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ABSTRACT

The "ERIC Review" announces research results, publications, and new programs relevant to each issue's theme. This issue focuses on science and mathematics education for students in grades K-8. Articles include: "The New Three R's: The Importance of Science and Mathematics Education" (Steven J. Rakow); "When Should Children First Learn about...? (David L. Haury); "How Can I Help My Child Become More Interested in Science?" (David L. Haury and Linda A. Milbourne); "How Can I Help My Child Become More Interested in Math?" (David L. Haury and Linda A. Milbourne); "Why Is Homework Important?" (Linda A. Milbourne and David L. Haury); "Should Children Be Tracked in Math or Science?" (David L. Haury and Linda A. Milbourne); "Calculators in the Classroom: Is the Jury Still out?" (Jeffrey P. Smith); "How Can I Find out More about Science Fairs and Math Competitions?" (Wendy Sherman McCann); "A Parent's Guide to Student Performance in Science and Mathematics" (David L. Haury); "National Math and Science Standards: A Primer for Parents" (Wendy Sherman McCann and S. Asli Ozgun-Koca); "A Comparison of Math and Science Education Here and Abroad" (S. Asli Ozgun-Koca and Wendy Sherman-McCann); "Best Practices in Science Education" (Judith Sulkes Ridgeway, Lynda Titterington, and Wendy Sherman McCann); "Promising Practices in Mathematics Education" (Terese A. Herrera and S. Asli Ozgun-Koca); "Minorities in Science and Mathematics: A Challenge for Change" (Julia V. Clark); "Science and Mathematics Classes for Children with Special Needs" (Wendy Sherman McCann); "Mathematics Education for Gifted and Talented Children" (David L. Haury); "Science Education for Gifted and Talented Children" (Joyce VanTassel-Baska); "Addressing the Needs of English Language Learners in Science and Math Classrooms" (Cathleen McCargo); "Federal Support for Science and Mathematics Education" (Kevin Mitchell); "Math and Science Resource Organizations" (Linda A. Milbourne); "Books [an annotated list]" (Niqui Beckrum); "Journals and Newsletters [an annotated

list]" (Linda A. Milbourne and Susan Eshbaugh); "Internet Resources" (David L. Haury and Linda A. Milbourne); "Searching the ERIC Database on Science and Mathematics Topics" (Niqui Beckrum); and "Putting it All Together: An Action Plan" (Linda A. Milbourne, David L. Haury, and Susan Eshbaugh). (MES)

THE ERIC Review

Volume 6 • Issue 2 • Fall 1999

The Formula for Success

Educational Resources Information Center
National Library of Education
Office of Educational Research and Improvement
U.S. Department of Education

Student achievement in science and math has been, and continues to be, a source of great concern in the United States. In 1989, Congress and the nation's governors responded in part by establishing the National Education Goals, one of which stated that U.S. students would be first in the world in science and math achievement by the year 2000. By 1996, the National Council of Teachers of Mathematics and the National Research Council, respectively, had published math and science standards addressing curriculum, instruction, and assessment.

Notwithstanding these efforts, U.S. high school seniors continue to score below the international averages in science and math achievement.[1] Their performance is even more troubling in light of the above-average achievement of U.S. fourth graders in both subjects. Why do U.S. students, on average, lose ground in science and math as they progress through their education careers? What factors contribute to their lagging performance? And what can parents and teachers do to solve this problem?

This issue of *The ERIC Review* focuses on science and math education in the United States and suggests answers to these questions. It concentrates on U.S. students in grades K–8 instead of on older students, who typically exhibit lower achievement relative to their international counterparts. Why focus on younger students? Because students who enroll in algebra as eighth graders are more likely to complete higher-level math courses in high school—and to apply to four-year colleges—than those who don't.[2] Consequently, the efforts of the United States to elevate its high school students to world-class status in science and math will necessarily concentrate on grades K–8.

Steven Rakow's introduction to this issue of *The ERIC Review* describes the changing face of science and mathematics education in terms of teaching students how to reason, solve problems, and make decisions—skills necessary to succeed not only in science- and math-related careers but also in the increasingly high-tech world. *Section 1: Questions and Answers* contains several short articles that address common parental concerns about science and math education in a question-and-answer format. *Section 2: Performance, Policies, and Practices* begins with two articles that can help familiarize parents with new forms of classroom assessment and how the forms relate to national math and science standards. The remaining articles, which describe the international standing of U.S. math and science education and discuss best practices in the classroom, may be of more interest to teachers. *Section 3: Equity and Excellence* focuses on specific segments of the population and how each can succeed in, and contribute to, the fields of science and math if given the chance. Several articles in this section describe the critical need for girls, minorities, and English-language learners to pursue science and math education and related careers. Other articles discuss the challenges of educating students with special needs and gifted students in science and math. *Section 4: Initiatives and Resources* begins with an article that summarizes many federal programs and initiatives that support science and math education, as well as a variety of associated resources that teachers may find especially helpful. The remainder of this section includes descriptions of print and electronic resources that parents and teachers may find useful in their efforts to help children reach their full potential in science and math. The issue concludes with steps that parents, teachers, school administrators, and community members can take to facilitate effective education reform in science and math.

If you would like more information about what the Educational Resources Information Center (ERIC) has to offer, details on how to access the ERIC database, or a referral to one of the 16 subject-specific ERIC Clearinghouses, please call 1–800–LET–ERIC (538–3742), send an e-mail to accesseric@accesseric.org, or browse the ERIC system's Web pages at http://www.accesseric.org.

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[1] National Center for Education Statistics. 1997. *Third International Mathematics and Science Study*. Washington, DC: Author. (Available online at http://nces.ed.gov/timss)

[2] National Center for Education Statistics. 1999. *Do Gatekeeper Courses Expand Education Options?* Washington, DC: Author. (Available online at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=1999303)

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THE ERIC Educational Resources Information Center

Contents

The New Three R's: The Importance of Science and Mathematics Education

Steven J. Rakow

Once upon a time, all an educated child needed to know were the Three R's—readin', 'ritin', and 'rithmetic—at least according to the lyrics of the old song. But times have changed. Reading (or more broadly, language arts, which includes writing as well) is still fundamental to any future school success. But today, the New Three R's include reasoning (mathematical and scientific) and responsible decision making (the ideal outcome of sound reasoning).

In this context, science and math are critical parts of every child's school curriculum at every grade level. But if you're an adult, you may not have seen any relevance in what you learned in science and math classes and, therefore, may have considered them of little value at the time. In many cases, that was justified—you may remember math class consisting of endless worksheets containing endless problems. And thoughts of science class probably conjure up images of memorizing complex formulas, trying to classify a bunch of old rocks, or performing smelly chemistry experiments.

But if science and math classes were the same today, this article wouldn't have been written. The new approach to science and math in the schools reflects society's view that mastery of these topics is vital to the development of citizens for the 21st century.

Why Is Science and Math Education Important?

The simple answer is that children need to be literate in these subjects, and in their associated thinking skills, to succeed. As society becomes increasingly technologically oriented, science and math courses become gateways to future careers. Children who decide not to continue in science and math classes during their high school years may limit their course and career options in college and beyond.

Children need to master an ever-increasing knowledge base in science and math. Not everyone is going to be a scientist or mathematician, but everyone is affected by science and math on a daily basis. For example, kids need to know not only how to make change and balance a checkbook but also how to operate computers and calculators, run sophisticated software packages, and program electronic appliances. All of these activities require the logical-reasoning, problem-solving, and decision-making skills typically taught in science and math classes.

These skills are perhaps more important than memorizing science and math facts and formulas. Society is rapidly becoming information dependent (in fact, recent studies of future jobs suggest that information technology jobs will be the hot careers of the next century). With the amount of information bombarding people every day, one of the most important skills that children can learn is the ability to make sense of information.

Steven J. Rakow is an Associate Professor of Science Education and the Program Chair for Curriculum and Instruction at the University of Houston—Clear Lake. He recently served as President of the National Science Teachers Association.

This focus on information is key to contemporary science and math education. The national standards in both science and math clearly show that the development of critical reasoning skills is of primary importance. The national science standards go beyond addressing the traditional content areas of biology, chemistry, physics, and earth science. The science standards focus on inquiry (the ability to ask questions and conduct investigations to answer those questions), the relationship between science and technology, the role of science in daily life and in society, and the history and nature of science. These elements are central to the knowledge base of the scientifically literate citizen.

