5. Science is taught in a lot of schools because it has always been taught, or because it's in the curriculum guide, or because the state says it must be taught. One of the most important considerations in developing a science curriculum plan is to ensure that science learning will be valuable to the lives of the children. The written plan should provide evidence that the basic reasons for teaching science have been considered. When we ask the question, "What's science good for?", we need to come up with some concrete, convincing answers, not educational gobbledygook.

Glenn Blough(2) describes the broad purposes of the elementary school:

> Certainly we must teach the skills of reading, writing, and arithmetic for they are essential equipment for enjoyment, for gaining information, and for communication.

Add the ability to use our hands to make them do what we want them to do, and the skill of seeing things around us and seeing them accurately. Include the skill of listening intelligently and of speaking effectively, so that we can express our ideas coherently and accurately. And the skill of sensing problems and solving them in a scientific way, so that results are dependable. This includes being open-minded, fair, careful at arriving at conclusions, accurate, and free of prejudice and superstition.

Without going into details and technicalities, we can sum up the objectives this way: The goal is to help children gain the ideas, understandings, and skills essential to becoming well-rounded adults who have achieved their fullest potential.

Science is important in the total elementary school curriculum because it is intrinsic to the goals of the entire school experience, both in content and in basic skills development. As we read what Blough has said, we can see how science can contribute to the lives of the children.

I.A.6. A weakness in many science programs is the failure to provide time for science in the school schedule. This presents a perfect opportunity for teachers simply to avoid teaching science. There are many who believe that the individual teacher does not have the right or prerogative to exclude or minimize the attention given to any subject matter area of the curriculum. The teacher should not, for personal or other reasons, become an impediment to effective instruction in science or any other subject (3).

One way to ensure that science will be taught is to include it in the school schedule and allot specified times or periods for teaching it on a daily or weekly basis. One recommended time allotment is 20-30 minutes per day for K-3 and 30-40 minutes per day for grades 4-6. Some schools set aside three days a week for science, with an average of 40-60 minutes per day. Other schools merely stipulate a definite amount of time per week, usually 120-180 minutes, and let the teacher allocate the time as needed throughout the week (4).

Having an allotted time for science increases the likelihood that it will be taught. Time for science in teachers' schedules also provides you with an excellent opportunity to visit science classrooms to observe science teaching and learning in action and to assess the overall effectiveness of your school's science program.

I.A.7. Teachers need to understand the goals of science instruction, the curriculum plan, and the time allocation. This information should be in writing, perhaps included as a part of the overall elementary school curriculum plan. It could be presented and discussed at a staff meeting or become part of an inservice program. However the information is presented, teachers must understand, clearly, what is expected of them in the science curriculum.

I.A.8. All major curriculum areas should be reviewed periodically. Each should be scrutinized to determine if the goals and objectives are still valid and are being met. Science is no exception. As principal, you can make sure that science undergoes a periodic curriculum review. For many schools, this review takes place every five years.

When the review is conducted, insist upon evidence that the science goals and objectives are being met. Insist on hard data--student work, evaluative measures, written parental feedback, and other forms of documented evidence.

I.B. SCIENCE IN YOUR SCHOOL BUDGET

Good science programs require reasonable expenditures of money. Science materials, supplies, equipment, and books are needed to keep a good science program going or to start one up. Equipment like dry cells, magnets, rulers, chemicals, and live organisms are as important to science instruction as books are to reading and pencils to writing.

Staff development also costs money. Funds for inservice programs, travel, and attendance at conventions should be anticipated in advance of need.

I.B.1. A good science program receives an <u>annual</u> allocation of funds. The amount of the allocation depends upon the means and priorities of the school system, but it should be at least equivalent to other major curriculum areas. Good science programs simply won't run without money. As principal, you, more than anyone else, must seek funds to support your science program. It is up to you to ensure that science needs are anticipated and included in your school's budget. Curricular areas are always in competition with each other for available dollars. The Council for Basic Education believes that all students should receive adequate instruction in the basic intellectual disciplines. Science is considered as one of those disciplines (5). Science must receive its rightful share of the educational dollar. You are in a position to see that it does.

I.B.2. Good science programs are materials-centered. Children have the opportunity to use thermometers to measure outdoor temperatures, keep live animals in terraria, grow plants, examine rocks with magnifying lenses, read science-oriented library books, see photos of Saturn's rings, and make use of hundreds of other learning resources. In fact, one of the major strengths of science is that it provides many opportunities for children to deal with material objects--to explore, to investigate, to manipulate.

If a science program is to remain alive, old items must be replaced and new ones purchased to meet new needs. Provisions for their purchase must be included in the budget.

I.B.3. Good science programs include budget provisions for discretionary funds for use by teachers who need to make local purchases with petty cash. Dry cells go dead, seeds are needed, vinegar supplies run short. Teachers must be able to make local purchases of inexpensive items as they are needed. You, the principal, can design a system and let teachers know how to use it. Some schools provide vouchers. Others reimburse the teachers for their out-of-pocket expenses. Whatever system is used should not discourage teachers from obtaining such items.

They should feel that a minimum of their own time, effort, and money has to be expended; otherwise, few science learning experiences requiring locally-purchased items will likely be provided.

I.B.4. Good science programs include science in-service programs for teachers and principals, funding for travel to science conferences and workshops, registration fees and other costs for staff attendance at science conventions. Whether your existing program could use an infusion of new life or you adopt an entirely new program, in-service instruction is critically important and needs to be anticipated in the annual budget.

Don't forget that you, the principal, can sharpen your leadership skills in science by participating in meetings of state, regional, or national science teachers' associations. Make allowances in your budget for your own attendance at conventions such as those provided by the National Science Teachers Association. You can consult NSTA for details.

I.B.5. Science should not be limited to classroom experiences. Good programs include walking field trips on the school grounds or areas in the immediate vicinity of the school; bus trips to zoos, museums, or science centers; and travel to other sites that can enhance students' in-school experiences. Transportation and other costs related to science field trips should be anticipated and included in the budget.

