Every Child a Scientist

Achieving Scientific Literacy for All

How to Use the *National Science Education Standards* to Improve Your Child's School Science Program

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Introduction

The astronomer Carl Sagan once said, "Everybody starts out as a scientist. Every child has the scientist's sense of wonder and awe." Sustaining this sense of wonder presents teachers, parents, and others close to children with a tremendous responsibility—and an extraordinary opportunity.

Parents and other adults can improve the quality of education in many different ways. This booklet is for those who want to take an active role in improving the science program in their schools. The *National Science Education Standards,* published in 1996 by the National Research Council, can be an important guide in realizing this goal. The *Standards* call for a kind of science education that is rare in science classrooms. While focusing on key scientific concepts, the *Standards* also stress the importance of how students learn. Students need to be able to ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. Students' learning needs to be assessed in ways that further their mastery of science. All students need supportive educational programs and systems that nurture achievement.

The first section of this booklet argues that science should be a part of all students' education. The second section provides a vision of the curriculum and teaching in a classroom where students can gain the understanding of science and technology that they

In a rapidly changing, increasingly technological world, all students need to understand science and technology. Teachers and administrators increasingly need parents and other members of the community to become partners in making sure our children know what they need to know.

need in today's society. Sections three and four outline how the *Standards* can help improve the quality of the science being taught and how it is assessed. The last section suggests what you can do to become a partner in improving science teaching and learning in your school.

As you read this booklet, consider what you can do to boost the quality of science education in your community. You might be able to raise this matter with your local parent-teacher association, talk to your child's science teacher, or become involved in establishing school policy at the district level. Your commitment—and help—are key. Your input can help make the difference between a mediocre science program and a world-class science education.

In a rapidly changing, increasingly technological world, all students need to understand science and technology. Teachers and administrators increasingly need parents and other members of the community to become partners in making sure our children know what they need to know.

Why Do We Need Science, Anyway?

Laser surgery . . . life in a meteorite from Mars . . . cable television . . . the Internet . . . gene therapy . . . faxes . . . . These are signs of our times, markers of the late 20th century's scientific and technological revolution. Science and technology have changed the way we work, communicate, and view the world.

As adults, we can remember a time—not so very long ago—when our homes and businesses were quite different. In the late 1960s, answering machines and VCRs were not commercially available. Now they are commonplace. In the 1980s, offices were beginning to use computers. Today, not only do most office workers have their own "PC," but many computers are part of an extensive network—the Internet—that can bring information, photographs, and moving images to individuals at work and at home.

TECHNOLOGY HAS CHANGED OUR LIVES

Computer technology also has revolutionized industry. Automobile manufacturing plants rely increasingly on automated systems to do the job hundreds of workers used to do. The workforce in such plants must have a radically different set of skills than did their predecessors.

Agriculture has been influenced by scientific advances as well. Through genetic engineering, farmers and scientists are working together to develop more productive, heartier, and disease-resistant crops.

These days, it is difficult to think of a job that does not require some expertise in technology. Take your neighborhood school. Right now, your school's cafeteria workers may be using e-mail to send the

QUESTIONS ON THE NAEP TEST

According to the National Assessment of Educational Progress (NAEP), only 14 percent of fourth-graders knew that it is easier to stay afloat in salt water than in fresh water and could explain why. Only 10 percent of eighth-graders knew why eating potato salad made with mayonnaise that has been left out in the sun could cause food poisoning. Only 26 percent of twelfth-graders could figure out how to use a sieve, a magnet, water, and a filter to separate a mixture of steel pellets, copper pellets, iron filings, sand, and salt.

school lunch orders to the dispatcher. The custodial staff may be in a workshop to learn how to operate the school's new, high-tech security system. The administrative assistant could be faxing immunization records to the school system's central office to expedite the registration of new students. Using the school's computer network, your child's teacher may be looking at grade reports as the principal reviews the agenda of the upcoming school board meeting.

During the past two decades, science also has become more integral to our daily lives. Twenty-five years ago, if a child injured her knee while playing soccer, parents would take her to the emergency room for an X-ray. Today, the doctor could recommend an MRI (magnetic resonance image) as well. The more familiar people are with such devices and procedures the easier it will be to make informed decisions about their use.