Similarly, the new math standards not only address the traditional content areas of algebra, geometry, measurement, and statistics but also emphasize reasoning skills through proofs, communications, connections, and representation.

Finally, both science and math represent a significant part of society's cultural history. Advances in science and math are some of the most important intellectual achievements in human history. Through an appreciation and knowledge of science and math, children also understand the impact of these disciplines on society.

How Can Parents Support Their Children in Science and Math Education?

Parents play a critical role in their children's learning—children benefit when their parents are involved in their education. To support children in science and math, parents can:

- Be positive. Regardless of your personal experiences with science and mathematics, communicate to your children that these subjects are important.
- Demonstrate the real-world value of science and math. Show your children how you use science and math every day (understanding momentum when driving a car; using fractions to change a recipe).
- Get involved in your children's school program. Ask your kids what they're doing in their science and math classes so that you can help them at home. When possible, volunteer to help in the school or provide resources. Sometimes science classes in elementary schools have limited equipment for conducting hands-on experiments. Often the children can use simple materials found around the home. Find out what they need and offer to donate it.
- Look for opportunities to "do" science ar l math with your children, such as taking trips to science museums. For more ideas, see the articles "How Can I Help My Child Become More Interested in Science?" on page 7 and "How Can I Help My Child Become More Interested in Math?" on page 9.

Children who see science and math as fun and important parts of their education will definitely have an advantage in adapting to today's ever-changing world. Parents and teachers working together play a critical role in communicating the importance of science and math and in helping children learn the New Three R's.

When Should Children First Learn About...?

David L. Haury

Algebra and geometry constitute the conceptual foundation for advanced topics in mathematics. Chemistry and physics provide the foundation for advanced study in science. As science and math reform movements continue in states and schools, parents and teachers wonder when children should first learn some of the key topics in these fields.

The following guidelines extracted from the national standards in science and math—developed by the National Research Council and the National Council of Teachers of Mathematics, respectively—summarize when children should be learning certain fundamental concepts. Parents can use this information to determine whether their children's schools are introducing key topics in accordance with the national standards. (For more information on standards, see "National Math and Science Standards: A Primer for Parents" on page 23.)

Algebra

Algebra can be thought of as a specific course in the math program, or it can be perceived as an array of concepts, skills, and procedures for representing and exploring mathematical ideas. It is strongly recommended that all children have introductory algebra by the eighth grade, preceded by algebraic thinking embedded throughout the elementary school math program. Benchmarks to gauge progress in algebraic thinking include the following:

By second grade, children should be...

- Sorting, classifying, and ordering objects by different properties, as well as recognizing patterns.
- Using pictures, words, and various forms of notation to illustrate mathematical ideas.
- Using numbers and words to make comparisons and describe change.

By fifth grade, children should be...

- Using tables and graphs to represent numeric patterns.
- Identifying and describing relationships between values that co-vary systematically, such as the length of the side of a square and its area.
- Learning about variables and using algebraic notation (x, y, other symbols) and operations to describe general rules and solve problems.
- Investigating varying rates of change and relationships between and among variables.

By eighth grade, children should be in an algebra class in which they...

- Use patterns to solve mathematical and applied problems.
- Represent relationships and functions with tables, graphs, verbal rules, and symbolic rules.

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- Solve linear equations and inequalities, identify variables, and learn to interpret graphs mathematically (intercepts, intersections, and slopes of lines).
- Study rate of change and its graphical representation.

Geometry

Geometry is the mathematics of shape, position, and direction. Studies in geometry bring numerical precision to the concepts of place and movement.

By second grade, children should be...

- Constructing, drawing, and describing two- and three-dimensional shapes.
- Recognizing congruent and similar shapes, as well as relating geometric ideas to numbers and measurements.
- Interpreting and applying the ideas of direction, distance, and relative position in space, as well as using coordinate systems.
- Transforming shapes through simple procedures and recognizing symmetry.
- Imagining geometric shapes and representing them from different points of view.

By fifth grade, children should be...

- Classifying and defining two- and three-dimensional shapes according to their characteristics, investigating their mathematical properties, and thinking about the relationships among shapes.
- Using geometric vocabulary, graphs, and coordinate systems to describe the location and movement of objects.
- Exploring symmetry and congruence in two- and three-dimensional shapes and objects.
- Visualizing and sketching three-dimensional shapes in two dimensions.

By eighth grade, children should be...

- Precisely describing, classifying, and comparing types of plane and solid figures according to their main features, as well as recognizing the application of geometry in art, science, and daily life.
- Using coordinate geometry to represent geometric relationships between related quantities.
- Examining the properties of geometric figures and using the Pythagorean theorem to solve problems.
- Using the concepts of congruence, similarity, and rotational symmetry to explore, describe, and classify polygons and polyhedra and their transformations.
- Proficiently using two-dimensional representations of three-dimensional objects, as well as using geometric models to represent and explain numeric and algebraic relationships and solving problems by composing or decomposing two- and three-dimensional figures.

Chemistry

Chemistry is the study of matter, the states of matter, and the nature of interactions among different substances.

By fourth grade, children should...

- Know that objects are made of one or more materials with characteristic properties that can be observed and measured using a variety of tools, such as rulers, balances, and thermometers.
- Understand that materials can exist in different states—solid, liquid, gas—and that some common materials can be changed from one state to another by heating or cooling.

By eighth grade, children should...

- Know that each substance has characteristic properties, such as density, boiling point, and solubility, and that often a mixture of substances can be separated into its original components.
- Realize that substances react chemically in characteristic ways to form compounds with different characteristic properties.
- Know that chemicals do not break down during normal laboratory reactions and that more than 100 known elements exist and combine to produce compounds.

Physics

Physics is the study of energy and matter in motion, from the interactions of subatomic particles to the natural choreography of star clusters.

By fourth grade, children should...

- Know that an object's motion can be described by tracing and measuring its position over time.
- Realize that an object's position and motion can be changed by pushing or pulling and that the size of the change is related to the strength of the push or pull.
- Discover that light travels in a straight line until reflected, refracted, or absorbed.
- Know that heat can be produced in a variety of ways and that it can move from one object to another through conduction.
- Know that electricity flows in circuits to produce light, heat, sound, and magnetic effects.
- Understand that magnets attract and repel each other.

By eighth grade, children should...

- Be able to describe the motion of an object on a graph in terms of its position, direction, and speed.
- Understand that an object will continue to move at a constant speed in a straight line unless subjected to an outside force.
- Know that multiple forces on an object will reinforce or cancel each other, depending on their direction and magnitude.
- Understand that energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the chemical nature of a substance.
- Understand that heat travels in predictable ways, flowing from

warmer objects to cooler ones until both reach the same temperature.

- Know that light interacts with matter by transmission, absorption, or scattering and that one sees an object when light emitted or scattered from the object enters the eye.
- Know that electrical circuits can be a means of transferring electrical energy when heat, light, sound, and chemical changes are produced.
- Know that most chemical and nuclear reactions involve energy transfer into or out of a system.
- Understand that the sun is a major means of energy that drives changes on the Earth's surface and that it loses energy by emitting light with a broad range of wavelengths, from infrared and visible light to ultraviolet radiation.

Sources of Information About Content Goals and Standards

Content Knowledge: The Mid-Continent Regional Educational Laboratory Standards Database
http://www.mcrel.org/standards-benchmarks

National Council of Teachers of Mathematics. 1989. *Curriculum and Evaluation Standards for School Mathematics.* Reston, V A: Author.
http://standards-e.nctm.org/1.0/89ces/Table_of_Contents.html

National Council of Teachers of Mathematics. (To be published.) *Principles and Standards for School Mathematics: Discussion Draft.* Reston, VA: Author.
http://www.nctm.org/standards2000

National Research Council. 1996. *National Science Education Standards.* Washington, DC: National Academy Press.
http://www.nap.edu/readingroom/books/nses/html

Project 2061, American Association for the Advancement of Science. 1993. *Benchmarks for Science Literacy.* New York: Oxford University Press.
http://project2061.aaas.org/tools/benchol/bolframe.html

A Message From Donna Shirley

Math was my worst subject in school. However, I knew I had to learn it to be an engineer, so I sweated it out. I was always kidded in high school for taking mechanical drawing instead of home economics. When I went to college, I walked into my advisor's office and he said, "What are you doing here?" I said, "I'm enrolling in aeronautical engineering." He responded, "Girls can't be engineers!" I told him I could, and I did!

—NASA Quest Project. Reprinted with permission.