I.C. THE PRINCIPAL'S LEADERSHIP ROLE IN SCIENCE INSTRUCTION

We believe that you, the principal, are the key to a healthy science program in your school. With your care and support, good science experiences for kids will flourish and grow. Without your attention, science can become sick and even die--and you may not even know it! Your leadership is absolutely crucial to the attainment of a quality program in science.

I.C.1. We believe that teachers and kids will take their science cues from you. If you are excited about science, they will be excited about science. If you think it's important, they will think it's important. If you are interested, they will be interested. We urge you to take a leadership role. Be an advocate for science.

In a recent survey among elementary principals in Pennsylvania, one of the principal's roles mentioned most often as important for successful science programs was the need for "demonstrating a positive attitude toward science." Principals felt that they had to show leadership--

in effect, be the "prime movers" for science, accentuating their own interest in the science curriculum(6).

Here are some things you can do to show your leadership:

a. Discuss science teaching with your teachers. Be interested.
b. Visit and participate in science classes.
c. Share science teaching "success stories" and innovative ideas with your teachers.
d. Get parents involved in science experiences at parent-teacher meetings.
e. Ask your school or community newspaper or other news media to do a story on some interesting aspect of your science program.
f. Initiate school and community science fairs and expositions.
g. Identify top-notch science-related community resources for your teachers.

I.C.2. Schedule times for science into a daily and/or weekly schedule and let teachers know, in no uncertain terms, that they are expected to teach science for the allotted times--this may be one of the most effective ways to improve your science program.

Many teachers let science slip or avoid teaching it entirely. It seems to them that no one really cares whether or not they teach it. Science is a major curricular area. It cannot be sloughed off. Let them know that you care. Insist that science be taught.

I.C.3. Most principals are required to make periodic evaluations of teachers, perhaps as many as two to four per year. These evaluative visits are excellent times for you to gauge the health of the science curriculum. Plan to visit classrooms when science is being taught and look for vital signs. Are the kids involved in science activities? Do they appear interested in the lesson? Do they have opportunities to investigate? Who does most of the talking, the kids or the teacher? Is there an emphasis on the development of problem-solving techniques, higher cognitive skills, and science processes? Is there evidence of on-going science activities? Are there science materials or projects around the room?

These evaluative visits can be multipurposed. Not only can you evaluate the teacher's performance as you are required to do, but you can also assess the condition of the science curriculum. If 15 to 20 percent of your visits occurred during science classes you would probably have a good idea of the overall quality of your science program. Visiting classes when science is being taught also has the added advantage of letting teachers know that you are interested in science.

I.C.4. You can avoid a lot of problems if you hire teachers who are prepared to teach science and confident in their ability to do so. When you interview teachers, question them about their views on science teaching. "How should science be taught?" "What are some important objectives?" "Do you like to teach science?" The hiring process is a good time for you to let teachers know that science is an important part of the curriculum in your school.

I.C.5. Problems can arise in any curriculum. The sooner you know about them the better you can deal with them. Be attuned to problems in your science program. Are the children bored in science class? Do the teachers grumble about the lack of time for science or the lack of equipment and materials? Are science classes difficult to distinguish from reading classes? If your answer is yes to such questions, then your science program may already be in deep trouble. Maybe it's time to form a committee to reassess your goals, determine if your program is meeting your goals, survey teachers to determine their needs, and consider a new curriculum. Maybe you can breathe some life into your old program by designing inservice programs to serve needs which have been specifically identified.

Once the program has been reviewed and you know where improvements can be made, then it's up to you to take the lead in making those improvements.

I.C.6. In a good science program, the principal plays a key role in providing inservice experiences in science for his or her teachers. Whether you have an existing program which could use a "shot in the arm" or adopt an entirely new program, inservice instruction in science is critically important. Take the lead in providing such experiences. Here are some things that you may wish to consider:

a. Survey your teachers to identify their inservice needs in science.

b. Put some pizzazz in your old curriculum by providing an inservice program to increase interest in science teaching.

c. Have your teachers participate in actual science experiences from a new curriculum.

d. Request a "rejuvenation" inservice program from the publisher of your current science program.

e. Request an area college or university to teach a science course for teachers in your school district.

f. Invite experts from other school districts, your state science teachers organization, or the National Science Teachers Association.

Whenever you provide a science inservice program, you, the principal, should take part in an active, visible, and interested way. Your presence alone can contribute much to the success of such a program.

I.C.7. Your participation with the curriculum selection group is crucial. You will want to lead, assist, encourage, and question without foisting your views on the committee. Research findings indicate that teachers cannot bring about program changes without the support and assistance of the school administration. Support from you, the principal, is a significant factor in achieving a successful program adoption and implementation(7).

I.C.8. Parents and the public in general should be kept informed of learning experiences in science. There are many ways you can do this. A very effective one is to devote a parent-teacher meeting to science. Get the parents involved in science activities similar to ones their own children have done. Have them <u>do</u> science--light bulbs, plant seeds, work pulleys, investigate mealworms.

Some schools plan science fairs and expositions. Children display projects, do demonstrations, and perform experiments. Others highlight their science activities through local news media. Newspapers often publish stories or photographs about interesting science activities. Articles about science olympics, field trips, special visitors to classrooms, and other interesting aspects of the science program can capture the interest of the public and keep them informed.

I.C.9. Some schools use standardized tests such as the Metropolitan Achievement Test, the Iowa Test of Basic Skills, or the Stanford Achievement Test. Some of the tests include science sections, others include skills sections which are related to science instruction. For example, the reading tests of the Iowa Tests of Basic Skills include skills such as observation, classification, time and sequence relationships, inferences, cause and effect, and others which can clearly be taught or enhanced through science. Regardless of which tests are used it is important that they be valid. They must measure your school's goals and objectives in science.

I.C.10. Standardized tests usually include normative data which allow comparison between your pupils and national samples. If your pupils are performing below the average or median scores, this could be an indication that your science program could be improved. If your school has test results ranging over a period of several years, you can compare them for trends. If the scores show a decline, this too, can be indicative of the need for action to improve.