Many of us in our own homes and workplaces are scrambling to keep up with science and technology, but our children cannot afford to be unprepared. They must be ready to take their roles as citizens, employees, and family members in a rapidly changing world and highly competitive global job market.

IS OUR EDUCATIONAL SYSTEM KEEPING UP?

Preparation for a more scientifically and technologically complex world requires the best possible education. Beginning in kindergarten, children must learn how to think critically, synthesize information accurately, and solve problems creatively. They also need new skills-facility with computers, the ability to communicate using all available media, and familiarity with the science and technology that form the foundation of the modern world.

Is our educational system meeting the changing needs of our students? Evidence from the 1996 National Assessment of Educational Progress (NAEP) suggests not. Administered to students in grades 4, 8, and 12, these tests are designed to provide a snapshot of our progress in science education. Although most students have some grasp of basic scientific facts and principles by the end of high school, they are not able to apply scientific knowledge to a new situation, design an original experiment, or explain the reasoning behind their answers.

THE PURPOSES OF NAEP AND TIMSS

For over 25 years, the National Assessment of Educational Progress (NAEP) has been the United States' only ongoing assessment of K-12 students' educational progress. This Congressionally mandated test measures what students know and are able to do against what has been agreed as desirable for students to know and be able to do in science as well as in other subjects. Whereas NAEP scores show the level of knowledge a student has (basic, proficient, or advanced), the Third International Mathematics and Science Study (TIMSS) is an international comparative study on an agreed upon set of topics in math and science.

The Third International Mathematics and Science Study (TIMSS) revealed a slightly different picture in 1997. When ranked against the other nations in this sample, U.S. fourth-grade students significantly outscored students from 13 nations in science. Only students from Korea performed better. Unfortunately, by the eighth grade, U.S. students scored only slightly above average in science among all 41 countries in the study. Students in Japan, Korea, Singapore, the Czech Republic, and Hungary surpassed U.S. students in science achievement. The chart below summarizes these results.

Although there probably are multiple reasons for the poor results on the NAEP and the eighth-grade TIMSS tests, the message from

Nations' Science Performance Compared To The U.S.*

Grade 4	Grade 8
NATIONS WITH AVERAGE SCORES SIGNIFICANTLY HIGHER THAN THE U.S.	**NATIONS WITH AVERAGE SCORES SIGNIFICANTLY HIGHER THAN THE U.S.**
Korea	Singapore Czech Republic Japan Korea Hungary
NATIONS WITH AVERAGE SCORES SIGNIFICANTLY LOWER THAN THE U.S.	**NATIONS WITH AVERAGE SCORES SIGNIFICANTLY LOWER THAN THE U.S.**
England Canada Singapore Ireland Scotland Hong Kong New Zealand Norway Iceland Greece Portugal Cyprus Iran	Spain France Iceland Latvia Portugal Portugal Lithuania Iran Cyprus

* (Table amended from *Pursuing Excellence* [two studies], U.S. Government Printing Office, 1996, 1997)

both is that, on the average, our schools are not providing the kind of quality science experiences our students need in a highly technical and competitive world.

GOOD SCIENCE TEACHING CAN MAKE A DIFFERENCE

The key ingredient in improving the quality of student learning are the experiences provided by a motivating teacher. Is there anything more exciting to a young child than watching chickens hatch from their eggs? Or when older students look at tiny organisms under a microscope and discover their wonderful construction? From this initial experience, teachers can help students learn what living things need to sustain life, show them what happens when they are deprived of those things, and help students develop a respect for living things.

Perhaps the most important role of science is to sustain that sense of awe and wonder in young people that comes from exploring and understanding the natural and technological world. Because science can make a unique difference in a child's life, it is important for it to be a central part of the school curriculum. When it is well taught and student engagement is high, science can be the academic subject that keeps a child's natural love of learning alive.

Start with a Vision of High-Quality Education

Imagine a classroom in which students are sitting in small groups, not in rows. The teacher is walking around the classroom answering questions and listening to ideas instead of standing in front of the class, reading from a book, or lecturing while the students take notes. This classroom is probably very different from the one you remember from your own school years.