Donna Shirley is the former manager of the National Aeronautics and Space Administration (NASA) Mars Exploration Program at the Jet Propulsion Laboratory, the lead U.S. center for robotic exploration of the solar system. Ms. Shirley is the original leader of the team that built the Sojourner Rover.

To participate in NASA's interactive education projects, visit the NASA Quest Project Web site at http://quest.arc.nasa.gov. To learn more about other NASA education programs, curricula, and services, go to http://education.nasa.gov.

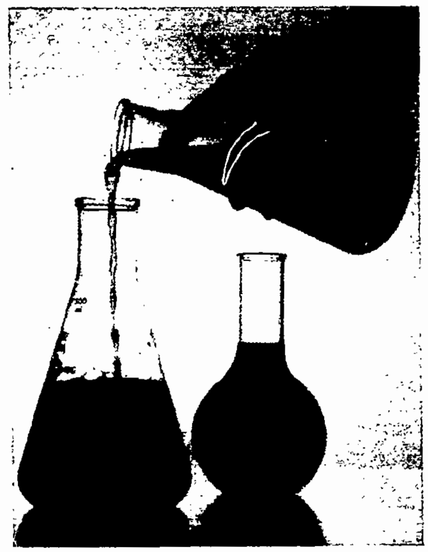
1

How Can I Help My Child Become More Interested in Science?

David L. Haury and Linda A. Milbourne

Success in science involves being curious, asking questions, and learning how to find the answers. Children are naturally curious, but they need help in understanding how to make sense of what they observe or experience. Unfortunately, many parents consider themselves unqualified to provide this kind of help simply because they don't have a degree in science.

As a parent, all you need is a willingness to observe and learn with your child and, above all, a willingness to commit the necessary time and energy to nurture your child's natural curiosity. Your level of involvement in your child's education is strongly related to his or her success in school.



Set the Example

One of the most important ways you can help your child develop an interest in science is by exhibiting attitudes and values supportive of learning. Focus on developing your child's "scientific" skills (observing, classifying, predicting, and quantifying). Observation is an important first step toward scientific explanation, so help your child observe objects carefully.

Encourage your child to ask questions and seek answers. No one knows all the answers, but children can learn to propose answers and test them. Also, ask your child open-ended questions—those that require more than a "yes" or "no" answer—that require close attention and stimulate imagination as you explore the neighborhood, grocery store, local park, or fire station. For instance, you could ask, "What shapes do you see in that spider web?" to draw your child's attention to small details.

Listen to children's ideas and explanations. Your attention gives them confidence, and expressing their ideas helps them figure out what they know and don't know (for more suggestions for strengthening your child's skills and concepts, see *Doing Science With Your Children* at http://www.ericse.org/digests/dse94-1.html).

What you say to your child is also important. For instance, if you say, "I never liked science in school," or, "I got my worst grades in science," you reinforce the idea that science classes are boring or difficult, or worse, that poor performance in science is acceptable. However, if you say, "I wish I could do that experiment with you," or, "I'm so glad that you are having opportunities that I missed," you will open doors for your child.

Help Children See the Science Around Them

Help children recognize the science of daily life, and engage them in games and activities that foster familiarity with science concepts and scientific thinking. Here are a few suggestions:

- Encourage your child to take things apart. Old toys, clocks, and household appliances provide great lessons—and don't worry about putting them back together! Don't forget about safety. Supervise young children as needed. Remember, too, that girls are as curious about science as boys are. Buy your daughter a tool kit, and remember that science is often "messy." Recognize the difference between the clutter that comes from

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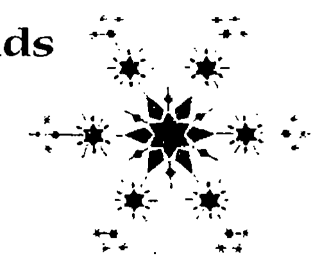
enthusiastic activity and the sloppy piles that result from neglect.

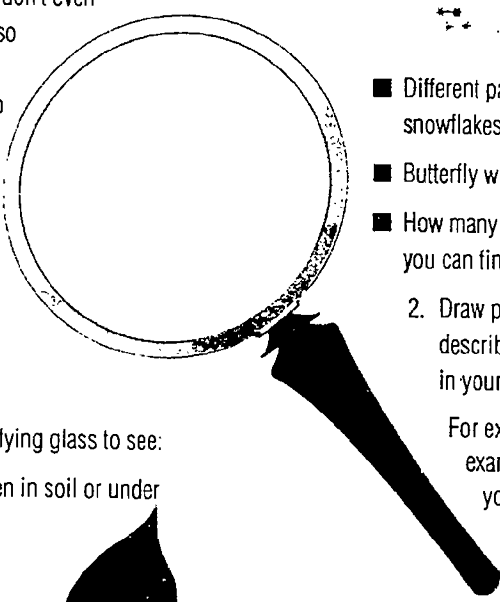
- Talk about school science with your child. Find ways to discuss and extend school science lessons in the home and other familiar places. You can also find science activities for children in grades K through 8 on the Internet or in library books and magazines. Many of these activities make use of community resources or common materials found around the home (for example, see the box "Science Activities for Kids" on this page).
- Discuss science and technology careers. When you encounter people in science-related careers, encourage your child to ask questions about their jobs and the education needed for them.
- Take a family field trip to an informal education site. Science centers, museums, and zoos give children the chance to make independent discoveries and to participate in scientific processes while having fun. You could also help coordinate a science-related field trip for your child's class or bring to your child's classroom guest speakers who could describe how science is related to their jobs (for more hints on helping your child explore science, see the National Science Teachers Association Web site at http://www.nsta.org/parents).

Science Activities for Kids



The Big Picture

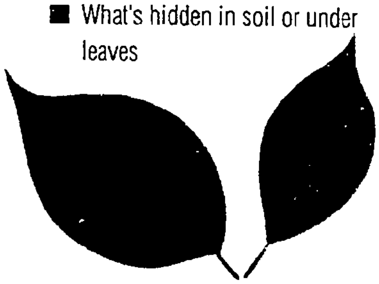
Looking at objects closely is an important part of science, and a magnifying glass lets you see things you don't even know are there. It also helps you see how objects are similar to or different from each other.



What you'll need: A magnifying glass and your science journal

What to do:

1. Use your magnifying glass to see:
   - What's hidden in soil or under leaves



   - What's on both sides of leaves
   - How mosquitoes bite
   - Different patterns of snowflakes
   - Butterfly wings
   - How many different objects you can find in the soil
2. Draw pictures, or describe what you see, in your notebook.

For example, if you examine a mosquito, you will probably see how it bites something—with its proboscis, a long hollow tube that sticks out of its head.

For more science activities appropriate for children in grades K through 8, see the guide *Helping Your Child Learn Science* at http://www.ed.gov/pubs/parents/Science.

Common Myths About Science

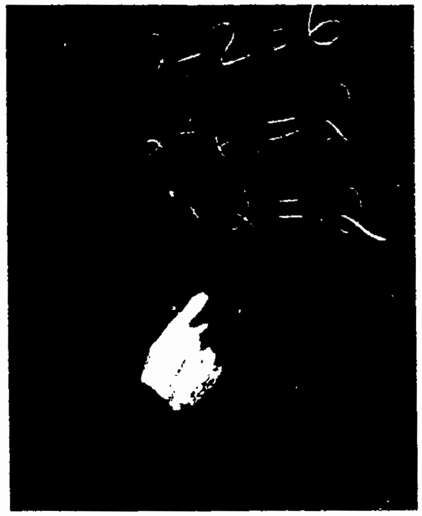
- **Myth #1: Science is difficult.** Really, science is more than facts and figures—it's a way of seeing the world and solving problems.
- **Myth #2: You need to know a lot about science to teach it to your children.** Not true! Saying, "I don't know; let's find out together," is actually better than giving answers.
- **Myth #3: Science requires equipment.** Actually, science is everywhere, and the best way to begin learning is by asking your child open-ended questions and listening to his or her response.
- **Myth #4: Science skills should wait for reading skills.** The developmental skills of preschool children are actually more suited to doing science than reading. Learning about science also can motivate children to read.

For more information on helping your child explore science, see the National Science Teachers Association Web site at http://www.nsta.org/parents.

How Can I Help My Child Become More Interested in Math?

David L. Haury and Linda A. Milbourne

Everyone struggles with math, whether learning the multiplication tables or trying to figure out how to stretch the monthly income to pay bills. Some find mathematics easier than others, just as some find spelling easier. Some use mathematics extensively in their work, just as some make more use of hammers. Everyone, though, uses mathematics daily, and limited math proficiency leads to limited success in handling society's daily challenges.