I.C.11. Giving grades in science is a problem for many teachers. Even though the school has a grading system, maybe A,B,C, etc., many teachers find it difficult to assign grades except on the most arbitrary bases. This is particularly true if your program is an activity-centered program where it's hard to judge if someone gets a B or C in constructing and maintaining an aquarium, or an A or a B in observing a mealworm. As principal, you can help teachers, first by recognizing the difficulty they may have in assigning grades, and secondly, by examining alternative approaches to grading. Many schools have found criterion-referenced checklists effective. Others have moved science into a satisfactory-unsatisfactory reporting system or some modification of it. Still others have carefullly defined what is meant by an A, B, or C in science. It is important to lead your teachers into a grading system for science which they, the children, and the parents can live with.

I.D. REVIEWING YOUR STAFF DEVELOPMENT PRACTICES

The principal has a key role in providing inservice experience in science for his or her teachers. Whether you have an existing program that could use a burst of energy, or you adopt an entirely new program, inservice instruction is critically important. No science program will be effective unless the teachers are willing and able to teach it. Your leadership in providing inservice programs can provide teachers with the confidence and skill required to teach science successfully.

I.D.1. We wouldn't expect our automobiles, or even our bodies, to run without some routine maintenance, but we often expect our science programs to keep going and going with little or no attention. There will always be problems, and if they are allowed to accumulate, eventually they will kill the program. Periodic inservice programs on science can help avoid science program mortality. An inservice program every year or two can help head off problems before they become too serious--and these programs must be specifically designed to serve the needs of your science curriculum. It does little good to have an inservice program which demonstrates outdoor education teaching techniques if your teachers perceive their problems as a lack of time for teaching science or a lack of supplies. Your inservice programs must be designed to meet the needs of your teachers and your curriculum.

I.D.2. Teachers are often very critical of inservice programs. Many consider them a waste of time. One way to make them useful is to involve your teachers in their design. Ask them, through surveys or other means, what their problems are in science and what kinds of help they need. Ask them to assist you in designing programs specifically to meet their needs.

I.D.3. Successful science inservice programs are often those which allow immediate application to classroom use. The program should enable them to teach science more effectively in their own classrooms with their own pupils. While esoteric programs on the relation of science and technology or the merits of the space program may be inherently interesting, teachers may not be able to translate them into classroom use. Most teacher surveys show that teachers want inservice programs that are applicable to their own classrooms.

I.D.4. When a new science curriculum is adopted, one of the most effective science inservice programs is one which involves teachers in using program materials or teaching techniques that they will be expected to use with the children. For example, if the program includes activities like constructing simple electrical circuits, designing pulley systems, or operating simple machines, teachers should be involved in those activities in much the same way as their pupils will be. If the new program involves new teaching skills such as questioning or evaluation techniques, the teachers should be assisted in learning such techniques. If the new program involves a new teacher's guide, it should be reviewed with teachers before they have to use it. If your former science program consisted primarily of reading and your new one includes liberal doses of hands-on activities, your teachers should be involved in inservice programs which give them the opportunity to practice those hands-on activities.

I.D.5. Your participation in the inservice programs is important to achieving success. We know that you have a busy schedule, but your investment in time will be worth the effort. Our experience and reports in the literature of science education show that as principal participation in inservice programs increases, the chances for a successful program implementation increases. Don't limit your participation purely to observation or to in-and-out visits. Get actively involved! Your participation will show the teachers that you are interested and that you do care. What you learn will help you to help them.

I.D.6. Opportunities are often available for teachers to become involved in science workshops, courses, or meetings provided by colleges and universities, professional associations, or other educational agencies. Advertisements concerning such programs can be passed along to teachers, and they can be encouraged to participate. You may wish to ask representatives of these agencies if they would be willing to design a science teacher education program to fit your local needs. For example, a college or university may be willing to provide a course in your school specifically designed to assist your teachers to implement a new science curriculum. Such a course may be provided for graduate credit. Or perhaps you have a local, regional, or state science teachers' organization willing to assist you in identifying your science goals or planning a science curriculum for your school. You can improve your science curriculum by helping your teachers to identify and participate in organized inservice experiences in science.

I.D.7. Teachers need time to improve their science teaching skills. If such time is not provided during the school day, many teachers are increasingly reluctant or unable to attend programs during evenings or weekends. Schools may wish to schedule inservice days for times during which teachers can participate in organized science inservice programs. For example, the Pennsylvania Science Teachers Association recently scheduled its annual fall conference to coincide with the inservice days of regional schools.

Many schools provide release time for teachers to attend conventions of their state science teachers organization or the area or national conventions of the National Science Teachers Association. Teachers are often sent to these meetings with a mission--to examine new curricula, to attend sessions which address local problems, or simply to become better informed about new trends and practices in science education. Providing release time for teachers to participate in such programs can result in a more effective science curriculum in your school.

I.D.8. If your school doesn't have _Science and Children_ and other professional journals available, it should. Journals such as _Science and Children_, _Science Activities_, the Newsletter of the Council for Elementary Science International, the newsletter of your state science teachers association, and others provide valuable ideas and resources for elementary teachers--ideas and resources they can use in their own classrooms. If you already have such journals in your school, make a note to call them to your teachers' attention. You may want to look them over yourself and duplicate an article or two that you believe would be useful to your teachers.

II. SCIENCE TEXTBOOKS AND/OR WRITTEN CURRICULUM MATERIALS

You can learn a lot about your science program by examining your science textbooks and/or other written curriculum materials. In this section we shall guide you in the review of those curriculum materials, looking specifically at science content, processes, and other factors which may contribute to an effective science curriculum.