This particular class, a group of second-graders, is beginning a unit on weather. As an introduction to the subject, the teacher has asked the children what they already know about weather and what they would like to learn. She discovers that they already have some basic ideas related to weather; they know about temperature, wind, rain, and snow and that weather can be predicted.

Then the teacher divides the class into small groups. One group is learning how to use a thermometer. They are responsible for going outside each morning, reading the temperature, and recording it on a class weather chart. Another group is looking up wind speed in the paper each day and recording that information while learning how scientists measure its strength and direction. A third group is measuring daily precipitation by using a rain gauge. These data, too, are recorded on the class weather chart. After several days of data collection, the groups rotate responsibilities. As the data accumulate, the class reviews its weather data and summarizes the weather in a class weather bulletin. One group enters the data in a student network program on the Internet and compares these data with those from students in other states.

In this classroom, the teacher has a different role from what most people have experienced in school. The teacher is a guide who selects and designs activities, listens to what the children have to say, and asks appropriate questions to help these already curious children learn more. The teacher is well versed in the subject matter, is working with exemplary curriculum materials, and is familiar with a range of teaching strategies.

This kind of classroom reflects a vision of high-quality science education. Children are engaged through the use of materials and experimental techniques to answer questions that they have helped to formulate. Children who learn best through reading have an opportunity to do so; those who learn through discussion with others can work collaboratively. All children—from the academically gifted to those with learning disabilities—have a conviction that they can succeed in science class and are provided with the opportunity to do so. Parents and school staff hold high expectations that all students will learn what they need to know.

KEY INGREDIENTS OF SCIENCE EDUCATION: IMPORTANT CONTENT AND ACTIVE LEARNING

What is unique about exemplary science teaching and learning? Two variables that stand out are well-selected, important content and a teaching approach that develops a deep understanding of the content.

Content. In the previous example, students were not memorizing the terminology of weather. They were focusing on what these words mean and how they can be used to describe the weather. The teacher did not introduce specific facts in isolation. Information was presented in context so that students could incorporate it into growing bodies of knowledge.

Another example that can be extended throughout elementary and secondary education involves life in an aquarium. In the third grade, a group of two students can maintain an aquarium and be responsible for feeding the animals and keeping their environment clean. As they observe the animals, these students learn what organisms need to survive. Students then can apply these concepts to organisms in any setting (a pond, a desert, a rain forest, or an urban park).

TEACHING SCIENCE THE OLD-FASHIONED WAY

In many science classrooms around the country, students are still being taught in traditional ways. They read aloud from science textbooks, memorize long lists of scientific terms, and prepare to take tests that call for simple rote recall. Laboratory experiences are usually designed to confirm what they have read or been told. Opportunities that allow students to think critically are few and far between.

According to NAEP data, most students taught in this way lose interest in science as they move through school to higher grade levels. As they lose interest, achievement declines.

By middle school, students are ready to extend these early ideas to learn about the structure of life at the cellular level and to understand the processes of reproduction and behavior. Similarly, in high school, students can deepen their understanding of the cell by adding concepts of molecular genetics. At each level, subjects are introduced in a systematic way, building on what was learned in earlier grades. By the time students graduate from high school, they have developed a deep understanding of the characteristics that all living things share. A similarly well-ordered, progressive development of ideas can take place in all the science disciplines.

Effective teaching in the physical sciences should have a similar focus on important concepts and effective learning experiences. In grades K-4, for example, students are expected to learn about the distinctive properties of the materials that surround us, as well as methods for measuring those properties. They may be given two solid powders—baking soda and cornstarch—and asked to perform a number of tests to determine their properties. Knowing these properties, students can identify the powders in a mixture with other powders.

Later, students may mix the powders with liquids, use a filtration process to separate the solids from the liquids, and heat the mixture as part of the experimental process. Through these investigations, children learn to recognize the states of matter and begin to understand how to transform materials from one state to another.