Set the Example

One of the most important ways you can help your child develop an interest in math is by exhibiting attitudes and values supportive of learning. Here are a few suggestions:

- Accept your child's struggle as a normal part of doing math, just as you accept his or her struggle to become better in sports. Help uncover difficulties, and offer suggestions for overcoming them.
- Encourage mastery. Just as it is important to repeat fundamentals again and again in sports until they are performed automatically, it is important to see practice in math as the development of mastery, not as a chore.
- Look beyond the grade. Math grades are often based on percentages of correct answers on tests and assignments accumulated during a grading period, so they may not reflect understanding that your child has developed over the course of a grading period. Help focus on understanding and try to identify specific difficulties.
- Discover the textbook. "Reading" math can be difficult, and math textbooks are often used as collections of assignments and homework problems. Help your child learn how to read the math textbook, see the underlying structure, and learn from the examples provided.

Help Children See the Math Around Them

Help children recognize the use of math around them in daily life, and engage them in games and activities that foster familiarity with numbers and mathematical thinking. Many activities make use of coins, containers, playing cards, or other simple household materials (see the box "Math Activities for Kids" on page 10).

Other activities include sorting socks together on laundry day (sorting is a major function in math and science); cooking a meal together (cooking involves math and science as well as thinking about good health); telling and reading each other stories (storytelling is the basis for reading and writing); and playing a game of hopscotch together (playing physical games will help your child learn to count and start on the road to lifelong fitness). By doing these things together, you will show your child that learning is fun and important.

You can also help your child develop an interest in math if you keep the following points in mind:

- Wrong answers can help!
  - ✦ Be patient; incorrect answers tell kids that they need to look further, ask questions, and figure out what they don't understand.
  - ✦ Sometimes a wrong answer is the result of misunderstanding the question.
  - ✦ Ask your child to explain how he or she solved a problem; responses may clarify whether help is needed with a procedure, the "facts" are wrong, or a crucial concept is not understood.

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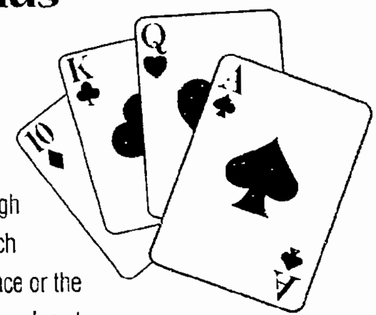
- ✦ Wrong answers may reveal something that the teacher would find helpful. A short note or telephone call will alert the teacher to possible ways of helping your child.
- ✦ Help your children become risk takers. Help them examine wrong answers, and assure them that right answers come with understanding.

■ Problems can be solved in different ways. Although a problem may have only one correct solution, there are often many ways to get the right answer.

■ Doing math in your head is important. The widespread use of calculators and computers makes it increasingly important that kids be able to determine whether an answer is reasonable.

Math Activities for Kids



Here is a simple math game you can play with your child that makes use of playing cards:

Make 100

Take out all the cards from a deck except ace through 6. Each player draws eight cards from the deck. Each player decides whether to use a card in the tens place or the ones place so that the sum of the numbers comes as close to 100 as possible without going over. For example, if a player draws two aces, a 2, a 5, two 3s, a 4, and a 6, he can choose to use the numerals in the following way: 30, 40, 10, 5, 6, 1, 3, 2. This adds up to 97.

For other math activities appropriate for grades K through 8, see the guide *Helping Your Child Learn Math* at http://www.ed.gov/pubs/parents/Math.

A Message From John Glenn

I think space exploration offers teachers a wide variety of opportunities to engage students in all sorts of academic disciplines, especially the sciences and mathematics. The astronauts currently flying on the Space Shuttle and who soon will fly on the International Space Station are trained in a variety of disciplines spanning the science and engineering spectrum....

Perhaps the single most important lesson for students from our space exploration program is that a rigorous, methodical approach to a problem or question using the scientific method can yield answers previously thought unknowable. Instructing students [in] the scientific method will not only enable them to follow the nearly daily discoveries in space exploration (and perhaps participate in them directly) but will also allow them to apply rigorous, logical thought to other aspects of their lives.

John Glenn has distinguished himself as an aviator, astronaut, U.S. senator, and Space Shuttle payload specialist.

To learn more about astronauts or to submit questions of your own, see the "Ask An Astronaut" Web site at http://www.askanastronaut.com. To learn more about National Aeronautics and Space Administration (NASA) education programs, curricula, and services, go to http://education.nasa.gov.

Why Is Homework Important?

Linda A. Milbourne and David L. Haury

Homework is intended to be a positive experience that encourages children to learn. Teachers assign homework to help students review, apply, and integrate what has been learned in class; to extend student exploration of topics more fully than class time permits; and to help students prepare for the next class session.

But there's more to learning than simply mastering content. Learning has many facets and requires many skills that children have to build. So teachers also assign homework to help children:

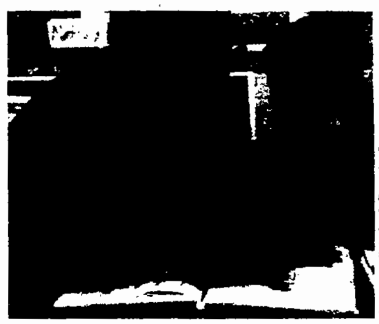
- *Acquire effective habits of self-discipline and time management.*
- *Develop initiative and learn to work independently.*
- *Gain a sense of personal responsibility for learning.*
- *Develop research skills, such as locating, organizing, and condensing information.*
- *Learn to use libraries and other reference resources.*

Homework can also bring parents and teachers closer together—parents who supervise homework and assist their children with assignments learn more about their children's education and about the school.

Does Homework Affect Academic Achievement?

During the past decade, research on homework began to focus on the relationship between homework and student achievement. Some recent studies suggest that, on average, children who spend more time on homework do better in school and that the academic benefits increase as children move into the upper grades (see *Helping Your Child With Homework* at http://www.ed.gov/pubs/parents/Homework). Similarly, a 1998 University of Missouri survey suggests that the more homework children complete, especially in grades 6 through 12, the better they do in school (see *Yes, Johnny, Doing Your Homework Is Important* at http://www.shpm.com/articles/child_behavior/homework.html).

Although homework may not immediately affect the achievement of children in grades K through 5, many teachers and parents agree that homework helps to develop children's initiative and responsibility—attributes that play a vital role in their long-term academic development—and fulfills the expectations of students, parents, and the public. Homework helps younger children develop the strong study skills necessary for high academic achievement later. And regard-



less of age group, children appear to get the most out of homework when teachers carefully plan the assignments and make them meaningful.

How Much Homework Is Reasonable?

The National Parent-Teacher Association and the National Education Association recommend the following amounts of homework:

- Kindergarten through grade 3: up to 20 minutes each day.
- Grades 4 through 6: from 20 to 40 minutes each day.
- Grades 7 through 12: generally up to 2 hours, but recommendations vary according to the type and number of subjects a student is

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taking. College-bound students will receive increasingly lengthy and complex assignments (for more information, see the brochures *Helping Your Child With Homework* at http://www.ed.gov/pubs/parents/Homework and *How Important Is Homework?* at http://www.accesseric.org/resources/parent/homewrk.html).

It will take some children longer than others to complete assignments. Children who listen carefully and participate actively in class often finish homework quickly, and those with particularly strong listening skills may be able to cut their homework time by 45 percent (see *Homework & Studying at Home* at http://henson.austin.apple.com/edres/parents/pfet/hwrkmenu.shtml). Lower-ability children may have to spend more time on homework to achieve equal gains (see *The Homework Debate* at http://family.go.com/Features/family_1998_11/metk/metk118homework).

However, teachers and parents need to be aware that children who generally take too long to complete assignments may need more instruction to complete the work successfully. While some homework is a good thing, too much can frustrate children and cause stress. It's also important that children have time to exercise, play, socialize, and pursue their own interests.

How Can I Help My Child With Homework?