II.A. SCIENCE CONTENT

Most science learning experiences are based on written materials, usually textbooks. Science facts, concepts, and generalizations are included in those materials. They represent the cumulative knowledge of hundreds of scientists over many years. These concepts or generalizations are the content or subject matter of science, the product of years of observation and experimentation. Generalizations like "most matter expands when heated and contracts when cooled," expresses several concepts. This generalization enables us to connect and explain a number of different events: a glass that breaks when we put boiling water into it, a steel bridge that is a tiny bit longer in summer than in winter, the rise and fall of fluid in a thermometer, electric power lines that sag more in summer than in winter, and so on. Such concepts help children to understand and interpret their environment and should be a part of the written curriculum materials.

II.A.1. "What should be taught in science?" is a question raised by many who have given some thought to the content of the science curriculum. Opinions differ about what should be "covered." We are all familiar with the emphasis that has been placed on the facts of science: the sun is

93,000,000 miles away, spiders have eight legs, water expands when frozen, magnets attract iron and steel, and so on. While most science educators agree that science content should be relevant to the lives of the children and that it should be learned through a "discovery" process, they do not agree on exactly what content should be included in science curricula. A review of elementary science curriculum materials reveals a diverse coverage, emphasis, and grade level placement of science content. Some curricula introduce electricity in second grade, others in fourth. Animal and plant life is a major unit in some first grade programs, others do not mention it until the third grade. Rocks are included in some curricula, omitted in others. A rule of thumb that many principals find useful is to compare the emphasis on content related to the physical, life, and earth sciences and look for an approximately equal emphasis among these three areas. While this technique certainly does not guarantee a good science program, it does make difficult the exclusion of whole areas of science content.

II.A.2. Science is not a subject that is studied only for the joy that it gives; rather, it is studied for the value it has for the children's lives now and in the future. Science should help children learn about themselves and the world around them. It should enable them to make wise decisions. It should help them to understand how their own bodies function; what causes day and night, the seasons, and weather; and how energy flows in ecosystems. It should help them to recognize societal issues related to science and technology, such as pollution, the use of pesticides to control agricultural pests, food production and nutrition, and energy production and consumption. Science classes are the place to begin learning and thinking about information relevant to issues concerning us now and in the future.

II.A.3. One of the main reasons for teaching any school subject is to help children apply what they learn to everyday life. Concepts related to energy can help children count calories in the food they eat, see the relationship between home insulation and money spent on energy, or enable them to explain how energy is transformed from one form to another in a kitchen. A unit on plants can help children identify those used for food; others, such as aloe and foxglove, used for medicine; and still others, such as crown vetch, used for erosion control. Concepts related to air and water can help children interpret weather forecasts, understand how our pollution produced in one part of the country can affect another part, and explain how cloud cover affects the Earth's surface temperature. Look for evidence of real life applications in your science curriculum. They will help children use the science concepts learned in school.

II.B. SCIENCE PROCESSES

Scientific inquiry is often described as the search for knowledge. It is what scientists do when they attack problems and search for solutions. When someone inquires or investigates or uses the methods of science they are involved in science processes. That is, they *do* science.

In the elementary school these processes include observing, classifying, communicating, measuring, hypothesizing, predicting, inferring, designing investigations and experiments, collecting and analyzing data, drawing conclusions and making generalizations. These process skills are basic to science as a discipline and basic in helping children learn how to learn. An elementary science program that lacks an emphasis on processes is probably not an effective program.

II.B.1. Good elementary science programs ensure that all the children will be involved in hands-on investigations for approximately 40 to 60 percent of their class time. The emphasis should not be on teacher demonstrations or investigations that the children read about but can't or won't do themselves. Rather, to learn science they must do it. They must participate. They must work with science materials. They must discover for themselves.

II.B.2. If your science program tells kids all the answers without letting them find out for themselves, it probably isn't a very good program. Read through some of the investigations. Are the kids told what to do, how to do it, and how it will come out? If the answer is yes, you can be sure that the investigations are cookbook. If the teachers and kids are required to follow recipes, they will lose the joy and excitement that comes from making their own explorations and discoveries. Cookbook experiments require few decisions and little thinking, and they deprive children of opportunities to learn how to learn--a basic skill that lasts a lifetime.

II.B.3. Look for evidence that children receive heavy doses of science processes. We become better observers by practicing observation. We learn to measure by measuring. We learn to analyze data by analyzing data. We learn to design investigations by designing investigations.

These process skills cannot be learned without opportunities to practice them. The science reading materials should help provide those opportunities.

II.B.4. The written materials should challenge children to solve problems by applying science process skills. For instance, primary grade children can be invited to measure the lengths of various objects with paper clip chains, infer the size and shape of hidden objects by observing their shadows, or classify materials according to their magnetic properties. Upper grade children can be invited to construct scale models to show the relative sizes and positions of planets in the solar system, design investigations to determine the types of soil in which seeds will grow best, or devise plans for saving electricity at school or home. In each example, the activity is designed, either in its written description or by teaching strategy, to invite children to use science processes to solve problems. Children are confronted with problem situations and apply science processes to solve them. Look for such opportunities in your science program.

II.C. OTHER CONSIDERATIONS FOR WRITTEN SCIENCE MATERIALS

Since your written science materials are the common guides for your science curriculum, you will want to ensure that they emphasize not only content and processes, but that they are consistent with your goals, that they are interesting and make sense to the children, and that they are designed for easy and effective use by teachers. This section will focus on additional considerations for you to think about as you examine your written science curriculum materials.

II.C.1. Your curriculum materials should help achieve your science goals. If one of your goals is to "help children understand the environment and make wise decisions about it," then your curriculum materials should include environmental science and opportunities for children to practice decision-making skills. If one of your goals is to "help children develop problem-solving skills," then the written materials should include opportunities for children to use process skills such as classification, inferring, predicting, and formulating and testing hypotheses. Your goals tell you where you want to go, your curriculum materials tell you how you will get there.

II.C.2. Good science programs include materials which are clearly written, accurate, and up to date. Spot check your written materials. Would most children be able to read and understand them? Do they appear accurate? Are they up-to-date? What is the most recent copyright date? Are references linked to recent discoveries in science and technology and current problems confronting society?