Students in grades 5-8 build on this base while learning about chemical elements, chemical reactions, and compounds, such as those we encounter in living and nonliving things. High-school students are

able to relate their observations of the chemical reactions to atomic-scale interactions they infer from their understanding of the structure of atoms. These students do far more than just memorize the names of the elements in the periodic table. They are expected to connect the behavior of chemical elements to their atomic structure.

Active Learning. Parents, teachers, and psychologists have long known that children learn best through concrete experiences. Young children often need to have an experience first, before they are ready to read about or discuss an underlying concept. Older students also benefit from engaging in scientific investigations to learn important science concepts.

An instructional approach patterned after the way scientists study the natural world, called *inquiry,* can achieve several important results. Through a combination of "hands-on" and "minds-on" learning, inquiry engages students in a process through which they learn science content best. By carrying out investigations, students learn how to make observations, pose questions, plan investigations, use tools to gather information, make predictions, propose explanations, communicate results, and reflect on the processes they have used. As students engage in these processes, they develop the ability to think critically and

ACTIVE LEARNING: BELIEF VS. PRACTICE

According to the 1993 National Survey of Science and Mathematics Education, approximately three out of four teachers surveyed in all grades said that hands-on activities should be a part of science instruction. However, the same survey reported that in half of the elementary science classes studied and in nearly two-thirds of the middle- and high-school classes studied, terms and facts were emphasized, and the largest proportion of class time was devoted to lecture and discussion.

to learn how to learn. They learn to use inquiry to acquire ideas and information on their own.

In addition, students learn that what they are doing is similar to the way scientists develop hypotheses, test their ideas, and discover new ideas or create new products. The uniqueness of science and a major reason it has made a major contribution to civilization is its basis in observations and experimentation. Scientists learn by starting with what is already known and asking questions, inquiring into what they do not know. These questions often lead to hypotheses about what the answers might be. The most useful hypotheses are those that can be tested experimentally. When the experimental results are those predicted by the hypothesis, a scientific theory begins to emerge. If the results are confirmed by others and no evidence to the contrary is found, scientists become more and more confident in the theory, and it becomes treated as a fact.

This ability to learn how to learn through inquiry should also be a crucial component of exemplary science teaching and learning. Knowing how to learn means that young people can locate new information and data, answer their own questions about the natural world, and solve problems with new technologies. It is a process not used in other subjects and one of the reasons science should be a part of all students' education from the beginning.

IT'S TIME TO RAISE EVERYONE'S EXPECTATIONS

Higher student achievement requires excellent teachers who are trained in teaching strategies that promote active, inquiry-based learning. An understanding of science content is not enough. Teachers need to be able to let students explore their own questions and raise issues in class with which teachers may be unfamiliar.

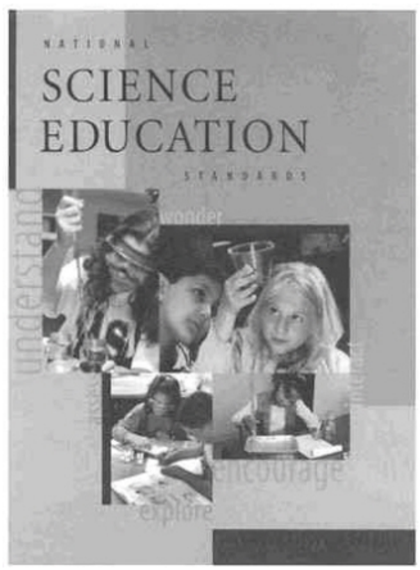
To improve achievement, teachers are not the only people in the classroom who have to change. Students must change, too. They must become more responsible for their own learning. Students may have to work harder and spend more time on projects before and after school. Teachers and administrators must hold students to higher standards than they have in the past.

Use the Standards to Bring Science to Everyone

Bringing exemplary science teaching into our schools nationwide is a challenge. It involves designing high-quality curricula, selecting appropriate instructional materials (textbooks, software, kits, lab equipment, and so on), preparing teachers to use the new materials, developing ways to assess student achievement, and building community support for the program. To make this transition, schools and school districts need the right tools. Fortunately, such tools exist.