First, avoid doing the homework yourself! Doing homework for your child sends the message that he or she is incapable of doing the work and that perfection is the main objective. It also denies your child the opportunity to develop skills and gain understanding from the experience. Remember, doing homework should help children plan, manage, and complete work on their own. Second, familiarize yourself with the school's homework policy so that you know what is expected of you and your child. Here are some other ways you can help your child get the most out of homework:

- Exhibit a positive attitude toward homework in what you say and do—show your child that you think homework is important and education comes first. Your attitude not only has a direct, positive effect on your child's attitude toward homework but also can affect his or her academic achievement (see *Yes, Johnny, Doing Your Homework Is Important* at http://www.shpm.com/articles/child_behavior/homework.html).
- Encourage your child to take notes on homework assignments when they are given.
- Discuss homework assignments with your child to become familiar with what he or she is studying. Talk together about the topic of an essay before writing begins, and do short quizzes on the day before a test.
- Limit afterschool activities to allow time for homework and family activities.
- Limit telephone use by agreeing ahead of time what will be allowed.
- Plan homework schedules and routines that allow some free time when assignments are completed. Make sure your child is well rested and fed and has had time to wind down after school. Also, avoid scheduling homework right before bedtime when children will be too tired or feel pressured to finish. For long-term projects, mark plans and deadlines on a calendar.
- Monitor television and radio use. If your child's favorite show comes on during scheduled study time, arrange to record the show if possible.
- Do some assignments or questions together when your child asks for help. Sometimes children need help learning how to break down large assignments into manageable pieces.
- Stay nearby—reading, writing, studying, or catching up on paperwork. Be available to help if asked, but avoid imposing your help or your way of doing something.
- Check completed assignments and review homework that has been marked and returned. Avoid negative comments, but contact the teacher if your child consistently gets 25 percent or more wrong on homework problems and assignments or if he or she never seems to have any homework.
- Provide your child with a convenient, quiet, and comfortable work area that is well lit, free of family traffic, and stocked with the materials needed to complete assignments. Some children study better with music or background noise, so try to accommodate your child's preferred learning style.
- Encourage the use of reference materials, such as dictionaries and encyclopedias, and provide a computer and a calculator if possible. If a computer is not available at home, plan regular visits to a public library or community learning center that provides access to computers (for more information, see the box on page 13).

You may also find it helpful to talk to the teacher, counselor, or principal if your child develops a consistently negative attitude toward homework, continually fails to fully understand or complete assignments, or fails to make any academic progress. Homework is an essential component of the total educational program. It should enhance the intellectual development of your child while creating greater interest and success in learning and studying.

For more information about helping your child with homework, see *Homework Helpers For Parents* at http://family.go.com/Features/family_1999_02/nwfm/nwfm29homework and *How Parents Can Help With Homework* at http://family.go.com/Features/family_1998_09/sano/sano98homework/sano98homework.html.

The Homework-Computer Connection

The computer has become a common and essential tool in learning many school subjects, particularly mathematics and science. You and your child can use a computer to:

- Complete reports and assignments using word-processing programs and other software.
- Find information using reference materials on CD-ROMs; many are typically available from school and public libraries.
- Access educational software that teaches science or math concepts and skills in interesting and enjoyable ways.
- Access the abundant science, math, and general homework resources and assistance freely available on the Internet. For a list of these resources, see the Homework Companion on the ERIC Clearinghouse for Science, Mathematics, and Environmental Education Web site at http://www.ericse.org/homework.html.

Should Children Be Tracked in Math or Science?

David L. Haury and Linda A. Milbourne

There seems to be no simple answer to the straightforward question, "Should children be tracked in math or science?" The answer depends on whom you ask and what learning outcomes are considered most important. Studies focusing on student achievement and studies focusing on equity issues seem to yield different results, and in both cases questions arise about the educational significance of the findings. Though many members of the education community consider the practice outdated, or even harmful to some children, many parents and teachers strongly endorse tracking.

What Is Tracking?

Tracking refers to the practice of separating children into different courses or course sequences ("tracks") based on their level of achievement or proficiency as measured by some set of tests or course grades. This practice has been common in the United States throughout the 20th century. Even in schools where no formal system of tracking exists, the higher-achieving (upper-track) children take special courses—honors classes or Advanced Placement classes. By the time they reach eighth grade, more than two-thirds of U.S. students are tracked in math (Mullis et al., 1991).

Tracking differs from ability grouping. Ability grouping refers to the practice of separating children into distinct groups within the same classroom. For example, teachers often form reading groups or math groups on the basis of student ability. This instructional strategy enables teachers to meet the needs of individual children more effectively. Children can move from group to group as they progress, and the whole class receives the same basic instruction.

What Does Research Say About Tracking?

Many members of the education community began questioning the practice of tracking in the 1970s. Studies began to show that minority and low-income

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children were overrepresented in the lower tracks, in which they typically received less-challenging instruction from less-qualified teachers (Oakes, 1990). In addition, some argued that children of all ability levels did no better in tracked classes than in classes of mixed ability (Slavin, 1990). These findings prompted many schools to abolish tracking.

More recent findings, however, have caused some researchers to take a more cautionary approach when considering the effects of tracking. For example, one nationwide study shows that when children are detracked—that is, moved back into mixed-ability classrooms—the achievement scores of the children formerly in the lower tracks improve, but those of the children formerly in the average and upper tracks decrease somewhat (Argys, Rees, and Brewer, 1996).

Another study shows the same net effect but states it in a slightly different way: tracking boosts the achievement of children placed in the upper track but lowers the achievement of those placed in the lower track (Gamoran, 1987). The same study also reveals that the difference in achievement between children in the upper and lower tracks is even greater than the difference between those who stay in school and those who drop out. One outcome of tracking, it seems, is a widening of the gap between high achievers and low achievers.

Why Does Tracking Widen the Achievement Gap?

The effect of tracking on achievement may be attributable to classroom environment—there may be significant differences in the way that children and teachers interact in honors, regular, and remedial classrooms. For example, one study suggests that upper-track teachers tend to place more emphasis on reasoning and inquiry skills than other teachers do (Gamoran et al., 1995). The same study suggests that children in the lower tracks spend more time reading textbooks and completing worksheets, while those in the upper tracks are more likely to participate in hands-on inquiry and write about their reasoning process in solving mathematics problems.

Also, math and science courses with higher proportions of minority children are more often designated as "low-ability" courses than those with lower proportions of minority children (National Science Foundation, 1996). Among 10th graders in 1990, black, Hispanic, and Native American children were less likely than other 10th graders to be in an upper-track course in science or math (Peng et al., 1995). This underrepresentation of minorities in upper-track math and science courses, and in related careers, is most troubling (also see the article "Minorities in Science and Mathematics: A Challenge for Change" on page 40).

Where Do We Go From Here?

One of the problems in attempting to take a decisive stand on the issue of tracking is interpreting the array of conflicting results produced by different studies. Some researchers suggest that detracking will be counterproductive, that it will hurt most those it intends to help (Loveless, 1999). This school of thought asserts that detracking will reduce the achievement of children removed from the average and upper tracks but will do little if anything to boost the achievement of children removed from the lower tracks. Supporters of tracking also claim that parents of upper-track children will likely transfer their kids out of schools that abolish tracking, or they will find other means to nurture their children's higher achievement.

In addition, some research suggests that tracking does not necessarily have the same effects in all courses. For example, one study showed that tracking helped all children in certain algebra classes but not in some math survey courses (Epstein and MacIver, 1992).

Despite all the debate on the issue of tracking, no rigorous, large-scale study exists that provides a definitive accounting of tracking's costs and benefits. Until such a study is conducted, the best that educators and parents can do is to decide what outcomes are most important, then use the most relevant findings to make local decisions.

But one thing is clear: U.S. students, in general, do not graduate from high school particularly well prepared in science or, especially, in math (see the article "A Comparison of Math and Science Education Here and Abroad" on page 26). Traditional educational practices that so many cherish, including tracking, do not seem to be serving children well. Given the evidence that any small benefits gained from tracking by higher-achieving students come at the cost of increased barriers to lower-achieving students, the continuation of tracking seems unwarranted. If consideration is given to the potential benefit of using Internet resources (see "Internet Resources" on page 66) to help kids manage some of their own learning, higher-achieving students would likely be just as well served by having different assignments within mixed-ability classes.

So, should children be tracked in math and science? For most children, the answer is clearly no; for others, tracking has a small, positive effect. But alternative instructional strategies within mixed-ability classes may hold more promise.

References

Argys, L. M., D. I. Rees, and D. J. Brewer. 1996. "Detracking America's Schools: Equity at Zero Cost?" *Journal of Policy Analysis and Management* 15 (4): 623–645.