II.C.3 Everyone knows that children "learn by doing." But Piaget, a Swiss researcher who has made a great impact on the design of elementary science curricula, puts it somewhat differently: not only do children learn by doing but they learn by <u>thinking</u> about what they are doing. Piaget has divided the thinking processes of school-age children into three broad overlapping stages: preoperational thought, lasting from about age four to seven years; concrete operations, from about seven to twelve years; and formal operations, from twelve years on. Since preoperational, concrete, and formal thinkers differ in how they operate mentally, teachers must design experiences to fit what they can do.

In general, this means that primary-level children learn best when their science activities stress perception. Preoperational thinkers use all their senses to help them describe and organize, in simple ways, the properties of living and non-living things. Children in the middle grades (ages eight and nine) usually work well with problems and ideas that refer to concrete materials such as magnets, electrical circuits, gerbils, and rocks. Upper-grade children (ages ten on) still need the concrete experiences to work from, but often are able to develop abstract ideas (transfer of energy, interdependence of living things, water cycle, and so on) from their experiences(8). The written portions of the science program should reflect experiences which take into account the developmental levels of the children.

II.C.4. Science materials that children are expected to read should be appropriate to their level. If they are not, boredom and frustration often result. Most written science materials (texts) have had readability formulas such as the Fry or the Dale-Chall applied to them. Look for information about readability levels in the teacher's guides or request such information from the publisher. If this information is not readily available, you may wish to ask your school reading specialist to review the materials for grade level applicability.

II.C.5. Research shows that children have a high interest in science and that they like to read science-related books. As you review the written science materials put yourself in the children's place. Are the materials interesting? Do they arouse your curiosity? Do they stimulate excitement? A good way to kill kids' interest in science is to select science books that are dry, dull, and boring.

II.C.6. While only a few children in your school are likely to become scientists, many will pursue careers that are related to science and technology. The elementary school is a good place to have kids begin thinking about career options and reading about laboratory technicians, engineers, health specialists, ecologists, and others who serve as occupational role models. The written materials should include information on science-related careers.

II.C.7. Teachers often complain about the lack of evaluation materials in science-programs--and rightly so. Good science programs provide tests and other evaluative instruments for use by teachers. Such instruments should be valid. They should measure the children's progress toward achieving the goals and objectives of the program.

And they should go well beyond the simple recall and memorization of science content. They should evaluate the pupils' higher-level thinking skills. Can the children control variables? Can they design investigations? Can they analyze data? Can they do what the curriculum is designed to have them do?

II.C.8. The teacher's guide for written science materials is especially important. A good guide will help ensure good science classes. It will be by the teacher's side for reference and use. It should be organized and written so that teachers can understand it. It should be easy to use and take little time from their busy schedules. It should contain objectives, teaching strategies, materials needed, and other ideas for teaching science effectively. Teachers must perceive that the teacher's guide is useful to them, otherwise, they may not use it and science may not be taught.

II.C.9. Finally, the written science materials should include many practical examples of how science applies to the children's lives. Studies of the human body should be related to their bodies. The study of rocks and minerals should begin with those commonly found where they live. The study of electricity should include technological applications with which they are familiar, such as flashlights, car batteries, and electrical appliances in their homes. Children should be encouraged to investigate and explore their immediate environment, relating science concepts to those experiences and using science processes in their daily lives.

III. VISITING YOUR SCIENCE CLASSROOMS

One of the best ways to learn about your school is to go where the action is, where teachers teach and students learn--the classroom. This section focuses on what you can learn about your science curriculum by observing teachers teaching science and students learning it.

III.A. OBSERVING TEACHER BEHAVIOR

Observing teacher behavior is one of the keys to judging the effectiveness of your science program. Their attitudes toward science, the teaching strategies they select, their questioning techniques, their integration of science with other curricular areas--all are indicators of overall program effectiveness.

III.A.1. Times for teaching science, either by minutes per week or by scheduled times each day, or both, must be adhered to by teachers. One of the most important actions you can take to achieve an effective science curriculum is to let teachers know they are expected to teach science and determine if they are, in fact, teaching it. Make it a point to schedule your visits to classrooms to coincide with scheduled teaching of science.

III.A.2. Teachers who dislike science will usually do a lousy job of teaching it or avoid it altogether. Many teachers will take their cues from you, the principal. If you show an interest in science, they will show an interest. If you talk it up, they will talk it up. If you show that it's important to you, it will likely become important to them. Help your teachers to accentuate the positive and eliminate the negative. Help them to feel better about teaching of science. Talk to them. Find out about their feelings toward science.

III.A.3. "Variety is the spice of life." That old adage also applies to the science classroom. Although we may have food favorites, a steady diet of the same thing would certainly become boring. So it is with science classes. While children must be involved in science investigations, class after class of investigations can become boring and counterproductive, just as a class after class of reading and recitation can become boring and counterproductive. A good science teacher will use a wide variety of teaching methods, keeping the children interested while achieving the objectives.

Good teachers know that variety helps to stimulate and maintain interest. Look for evidence that children participate in a variety of experiences during their science classes: experiences such as investigations, reading, gaming, role-playing, field tripping, discussing, working alone or in small groups, writing, doing projects, and so on.

III.A.4. In the past, much of science teaching has focused wholly on science content. Electric current is the flow of electrons. Like ends of magnets repel, unlike attract. Mammals have hair. Rocks are igneous, sedimentary, or metamorphic. These are all examples of science content we have learned. While content is still important, science teaching cannot be effective unless it includes opportunities for children to participate in science processes. Teachers must see to it that children develop skills like observation, communication, measurement, identification and control of variables, and experimental design. These processes have lasting value because through them children are learning how to learn.

But learning content and processes is only part of the task. Equally important is the need for children to learn how to <u>apply</u> the content and processes to their own lives. And application is learned through practice.

Teachers should provide opportunities for children to apply what is learned. For instance, the predator-prey relationship may be best learned in a simulation game in which some children play the role of wolves and others antelopes. Or children's investigations of their own reactions to touch, sound, and sight stimuli can help them learn to formulate and test hypotheses while learning about their own nervous systems. And societal issues such as pollution, energy availability and cost, strip mining, or the use of pesticides can be introduced through role-playing. First, children read about an issue, then advocate a particular point of view, much as adults might do at public hearings.