In 1996, the National Research Council of the National Academy of Sciences published the *National Science Education Standards.* Conceived and written through a collaborative process involving more than 18,000 people (teachers, school administrators, parents, curriculum developers, college faculty, administrators, scientists, engineers, and government officials), the *Standards* represent a broad consensus about the type of science education that must be in place for all students to succeed.

The *Standards* are not "national" in the sense that they have the approval of or derive authority from the federal government. Rather, they are "national" because they were developed by a broad, representative group. They are a model or guidelines for state and local education agencies who have the authority and responsibility for science education. Parents and educators who use the *Standards* to make changes in science education programs can be assured that they represent the best efforts this country can offer its citizens.



WHAT ARE SCIENCE EDUCATION STANDARDS?

Educational standards for science, whether they are written at the local, state, or national level, are a detailed, descriptive vision of what it takes to produce a scientifically educated citizen. The overall goal of the

Standards, therefore, is to enable all students to achieve scientific literacy-the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity.

Although the *Standards* address many areas of the science program, the one that is probably the most familiar is the content—and for good reason. The content is the heart of the science program, what teachers teach and students learn.

The content standards outline what students need to know, understand, and be able to do at the completion of grades 4, 8, and 12. The following example illustrates statements from one earth science standard at each of these levels.

Example of Statements from the Earth Science Standards at Three Grade Levels

Grade Level	What Students Should Understand
K-4	The sun provides the light and heat necessary to maintain the temperature of the earth.
5-8	The sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents, and the water cycle. Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the earth's rotation on its axis and the length of the day.
9-12	Heating of earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.

(*National Science Education Standards,* National Academy Press, 1996)

A coherent, supportive educational system is necessary for all students to learn the content outlined in the *Standards.* This system includes six important areas: teaching, professional development of teachers, assessment, the content to be learned, the K-12 science program, and the larger educational system. Standards for these areas are vital components of the *National Science Education Standards.*

HOW CAN THE NATIONAL SCIENCE EDUCATION STANDARDS IMPROVE THE QUALITY OF SCIENCE EDUCATION?

Think of the *Standards* as criteria that community members and educators can use to judge the quality of the educational system—the content that students should learn; the quality of the curriculum, including the textbooks and other resources used; the professional development of teachers; the teaching and assessment strategies used; and the support provided for teachers. Working to achieve the *Standards* can improve the quality of science education by bringing consistency and coherence to local and state systems.

How can the *Standards* increase consistency and coherence? They show how all parts of the program should relate to one another. For example, the development of concepts in the biological and physical sciences, starting in kindergarten and ending in high school, needs to show an orderly progression that teaches appropriate concepts at each grade while building a strong foundation in science.

When the science program lacks this coherence, there are gaps in the subject matter, material is repeated unnecessarily, and content is presented in inappropriate ways at the wrong age. Such a program wastes the school's—and the students'—time and resources and can result in lower student achievement.

One useful way to view the *Standards* is as a building code for science education. Just as building codes ensure that our houses and office buildings are safe and meet the needs of their occupants, so do science education standards serve as safeguards to protect our children's educational well-being in an increasingly scientific and technological world.

However, just as building codes do not inhibit the creativity of architects and builders, the criteria for a high-quality educational program presented in the *Standards* do not constrain the creativity of states

Six Areas of the *National Science Education Standards*

TEACHING

Describe effective science teaching.

PROFESSIONAL DEVELOPMENT

Describe the learning experiences teachers need to teach science effectively.

ASSESSMENT

Outline effective assessment of students and opportunity to learn.

CONTENT

Describe what students should know and be able to do in levels K-4, 5-8, and 9-12.

PROGRAM

Provide criteria for designing or assessing the science education program in a school or district.

SYSTEM

Provide criteria for judging how the larger education system—at the community, state, national levels—supports good science education.

and local districts. Although the *Standards* specify the important content that students should learn to become scientifically literate, they do not specify how it is arranged in the units and courses that make up each district's curriculum. The curriculum is left to the decisions and creativity of teachers, administrators, and community members in each district.

Teachers, administrators, and parents must share a strong commitment to providing students with a foundation of scientific skills and knowledge crucial for success in modern society. The *Standards* are designed to be adapted by states and local districts to serve their own commitment to excellence.