Epstein, J. L., and D. J. MacIver. 1992. *Opportunities To Learn: Effects on Eighth Graders of Curriculum Offerings and Instructional Approaches.* (Report No. 34.) Baltimore, MD: Center for Research on Elementary and Middle Schools, Johns Hopkins University. ERIC Document Reproduction Service No. ED 343 715.

Gamoran, A. 1987. "The Stratification of High School Learning Opportunities." *Sociology of Education* 60 (3): 135–155.

Gamoran, A., et al. Winter 1995. "An Organizational Analysis of the Effects of Ability Grouping." *American Educational Research Journal* 32 (4): 687–715.

Loveless, T. 1999. "Will Tracking Reform Promote Social Equity?" *Educational Leadership* 56 (7): 28–32.

Mullis, I. V. S., et al. 1991. *The State of Mathematics Achievement: NAEP's 1990 Assessment of the Nation and the Trial Assessment of the States.* Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

National Science Foundation. 1996. *Women, Minorities, and Persons With Disabilities in Science and Engineering: 1996* (NSF 96–311). Arlington, VA: Author. (Available online at http://www.nsf.gov/sbe/srs/nsf96311/start.htm)

Oakes, J. 1990. *Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities To Learn Mathematics and Science.* Santa Monica, CA: RAND Corp. ERIC Document Reproduction Service No. ED 329 615.

Peng, S. S., et al. 1995. *Understanding Racial-Ethnic Differences in Secondary School Science and Mathematics Achievement.* National Center for Education Statistics Research and Development Report No. NCES–95–710. Washington, DC: National Center for Education Statistics; National Science Foundation.

Slavin, R. 1990. "Achievement Effects of Ability Grouping in Secondary Schools: A Best Evidence Synthesis." *Review of Educational Research* 60: 471–499.

Calculators in the Classroom: Is the Jury Still Out?

Jeffrey P. Smith

After nearly three decades of debate on the use of calculators in schools, is the education community any closer to reaching consensus on how calculators affect children's understanding of math and science? Regardless of philosophical, theoretical, or research-based arguments, both advocates and opponents realize the importance of this debate, especially at a time when school control has become such a hot issue.

At least three key factors seem to influence the technology policies of schools: (1) the increasingly rapid development of new technologies; (2) the national outcry for today's student (tomorrow's productive citizen) to be technologically literate; and (3) the rising comfort level of adults who are using technology. With all of these forces at work, it becomes difficult to sort through the logistics of using calculators in the classroom. What are the recommendations?

Recommendations for Curriculum Content

The National Council of Teachers of Mathematics and the National Science Teachers Association have been strong proponents of using calculators in grades K through 12. The draft document *Principles and Standards for School Mathematics* (online at http://www.nctm.org/standards2000) lists technology as one of the six guiding principles for mathematics instruction and specifically discusses the use of calculators:

> *With calculators, students can have access to a wider range of complex problems, and they can address these problems earlier in their school experience. Students at all levels should have access to calculators and other technology as they solve problems. Research affirms the positive impact of calculator use on the development of problem solving strategies and performance.*

Furthermore, textbook publishers have recognized that calculators are now a mainstay in society. Nearly all publishers include calculator-based instructions and exercises in their K–12 math textbooks. They also supply teachers with resources for designing and implementing calculator-friendly lessons. So at all grade levels in math and science, technology has created a need to re-examine both the scope and sequence of curriculum content.

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Recommendations for Instruction (Grades K–4)

In the elementary grades, calculators are used to emphasize pattern generation and recognition and to help children enhance their sense of numbers and develop mathematical intuition. For example, technology helps children in kindergarten and grade 1 learn to count orally. Handheld calculators with a constant function help those children *count on, count back*, and *skip count* (see "Counting With a Calculator" on this page).

Calculators can also be used to reinforce computational skills. In the activity "What To Do With a Broken Calculator?" (see the figure on this page), children are challenged to find a series of keystrokes that will produce a specified, target answer. It sounds easy enough—until they're told that some of the keys are off-limits.

Counting With a Calculator

	Keystrokes	Display
Counting On (by ones)	3 + 1 = = =	4, 5, 6
Counting Back (by ones)	10 – 1 = = =	9, 8, 7
Skip Counting (by fives)	5 + = = =	5, 10, 15

—Adapted from *Mathematics and the Young Child* (National Council of Teachers of Mathematics, 1990)

What To Do With a Broken Calculator?

Target	Restrictions	Possible Keystroke Sequence	Number of Keystrokes*
16	Using only 3, 5, and all arithmetic operations	(5 – 3) x (5 + 3) =	12
29	Using only 2, 7, and all arithmetic operations	7 x (2 + 2) + (2 / 2) =	14
55	Using all numerals (except 0 and 1); only addition and division	54 + (5 / 5) =	9

*For an added challenge, find the minimal keystroke sequence that yields the target number.

—Adapted from *Mathematics and the Young Child* (National Council of Teachers of Mathematics, 1990)

Recommendations for Instruction (Grades 5–8)

Middle school students are encouraged to use technology to collect, sort, and analyze data. In science classrooms, many teachers are designing activities that involve graphing calculators and calculator-based lab (CBL) equipment. CBL probes can be used to collect data on phenomena such as light, temperature, and motion.

By retrieving and analyzing real-time data in lab activities, children learn to apply scientific principles in meaningful and relevant ways. The topic of periodic motion, once reserved for the calculus classroom, now grounds itself in the middle grades—with calculators assisting in the experimentation process.

Recommendations for Instruction (Grades 9–12)

In addition to recognizing the power of graphing calculators, educational technology specialists believe the next big wave in handheld computing will come in the form of calculators that can perform algebraic manipulations. With a few simple keystrokes, computer algebra systems (CAS) calculators can do all the symbol pushing that used to require more time, patience, and paper than many high school students were willing to sacrifice. Many problems, such as solving the equation $x^3 - 27 = 0$, become readily accessible to children, with the focus shifting away from cumbersome algebraic manipulations and moving toward the meaning behind complex numbers as solutions.

The use of CAS calculators, however, does not replace the need for children to learn to perform algebraic manipulations fluently. Teachers should help children learn to use technology appropriately as a tool for discovering more about math and science, not for covering up the concepts or content.

Recommendations for Assessment

In the mid-1990s, standardized testing agencies recognized the importance of calculators in K–12 education and adopted policies allowing the use of handheld technology during exams. In fact, today's high school student is encouraged to use a scientific or graphing calculator when taking standardized exams, such as the ACT, SAT, or PSAT–NMSQT (although CAS calculators are forbidden). Furthermore, even the College Board's Advanced Placement Calculus Exam permits the use of graphing calculators on some sections of the test. This acceptance of calculators at the national level has had a tremendous impact on teachers and students at the classroom level.

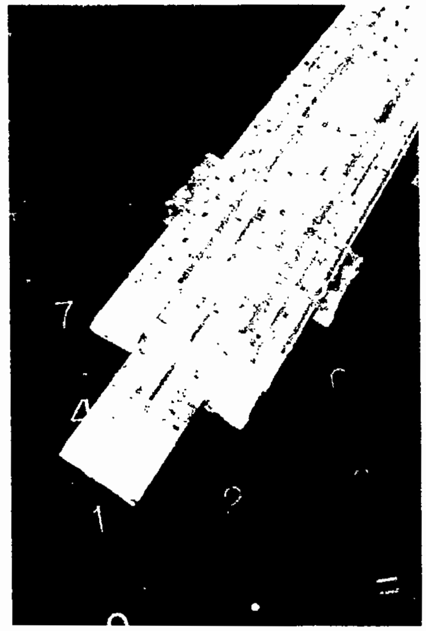
Many teachers are creating math and science tests that have three types of questions: (1) those that require the use of calculators; (2) those that prohibit the use of calculators; and (3) those that permit the use of calculators ("calculator-friendly" questions). Although it is easy and philosophically pleasing to say that the best test incorporates problems of each type, little research exists to support claims that children need to be evaluated at all three levels to demonstrate understanding. When preparing assessments, teachers are therefore left to use their best professional judgment to weigh the importance of each of the three question types on an item-by-item basis.

Final Remarks

In an era when technology has become a hallmark of societal needs, the question of whether or not children should be using calculators in math and science seems outdated. The recommendations for curriculum, instruction, and assessment reflect widespread support for the use of handheld technology in schools. The question, "Should kids be using calculators?" has been replaced with, "In what ways should kids be using calculators?" The latter question will certainly be a much more complex case to decide.

Reference

National Council of Teachers of Mathematics. 1990. *Mathematics and the Young Child*. Reston, VA: Author.