When you observe science classes, look for children learning the content and processes of science and how to apply them to their everyday lives.

III.A.5. Your science curriculum may be in trouble if most classroom experiences focus on a science book or on the teacher. Science is best learned by participating in it; by making observations and doing investigations; by discussing results with others, children and teachers; by working alone and in small groups; by discovering things you didn't know before; by testing ideas. Reading, teacher lecture, and recitation are still important parts of science classes, but the heart of those classes must be active, manipulative, hands-on experiences. Teachers who do not provide substantial numbers of those experiences for children are probably not teaching science effectively.

The work of Piaget has shown us clearly that if we want to help children to develop their thinking skills then they must be allowed "to think with their hands." Words, spoken or written, are helpful to most children only to the extent that they have an opportunity to manipulate concrete objects. They must work with real materials before they can grasp abstractions. Experience with real objects provides the foundation upon which abstract thought is built. Children must have an opportunity to manipulate a wide variety of material objects, and the science class is a natural place for this to occur(9).

III.A.6. During class investigations teachers should become guides and helpers. They should set the stage and then get out of the way while the actors perform. They should move about the room observing, evaluating, asking questions to clarify concepts or spark more interest. They should lend their hands where they are needed and give pats on the back where they're deserved. They should exhibit interest, enthusiasm, and encouragement.

III.A.7. All too often teachers of science kill curiosity by telling the children too much. They tell them what to do, and how it's going to turn out--before the kids have an opportunity to discover for themselves. How many times have we heard teaching go like this, "Electric current is the flow of electrons in a circuit. Simple circuits include a source, a path, and an appliance. In the circuits we will make, the dry cell is the source, the wire is the path, and the bulb is the appliance. Now, take your cell and ..."

A far better technique, both in terms of interest and retention, is to pass out a cell, a bulb, and a wire to every pupil and challenge them, "Can you make the bulb light?" Once pupils have discovered how to make the bulb light, perhaps by several different arrangements, the teacher can then "invent" the concept of simple circuits. The difference in these two approaches is that in the latter, the children's concepts are built on a foundation of experience--the way it should be according to what is known about how children learn to think. Good science teachers provide experiences first, then help children build concepts related to them.

III.A.8. When describing questioning techniques, wait-time is defined as the amount of time that elapses from the time the teacher completes the asking of his or her question until the time a student responds. In her study of questioning behavior of teachers Mary Budd Rowe(10) found that teachers, on an average, wait less than one second for students to reply to their questions. When wait-time is increased to an average of three seconds or more, the following occurs:

a. The length of student response increases 400-800 percent.

b. The number of unsolicited but appropriate responses increases.

c. Failure to respond decreases.

d. Confidence of children increases.

e. The number of questions asked by students increases.

f. Slow students contribute more. Increase is from 1.5 to 37 percent.

g. The variety of types of responses increases. There is more reacting to each other, structuring of procedures, and soliciting. Speculative thinking increases as much as 700 percent.

h. Discipline problems decrease(11).

Questions require thinking. Wait-time increases the likelihood that children will have a chance to think. Measure the wait-time of your teachers. Encourage them to allow pauses of at least three to five seconds.

III.A.9. Communication skills can be sharpened during science class. As children observe, work on investigations, and make discoveries, they often have ideas they wish to share. Through such verbal interaction children often display considerable insight, innovation, or unusual perception. Teachers can encourage such behavior by listening carefully and attentively to what children say. Listening to the children can also help the teacher assess the pupils' level of understanding.

III.A.10. The attitudes that children learn in school are among the most important things they will ever learn, and they are likely to stay with them the longest. Science class is a good place to encourage favorable attitudes. The Science Curriculum Improvement Study (SCIS) identifies several attitudes which are a part of scientific literacy:

a. curiosity--paying particular attention to an object or event and spontaneously wishing to learn more about it

b. inventiveness--generating new ideas

c. critical thinking--basing suggestions and conclusions on evidence

d. persistence--maintaining an active interest in a problem or event for a long period of time(12)

To this list we could add

e. open-mindedness--a willingness to hear many points of view before drawing a conclusion

f. responsibility--care in handling equipment and promptness in meeting assigned tasks, and others

These are attitudes and behaviors which can be encouraged by teachers who make science fun, interesting, and challenging; by teachers who encourage success, who build children's self-esteem, and who serve, themselves, as role models of such behaviors.

III.A.11 Mainstreamed handicapped students--the visually, hearing, or orthopedically impaired, the mentally handicapped, the learning disabled--should also be involved as participants in science experiences. Though their handicaps may represent challenges, these children can profit just as much from hands-on science experiences as others. The extent of their participation, including the use of special instruction or materials, can be noted in their Individualized Educational Programs (IEP).

III.A.12. Science can enhance skills from other parts of the curriculum. When pupils look up information about planets in an encyclopedia, they are reading. When they measure and graph changes in plant growth, they use mathematics. They use language skills to organize and report their observations and experiments. When children plan and draw a large picture to illustrate the bones in their bodies, this is art. Such integration of subjects is both desirable and usually necessary if you want to promote useful learning.

There are also times when content subjects or parts of subjects are integrated with science. Energy and environmental education, social studies, health and safety are often treated in this fashion. Drawing on skills and content from several subjects makes it easier for cohesive, whole understandings to form in pupils' minds(13).

Research on science as a vehicle for helping children learn the basic skill subjects is both massive and convincing. It shows that programs based on manipulative materials are especially helpful in building reading and language readiness levels in primary pupils. And it shows that first-hand experiences in science expand pupils' vocabularies and reading comprehension at all levels(14). Look for evidence that teachers integrate science with other subject areas. Such integration can have salutary effects on skills developed, content learned, and time spent.