AN EXAMPLE OF POOR COHERENCE

Some current testing practices clearly illustrate the pitfalls of poor consistency and coherence in education. If the tests used by the school district or state are not consistent with the curriculum materials the teachers are using, the tests will not measure what was taught. When parents receive the test scores, they will be concerned about their children's poor performance. They will not understand that the reason for the gap is not that the student has not learned but that the student has not been tested on the knowledge that he or she has learned in class. Furthermore, teachers and students will not have useful information to help improve the learning process, and money will have been wasted. Attention to the *Standards* can help provide coherence among curriculum, teaching, and testing, thus preventing these problems.

Measure the Quality of Your School Science Program

The *Standards* define the academic goals that your children should—and can—achieve and the characteristics of the educational system that give them their best opportunity to do so. Any plan involving achievement of academic goals and the characteristics of the educational system should have assessments to help us gauge how well the plan is working. In contrast to what most people think, assessment is more than testing or assigning grades. It can be an effective tool in achieving desired improvements. For example, it can be used by teachers to improve their instruction; it can be used as a means of communicating what is valued to students, staff, and the community; and it can help parents and others to monitor the quality of their school science program.

ASSESSMENT AS A TOOL FOR IMPROVING INSTRUCTION AND LEARNING

To assess a student's level of understanding, teachers traditionally have used multiple-choice and short-answer tests given at the end of a unit of study. But in a classroom where students carry out their own science investigations, these types of tests cannot possibly measure whether students have learned all that is expected of them. Better methods are needed to assess both student understanding of important science concepts and the skills they acquire from an inquiry-based curriculum, such as designing experiments, making accurate observations and measurements, analyzing data, and reaching reasonable conclusions. Alternative assessments might take the form of longer essays, portfolios of student work, observation of student performance, and oral presentations. With this variety of assessments, teachers can choose which are appropriate for different purposes. Some will help the teacher check for student progress during a unit—not just after—and help the teacher modify his or her teaching based on the outcome.

ASSESSMENT AS A WAY OF COMMUNICATING WHAT IS IMPORTANT

Students of all ages have always known, "If it's important, it'll be on the test." In the same way, when teachers convey what is important for students to learn by assessing it in their classrooms, they also convey that value to parents and other members of the community. Likewise, when the school board members and school administration officials decide to include science in the district or school assessments, they are indicating to parents, teachers, and students that science is an important part of the curriculum for all students. Of course, not just any kind of test or assessment will do. Just as the classroom teacher must assess the full range of understanding and skills called for in the *Standards,* so should district- or school-wide testing.

USING ASSESSMENT RESULTS TO MONITOR YOUR SCHOOL'S SCIENCE SUPPORT SYSTEM

How well students are learning what is outlined in the *Content Standards* is only a part of what should be assessed. Assessment of how well the educational system is supporting the type of program that is outlined in the *Teaching, Assessment, Professional Development, Program,* and *System Standards* is critical. These *Standards* can help you under

stand the characteristics of the type of science program that will provide your children with the opportunity they need to learn what is expected. Assessment of the program will help you figure out what characteristics are lacking and what aspects of your school's science program need improvement. Questions you could ask include, Are the topics in your school's science curriculum consistent with those recommended in the *National Science Education Standards* or the state standards? Are students given adequate time and resources to learn? Are teachers given the time they need to prepare to teach science classes effectively? Are professional development opportunities available to teachers?

Your school system already may be striving to improve its science program. If such an improvement plan is underway, answers to such questions can help those responsible decide where support and resources are needed. If your school or district is just getting started on an improvement plan, comparing the results of an assessment against the expectations outlined in the *Standards* can provide a strong rationale for change. The next section describes how you can help bring about change in your school or district.

USING ASSESSMENT TO IMPROVE THE LEARNING OF STUDENTS AND TEACHERS

Assessment is a process of collecting data about part of the science education system and then using these data to improve that part of the system.

For example, a teacher can ask students to interpret a graph by answering a series of questions. By reviewing student answers, the teacher immediately can decide whether to move on to the next topic or to spend more time on the current one. By examining student performance on individual questions, the teacher can tell which topics need additional time.