How Can I Find Out More About Science Fairs and Math Competitions?

Wendy Sherman McCann

Parents, has your child suddenly become interested in determining which laundry detergent produces the most suds? Or has he or she developed a sudden interest in math problems? Have you noticed your child acquiring a bizarre collection of magnets, wires, and batteries lately? Does your adolescent seem to be speaking in tongues, mumbling about hypotheses, dependent variables, or problem solving? If so, then you may be feeling the effects of a science fair or mathematics competition, annual events in which kids compete for various levels of recognition by designing and carrying out scientific investigations or by solving math problems.

Science Fairs

Participation in science fairs is usually included in the science curriculum as a means for children to experience "thinking like a scientist." The types of projects students are expected to complete will probably vary by grade level. Younger children may simply build models or collections, or exhibit basic demonstrations of scientific phenomena. Older children are often expected to test a scientific hypothesis through a detailed, controlled experiment.

The rules that govern science fair projects also can vary across schools. Some schools allow kids to complete group projects, while others require individual work. Children may be asked to present their project results to teachers, classmates,

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or outside judges for evaluation. Some science fairs, but not all, allow invention-type projects, such as "designing a utensil for eating peas."

Many kids enjoy participating in science fairs, but others may need a bit of encouragement from teachers and parents. You can help ensure that your child's experience is a positive one by taking the following steps:

- Encourage your child to choose a project that will sustain his or her interest. Because the investigation will be carried out over an extended period of time, your child should be motivated to study the chosen topic (for project ideas, see the box on this page).
- Help your child prepare a realistic timeline for completing the project. Most science fair investigations take a good deal of time to complete and analyze. Be sure to allow time for mistakes and false starts—waiting to complete a science project until the night before the due date will never result in a satisfying experience!
- Help your child gather materials early. Take time to think about the project presentation and the materials needed for a neat, attractive display. Plan to photograph appropriate aspects of the investigation for later display on background posters.
- Make sure your child is aware of any restrictions that apply to his or her project. Keep in mind that many science fairs have strict rules about experimentation on humans and animals. Knowing the rules and expectations ahead of time will help avoid problems or even disqualification down the road.
- Make sure your child is aware of all project assignments and deadlines. Some teachers require literature searches, written reports, or in-class presentations in addition to the investigation itself.
- Be a supportive "practice audience" for your child. Many science fair contests require kids to give an oral report to one or more judges, who can then ask questions about the investigation. Listen to your child rehearse the oral presentation, and try to anticipate questions the judges may ask. Teachers can help by providing judging criteria for students and parents to consider.

For more help in choosing science fair topics, finding examples of science fair projects, or obtaining guidelines for completing projects, use the Internet resources listed on the ERIC Clearinghouse for Science, Mathematics, and Environmental Education Web site at http://www.ericse.org/scifair.html.

Math Competitions

Like science fairs, math competitions generally have local, regional, state, and national levels of competition and awards, but in other ways they differ fundamentally. In most math competitions, the sponsors—not the students—determine the nature of the problems to be solved. Most math competitions involve student teams, and most are extracurricular, so they generally are not part of a regular math class.

But there is tremendous variety in the types of competitions that are held. For instance, MATHCOUNTS competitions are treated almost as a sport, with children in grades 7 and 8 being coached for several months before the school selects a team of four kids to compete locally. Winners then proceed to state competitions, and winners at the state level go on to compete nationally. The questions can cover a number of math topics, including algebra, geometry, number theory, and statistics (for more information about MATHCOUNTS, see http://mathcounts.org).

The Mandelbrot Midlevel Competition (http://www.midlevels.org) conducts three rounds of competition for individuals and teams throughout the year. Though a school can select only one team for competition, there is no limit to the number of kids who can compete on an individual basis. The questions cover such topics as elementary algebra, geometry, combinatorics, and number theory.

In addition to generating an interest in mathematics, participation in math competitions serves to develop number sense, algebraic thinking, and problem-solving skills—all of which are important prerequisites for success in high school and college mathematics courses.

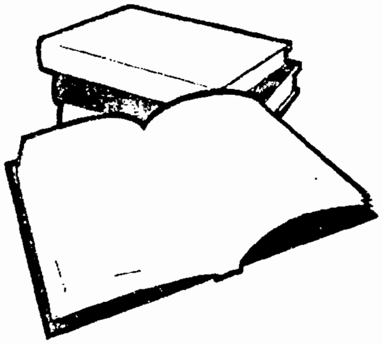
For more help in finding math competitions, preparing for competitions, or obtaining guidelines for various competitions, see the Internet resources listed on the ERIC Clearinghouse for Science, Mathematics, and Environmental Education Web site at http://www.ericse.org/mathcomp.html.

Cool Questions for Science Fair Projects

- Does the size or breed of a dog affect its heart rate?
- What container will keep a drink cold for the longest period of time?
- Are paper grocery bags stronger than plastic grocery bags?
- Which kinds of cereal get soggy the fastest and which stay crunchy the longest?
- Do members of the same family tend to have the same favorite color?
- Do taller people have bigger feet?
- Are snails attracted or repelled by light?
- Will a seed grow if part of it has been removed?
- Are guppies attracted to mirrors?
- Can you train an earthworm to do something?

—Taken from *Science Fair Projects: A Guide for Grown-ups*, produced by the Education Division of the American Chemical Society.

Print and Internet Resources About Science Fairs



Print Resources

Bochinski, J. B. 1996. *The Complete Handbook of Science Fair Projects,* Revised Edition. New York: John Wiley and Sons, Inc.

Iritz, M. H. 1996. *Super Science Fair Sourcebook.* New York: Learning Triangle Press.

Tant, C. 1992. *Science Fair Spelled W–I–N. First Place Tips for Students, Teachers, and Parents.* Angelton, TX: Biotech Publishing.

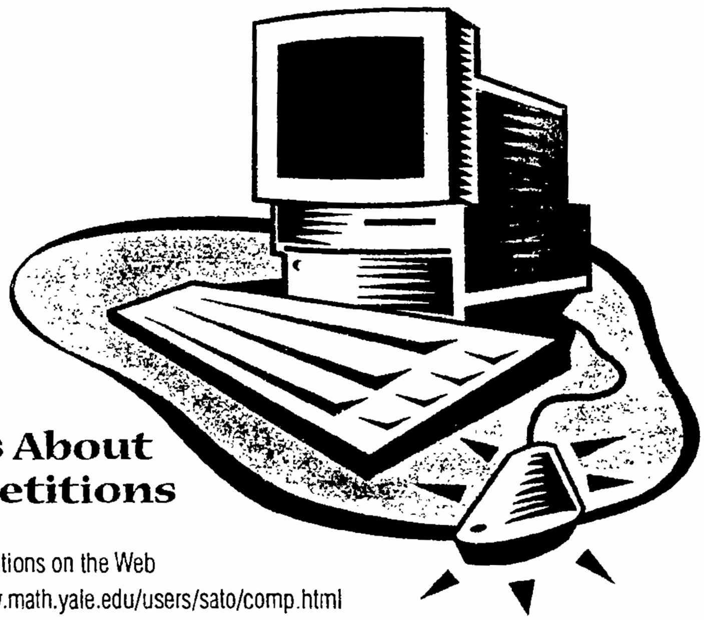
Internet Resources

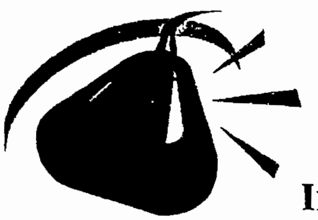
Intel Science Talent Search (formerly Westinghouse Science Talent Search)
http://www.intel.com/education/sts

IPL Science Fair Project Resource Guide
http://www.ipl.org/youth/projectguide

Science Fair Idea Exchange
http://www.halcyon.com/sciclub/cgi-pvt/scifair/guestbook.html

The World Wide Web Virtual Library: Science Fairs
http://physics.usc.edu/~gould/ScienceFairs





Internet Resources About Mathematics Competitions

American Mathematics Competitions
http://www.unl.edu/amc

American Regions Mathematics League
http://www.armlmath.org

International Mathematical Olympiad
http://camel math.ca/IMO

Mandelbrot Midlevel Competition
http://www.midlevels.org

Math Competitions on the Web
http://www.math.yale.edu/users/sato/comp.html

MATHCOUNTS
http://mathcounts.org

Mathematics Contest Page
http://www.olemiss.edu/mathed/problem.htm

World's Largest Math Event
http://www.nctm.org/about/wlme/wlme4/index.html

A Parent's Guide to Student Performance in Science and Mathematics

David L. Haury

After all is said and done regarding international comparisons of student achievement, national education goals, and standards for science and mathematics education, most parents simply want to know how their children are doing in class. Are they learning? Do they know what they are supposed to know? How are they doing compared with others their age? Are they ready for science or math in the next grade or class? Will they pass the state proficiency examinations? These are healthy concerns, and schools are becoming better at assessing student performance in ways that provide more helpful feedback to parents, teachers, and, ultimately, students.