III.A.13. Once you and your staff have decided where you want to go in science (your goals) and how you're going to get there (your planned learning experiences), you will want to know if you've arrived. Are you meeting your goals? Are you accomplishing your objectives? Teachers should make regular assessments of student progress toward objectives. Many techniques can be used including written or verbal tests, performance tests, classroom observations, competency check-lists, interviews, and others. Children should be given the opportunity to demonstrate their competencies, records of progress should be kept, and periodic reports made to both the children and their parents.

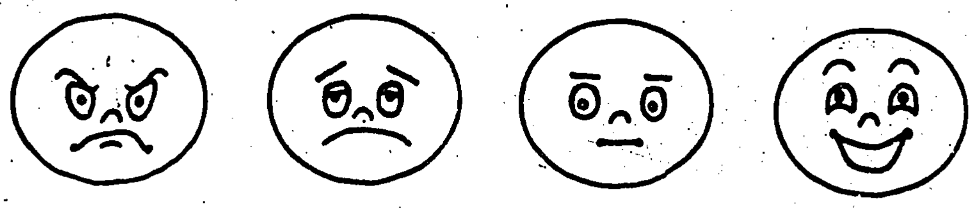
III.B. <u>OBSERVING CHILDREN'S BEHAVIOR</u>

You can also learn a lot about your science program by observing the children in action. Do they appear to like science? Are they interested? Do they participate in a variety of experiences? Are they responsible and careful in their use of science equipment? The answers to these and other questions are indicators of the overall strengths or weaknesses of your science curriculum.

III.B.1. How children <u>feel</u> about science may be more important to their achievement than any other variable. In studying data from 17 different countries Benjamin Bloom found that as children develop more positive attitudes and interests in science, their achievement increases(15). Children who like science and enjoy learning it are probably building positive attitudes both toward science and toward themselves. Children with positive self-concepts tend to be more successful in science. And success breeds success. Look for children who enjoy science; children who appear interested, enthusiastic, or excited about their studies; children who display an aura of joy in their work.

III.B.2. A good way to find out how children feel about science is to ask them. Children who respond, "I hate science," or who shrug their shoulders are obviously displaying less than positive attitudes. The Science Curriculum Improvement Study (SCIS) suggests an assessment that can be used to gauge primary children's attitudes toward science. Children are asked questions, such as those shown next, to which children respond by circling smiling faces.

What do you feel when we study science?



III.B.3. Classroom experiences in which children participate in manipulating objects, making discoveries that are new to them, describing and discussing their findings, and in utilizing the processes of science are involved in science activities consistent with modern learning theory and the goals of science education. Children whose science experiences are limited almost entirely to reading about science or listening to their teacher tell them about science are neither learning science as it really is, nor developing basic skills. Glenn Blough(16) advises us, "Don't overdo reading. Use it <u>after</u> first-hand experiences, not as a beginning activity. Encourage children to read on their own, but don't use it as the major activity."

III.B.4. Children working together in pairs, small groups, or as a whole class can learn much from ideas shared with each other. Explaining one's ideas in clear, understandable language is an excellent way to promote verbal skill development and improve thinking. Children who are exposed to various viewpoints will evaluate their own views more realistically. Class discussions also allow the teacher to gauge individual and class progress(17).

III.B.5. Many teachers are surprised when children who have difficulty reading perform as well as or better than other children during science. Perhaps they shouldn't be surprised. The rules of the game are different. In science they can observe, explore, and discover. They can practice thinking skills and express their ideas verbally, without dependence on the written word. For many children with limited reading skills, a hands-on science class is one of the few places in school where they can attain success. Activity-centered science classes provide many opportunities for children to demonstrate talents such as creativity, critical thinking, and speaking skills, which may not be demonstrated readily in classes heavily dependent upon reading.

III.B.6. More and more, teachers are recognizing that individual differences among children present a persistent problem that must be dealt with. More and more, they are saying that children should have some choice in what and how they learn. More and more, we are becoming aware that children can learn much from individual work with materials and from each other as from teachers(18). Look for children engaged in individual science projects or working at learning centers or discussing their ideas with each other. A good science program will provide activities to help teachers cope with individual differences.

III.B.7. Kids are natural explorers. They like to look under rocks, catch bugs, collect frogs and toads, and smell wildflowers. They like to push, probe, feel, and try. They are curious. There is no better place than in science to encourage children to explore, to learn about their environment and themselves, to find out what makes things tick, or to test the limits of their imaginations. Science, whether in a classroom, on the school lawn, or in a nearby park or woodlot, should be the place where discovery is encouraged, curiosity rewarded. Asking questions of nature and finding answers for themselves is the very essence of science and of learning how to learn for a lifetime.

IV. ASSESSING SCIENCE RESOURCES AND FACILITIES

Science materials and supplies form the backbone of a good elementary science program. Just as reading cannot be taught without books or writing without pencils and paper, science cannot be taught without materials and supplies for the children to get their hands on. Experiences are the basis of science, real experiences with objects and events. This section will consider the availability of science resources and facilities and the means to acquire them.

IV.A. LOOKING FOR SCIENCE IN THE CLASSROOMS

Most science will be taught in self-contained classrooms or, less often, in classrooms specifically designated for science instruction. Your judgment about the adequacy of your science resources and facilities will be determined by what you observe in those classrooms. Visit them and look for evidence that hands-on, activity-centered, participatory science can be taught and is being taught.

IV.A.1. Science materials should be available in sufficient quantities to allow <u>all</u> students to have hands-on science experiences. Look for objects the children use, objects such as magnets, batteries and bulbs, pulleys, aquaria, plants, rocks, buttons, and thermometers. If kits, such as SCIS, ESS, or others are available, spot check them to see if most of all of the materials that are supposed to be available are available.