As another example, in professional development programs, informal observations of novice teachers by experienced teachers can help determine where the novices need help. Then the professional development program can be tailored to meet those needs.

Take the First Steps Toward Science Education Reform

What can you do to move your school district toward the goal of exemplary science instruction? Begin by taking some small (but critical) steps toward the long-term goal.

Become informed. Find out what your son or daughter and other children in your community are doing in science class. Talk to them about the program and see whether they are learning what they need to know. Then talk to their teachers to get more detailed information. Take the time to visit your child's class to see for yourself what is going on there.

Bring science to your home and neighborhood. Show your own and other children that you, too, are interested in science. For example, you might take a group to local science museums, parks, or nature centers. Try incorporating science into your everyday life by buying a outdoor thermometer and asking your children and their friends to check the temperature each morning, setting up a bird feeder in your yard and keeping track of which birds visit and why, or planting a garden together and discovering which plants grow best in sun or shade, which need the most water, and which thrive in your yard.

Take your commitment to better science education to the next level. Learn about the philosophy and elements of inquiry-based science instruction by reading the *National Science Education Standards* and related publications. Call your school, district office, state department of education, nearby university, or state science teachers association to find out what activities related to science education reform are taking place in your community. Find out if there are state standards or frameworks that call for an improved science program.

Seek out like-minded adults in the community. Identify other parents, scientists, and business leaders who are interested in implementing change and create an informal committee. Start with your school's local parent-teacher association. Form a study group to become better acquainted with the *Standards* and to compare them with your school's philosophy and program. Then meet periodically to discuss your goals and plans.

Involve like-minded teachers. Look for interested teachers in your school or nearby schools known for their excellence. Solicit their help in determining how to bring the new science program to your community. Most teachers will welcome your involvement, and they will be able to recommend exemplary curriculum programs. Support and reinforce the teachers that are using an inquiry approach in their classrooms; it probably is requiring an extra effort on their part.

Discuss your ideas with your school's principal. As a group, meet with your school's principal to share your ideas. Reach consensus about what direction the group should take. Then arrange to meet with the principal, school administrator, teacher on special assignment, or science coordinator who has responsibility for the district science program. The support of these administrators helps gain the support of higher level administrators, such as the assistant superintendent for instruction and the superintendent of the school district.

Talk to scientists and engineers. Scientists from local industries and universities as well as physicians in the community can help you convince the community and school administrators of the need to reform the school science education program. You might try inviting scientists to a meeting to discuss their role in the reform effort. If scientists also happen to have children in the school system, they will become even stronger advocates.

You will find the following publications to be quite helpful. Mailing and web addresses where available are provided in the "Resources" Section. See page 25.

The National Science Education Standards (*National Academy Press,* 1996) *and a brochure summarizing the key ideas in the* Standards *are good places to start your study of science education. The brochure outlines succinctly what you need to know about the* Standards.

Science for All Children: A Guide to Improving Elementary School Science in Your School District *(National Academy Press, 1997) helps round out the vision of effective science teaching and learning through a series of "case studies" that fill the last third of the book. By reading about how other people have succeeded in reforming science education, you can get a good idea about how long it might take you in your community and how to overcome the obstacles you may face.*

Elementary School Science for the'90s *(Association for Supervision and Curriculum Development, 1990) provides guidelines for changing your science program and includes vignettes on effective teaching and learning.*

Active Assessment for Active Science, *by George Hein and Sabra Price (Heinemann, 1994) describes how to move from traditional to alternative assessments.*

Redesigning the Curriculum, *edited by R. W Bybee and J.D. McInerney (Kendall-Hunt, 1995) is a collection of essays about the* Standards *and their role in science education.*

Local Leadership for Science Education Reform, *by Ronald D. Anderson and Harold Pratt (Kendall-Hunt, 1995) outlines the steps needed to improve the quality of a district science program.*

The May/June 1997 issue of **Our Children,** *the National PTA Magazine, is a special issue on parental involvement with school reform. You might find the PTA's suggestions particularly relevant.*

Dragonfly, *from the National Science Teachers Association and Miami University, is a new science magazine for children ages 8-13. Individual subscriptions include the "Dragonfly Home Companion" for parents.*

Get Involved *(American Association for the Advancement of Science, 1996) summarizes a one-year study of parent involvement in science education.*

Take your ideas to the school board. Once you can reach this group and the superintendent, you will be close to putting your ideas into practice. In most communities, if the school board believes that improving the science program is a priority, you will achieve your goals much more quickly than if it does not.