Many educators feel that science cannot be taught without a lot of expensive, sophisticated materials. We know from experience that that is simply not true. Good science teachers take advantage of free and inexpensive materials and do an excellent job of involving children. Many commercial programs also stress the use of simple, relatively inexpensive equipment and supplies. Styrofoam cups or Big Mac boxes make excellent planters for seeds purchased in a supermarket. Wooden dowels make excellent shadow sticks. Soda straws make good building materials for testing durability and strength. Children can make their own "metersticks" from oaktag, cardboard, or construction paper. The possibilities are unlimited. However, many good science programs have never gotten off the ground because teachers were expected to provide too much equipment on their own and they simply had neither the time nor the interest to do so. Most successful science programs provide materials for use by the teachers.

IV.A.2. Many science supply areas and kits look like Mother Hubbard's Cupboard--bare. Every materials-centered program is going to require periodic replacements. Science is no exception. Spot check some of your science storage areas to determine if items have been reordered and replaced.

It is the classroom teacher's obligation to identify his or her science needs and initiate requests for replacement. As principal, it is your responsibility to see that such needs are met if they are realistic and within the parameters of your budget.

IV.A.3. The classroom should have adequate storage space for science supplies and equipment. Space may range from as little as several shelves in a closet to built-in cabinets provided specifically for science storage. If your science program includes kits, storage space is already provided in the kits. Examine the science storage areas in your classrooms. Are they adequate now? Would they be adequate if the school were to adopt a new program which included a considerable inventory of supplies and equipment?

IV.A.4. Most science lessons are probably taught without the use of running water, sinks, and electrical outlets, but it sure helps to have these facilities when they are needed. Such facilities, though not absolutely necessary, make the teaching of science more convenient for the teachers.

IV.A.5. Classrooms where science is taught should be interesting rooms to visit. Upon entering you should expect to see visible evidence that science is happening. Animals in cages, terraria, or aquaria, growing plants, on-going experiments, shelves of science-related books, bulletin boards, curiosity corners, science tables, or other science phenomena should readily meet the eye. If they do not, there is probably not much science teaching and learning going on in that room.

IV.A.6. Look around the room. Is there physical evidence that science content and processes are being applied to other curricular areas or to the students' lives in and out of school? Are there classroom displays of science-related stories, reports, or poems? Are there graphic or tabular displays of data from investigations? Are there drawings or posters of things children have studied? Are there projects or investigations which show evidence of their work in science? Children who are actively involved in science will have something to show for it. Look for it during your classroom visits.

IV.A.7. Experiences with objects and events are especially important for elementary school children. They are at the heart of a good science program. However, while children cannot possibly experience everything, they can build on their experiences through reading.

Books, in the classroom, can help extend their science experiences. A garter snake's visit to class is a natural lead-in to reading about snakes around the world. Building aquaria with guppies, snails, and water plants provides the foundation for reading about life in oceans. Using a cell and wire to light a flashlight bulb is the forerunner to reading books about electricity and other forms of energy. Books and other reading materials, selected for their potential to build on earlier science experiences, are valuable learning resources in good science classrooms.

IV.B. LOOKING FOR SCIENCE BEYOND THE CLASSROOMS

Science is not limited to the classroom. Good science programs extend science beyond the classroom walls--to the furnace room for an energy lesson, to the lawn for a food-chain game, to the graveyard to study the effect of air pollution on tombstones, to a stream to observe crayfish, to a zoo to study animal adaptations. What resources do you have near your school? Do you encourage your teachers to use them?

IV.B.1. Children can learn a lot of science outside the classroom. Field trips can be as short as to the school lawn or as long as to a museum miles away. The important thing is that they happen, that children have the opportunity to participate in real activities and observe real events. It's difficult to match the excitement of seeing flying squirrels glide from their nests during a trip to the forest, or the apprehension caused by the sight of a garter snake in the grass, or the curiosity created by an anteater at a zoo. Such experiences are the stuff of which interest is built and concepts conceived. Good science programs provide for such opportunities.

IV.B.2. Science books are popular among kids. Research supports that contention. Sarah Graham, a librarian in Rochester, New York, kept records of what books children signed out of her library for a year. She found that they selected science as the second most popular category of books. The first was fiction, and some of these books were in science fields or science fiction (19). Check your library shelves. Are your holdings in science adequate? Perhaps you can encourage your librarian and your teachers to be on the lookout for science books they can recommend for children. Science books can help children build upon and extend their classroom experiences.

IV.C. ACQUIRING SCIENCE MATERIALS

As principal one of your major roles is to ensure that teachers have materials to teach with and pupils have materials to learn with. Because science is a subject area that is so materials-oriented, it is imperative that you have a system for acquiring the needed resources, a system that is economical in terms of time, effort, and money and one that gets the materials efficiently and effectively to where they are needed--the classrooms.

IV.C.1. We have called materials the backbone of the science program because they are the objects of the pupils' hands-on experiences. Without them, little real science can be taught. Science materials and equipment should be located in the classrooms where they will be used. As Bethel and

George(20) point out, "equipment should be in a place where teachers and students have access to it quickly and easily at any time of the day."

IV.C.2. It is simply good sense to involve teachers who are expected to use science materials in their selection. While this sounds good in theory, it often doesn't work that way in practice. Frequently, teachers are not consulted and, as a result, feel that they have been saddled with someone else's selection. Often such purchases may be inappropriate to the needs of the teachers. Teachers must be involved in the selection and purchasing process. Not only will their participation increase the likelihood of wise choices, but by allowing them to share in the decision-making process, you will give them a stake in using the materials to make the science program work.

IV.C.3. If the procedures for ordering science materials are not reasonable, simple, and efficient, then it is unlikely that they will be used. As a result, there will be few materials for children to use in the classrooms. Review your ordering procedures periodically with your teachers. Ask how they can be improved and made more efficient. All too often elementary teachers simply don't know how to go about requesting or ordering materials. Make sure your teachers are familiar with your school's ordering procedures.

IV.C.4. Teachers have the main responsibility for inventorying, ordering, storing, and using science materials safely. As principal, you can help them by preparing inventory forms, by instructing them on ordering procedures, by providing storage facilities when required, and by setting standards for safety. But it is they who must follow through by carrying out these tasks. It is important for teachers to know both their responsibilities and your expectations.

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