TRY OTHER APPROACHES, TOO

The journey to better science in your schools does not always go smoothly. For example, the principal or some of the teachers in your school may not see a pressing need for change. In that case, you may need to involve more community members to participate in discussions of relevant issues, such as how children learn, why science education is important, and what different parts of the community can do to help.

Promoting new ideas in the media can be a good idea. Invite a reporter from a local newspaper or TV station to cover a meeting where you will be talking about or demonstrating the new, hands-on science kits your group is considering recommending for your school. Through such publicity, more interested people may come forward.

As you work to reform science education in your community, do not be surprised if you encounter roadblocks along the way. Finding time for professional development, funding for new curriculum materials, and ways to handle competing pressures from other disciplines are just a few of the common obstacles. But the effort is worth it. Our children's future is in your hands.

Resources

American Association for the Advancement of Science (AAAS), 1200 New York Ave., N.W., Washington, DC 20005; and for Project 2061, 1333 H St., N.W., Washington, DC 20005. (202) 326-6400 is the main number for both locations. AAAS's web address is http://ehr.aaas.org.

Association for Supervision and Curriculum Development (ASCD), 1250 N. Pitt Street, Alexandria, VA 22314; 1-800-933-ASCD or (703) 549-9110. ASCD's web address is http://www.ascd.org.

Council for Basic Education, 1319 F Street, N.W., Suite 900, Washington, DC 20004; (202) 347-4171; e-mail—info@c-b-e.org.

Heinemann, 361 Hanover Street, Portsmouth, NH 03801-3912. Heinemann's web address is http://www.heinemann.com.

Kendall-Hunt, 4050 Westmark Dr., Dubuque, IA 52004-1840; 1-800-KH-BOOKS. Kendall-Hunt's web address is http://www.kendallhunt.com.

National Academy Press (NAP), 2101 Constitution Ave. N.W., Washington, DC 20418; 1-800-624-6242 or (202) 334-3313. NAP's web address is http://www.nap.edu/bookstore.

National Center for Improving Science Education, 2000 L St., N.W., Suite 603, Washington, DC 20036; (202) 467-0652; e-mail—info@ncise.org.

National Institute for Science Education (NISE), University of Wisconsin-Madison, 1025 W. Johnson St., Madison, WI 53706; (608) 263-9250; e-mail—niseinfo@mail.soemadison.wisc.edu. The NISE web address is http://www.wcer.wisc.edu/nise.

National PTA—National Congress of Parents and Teachers, 330 N. Wabash Street, Suite 2100, Chicago, Il, 60611-3604; (312) 670-6782; e-mail—info@pta.org. The National PTA's web address is http://www.pta.org.

National Research Council (NRC), Center for Science, Mathematics, and Engineering Education (CSMEE), 2101 Constitution Ave., Washington, DC 20418; (202) 334-2353; e-mail—csmeeinq@nas.edu.

National Science Foundation (NSF), 4201 Wilson Boulevard, Arlington, VA 22230; (703) 306-1600. The NSF's web address is http://www.nsf.gov.

National Science Resources Center (NSRC), Smithsonian Institution, MRC 502, Arts and Industries Bldg., Rm. 1201, Washington, DC 20560; (202) 357-2555; e-mail—nsrc@nas.edu.

National Science Teachers Association (NSTA), 1840 Wilson Blvd., Arlington, VA 22201-3000; (703) 243-7100. NSTA's web address is http://www.nsta.org.

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Page 12. National Academy Press Image Archives.
Page 16. Student at Eastern Middle School, Silver Spring, MD.
Page 21. Parents and teachers at East Silver Spring Elementary School, Silver Spring, MD.
Page 22. Principal and teacher at East Silver Spring Elementary School, Silver Spring, MD.