This article serves as a parent's guide to student performance in science and math. Not unlike a nature guide, which helps you identify a bird, tree, insect, or flower by recognizing its key features, this guide will help you gauge your child's performance by recognizing and understanding the variety of assessments used in today's science and math classrooms.

How Do I Judge My Child's Performance?

Interpreting test results seemed to be easier in the traditional science and math classrooms of years past. After each unit, children would take a test—usually consisting of multiple-choice, true-or-false, or fill-in-the-blank items—and earn points for choosing correct answers. Earning 90 out of 100 points was very good; earning 49 out of 100 was not. At the end of the grading period, teachers would add up points, calculate percentages, and assign grades. In this scenario, assessment was somewhat narrow in focus, emphasizing the child's knowledge of important facts or the ability to solve structured problems. This type of assessment was also deceptively straightforward—children either got the right answers or they didn't. How they got the right answers—by knowing, memorizing, or lucky guessing—was seldom examined.

Though it is still considered important for kids to know certain fundamental concepts and ideas, the ongoing reform movements in science and math education have greatly influenced state standards and local programs with respect to the content and goals of instruction. The national math standards (National Council of Teachers of Mathematics, 1989), currently in revision for release in 2000; the *National Science Education Standards* (National Research Council, 1996); and the *Benchmarks for Science Literacy* (Project 2061, 1993) place increasing emphasis on active, inquiry-based learning and on the cognitive skills associated with critical thinking, decision making, and open-ended problem solving (for a discussion of math and science standards, see the article "National Math and Science Standards: A Primer for Parents" on page 23).

As a result, success in science and math now requires children to do more than simply recite facts or apply problem-solving procedures in a cookie-cutter fashion. For example, science educators now look to see if children can (1) understand some of the unifying concepts and processes that cut across the traditional scientific disciplines; (2) plan and conduct

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investigations; (3) identify and solve problems; (4) apply scientific concepts to issues of daily life and make decisions; and (5) understand the nature of science and scientific knowledge.

Like their science counterparts, math educators now look to see whether children can use key ideas to think and reason critically, solve problems, and make decisions. They also expect kids to be able to express mathematical ideas through words, pictures, diagrams, and other forms of communication. To reflect changes in the curriculum, math educators now place greater emphasis on certain content areas, such as estimation and statistics.

The important message for you, as a parent, is that your child needs to know more than just the right answers to succeed in science and math. As you attempt to gauge your child's performance, look for a wide range of skills, not just the number of points he or she scored on a test. Your task will be easier if you recognize the various forms of assessment, understand what each one measures, and realize that they can work together to provide a more complete picture of your child's abilities.

What Forms of Assessment Can I Expect To See?

Given the increasingly widespread use of assessment to guide learning, and the broader spectrum of knowledge and skills required of children, classroom assessments have become more varied and complex. As schools implement national standards and expect more of children, assessments will become more diversified.

Various terms have been used to describe the newer forms of classroom assessment, from *alternative assessment* and *authentic assessment* to *performance-based assessment* (herein, collectively, performance assessment). Though the meanings of these terms may have subtle differences, they all represent a break with past assessment practices.

Unlike traditional tests, in which children select answers from a set of alternatives, performance assessments require kids to perform a task, generate their own responses to questions, or create *products* that demonstrate both their knowledge and their cognitive or procedural skills. These tasks can take many forms, from doing mathematical computations or an experiment to writing an essay. The more common forms of performance assessment being used in science and mathematics classrooms include the following.

Computer Adaptive Testing

Computer adaptive testing requires children to respond to items or tasks with the aid of a computer. For example, a child may respond to several questions to determine his or her ability and then complete a performance task suitable for that ability level.

Concept Mapping

Concept mapping is a structured method for individuals or groups to clarify or organize their ideas and thoughts in pictorial form. The resulting concept map shows the key concepts of a topic and the relationships among them. As an assessment technique, concept mapping can be used to check student understanding of key ideas and their relationships or to diagnose misunderstandings. For more information about concept mapping, see http://www.to.utwente.nl/user/ism/lanzing/cm_home.htm.

Constructed-Response Questions

Constructed-response questions, which can appear on tests, quizzes, or assignments, require children to construct their own answers rather than select from a set of possible answers, such as those found on a multiple-choice test. Teachers often prepare tests made up of constructed-response questions that can take a variety of forms, from filling in blanks to producing graphs or diagrams to describing steps involved in solving a problem. Extended-response, open-ended questions require the child to produce an extended written response to an item or task that does not have one right answer (for example, an essay or a laboratory report).

Essays

Essays have long been used to determine student proficiency in using facts to make a point, explain n idea, or make the case for some action or decision. Essays demonstrate the child's ability to organize, describe, analyze, explain, or summarize ideas or events.

Experiments or Investigations

Experiments are often used in science classes to test student understanding of both science concepts and skills related to inquiry. Experiments require children to plan and conduct research, test hypotheses, use skills of measurement and estimation, and report findings orally or in written form. Many state proficiency examinations now require children to conduct experiments or interpret experimental results. Investigations in mathematics might involve applying process skills to some real-world situation or interpreting collected data to decide on a course of action.

Interviews

An interview requires the child to respond verbally to questions from the teacher or some other assessor. Sometimes interviewers pose questions according to a standard protocol.

Observations

During observation, the child performs a task or procedure while being observed and rated using a rubric, which is an agreed-upon set of scoring criteria (for more information about rubrics, see the box on page 22).

Portfolios

A portfolio is a collection or sample of the child's work. This concept derives from the visual and performing arts tradition in which portfolios serve to showcase artists' accomplishments and personally favored works. A portfolio can contain a child's best pieces and the child's evaluation of the pieces. It may also contain one or more works in progress that illustrate the evolution of a product—such as an essay—through the various stages of conception, drafting, and revision. Children typically participate in selecting materials to be included in their portfolios, and they are informed of the criteria to be used for evaluating the portfolio (for more information, see Resources at the end of this article).

Projects

Projects take many forms, from development of class demonstrations or oral presentations to library research and exhibits. Projects are often interdisciplinary and typically require a wide range of skills. Children usually complete projects over an extended period of time. Group projects require kids to work collaboratively in teams that plan, discuss, prepare, and present their findings or product. Teachers often evaluate projects using a rubric, or set of criteria, which informs participants of the expected standards before they begin.

Station Activities

Much like learning centers, station activities require children to move, either individually or in groups, from station to station to perform a sequence of tasks during a prescribed period of time. Children might be asked to sort objects, collect and interpret data, make comparisons, interpret graphs, or make inferences based on observations. Open-ended questions are designed to elicit specific thinking skills or process skills.

Conclusion

You may have already noticed the increased use of performance assessments in your child's math or science classroom. Expect to see a growing emphasis on products that are scored according to rubrics and, in science, increasing evidence of conformity to the national standards for assessment (for more information, see the article "National Math and Science Standards: A Primer for Parents" on page 23). As assessments become more refined and closely linked to the new content standards, you should also expect to see assessments that provide more detailed feedback about how to improve your child's performance. This information will help parents, teachers, and students focus on the concepts and skills that require the most attention as they anticipate state proficiency exams and national assessments. ■

References

National Council of Teachers of Mathematics. 1989. *Curriculum and Evaluation Standards for School Mathematics.* Reston, VA: Author. (Available online at http://www.enc.org/reform/journals/ENC2280/nf_280dtoc1.htm)

National Research Council. 1996. *National Science Education Standards.* Washington, DC: National Academy Press. (Available online at http://www.nap.edu/readingroom/books/nses/html)

Project 2061, American Association for the Advancement of Science. 1993. *Benchmarks for Science Literacy.* New York: Oxford University Press.

Resources

Beyond Test Scores: How Can Parents Judge the Quality of Their Schools? (http://www.cse.ucla.edu/CRESST/pages/ptaron.htm)

Making the Grade: What Every Parent Needs to Know About Changes in Assessments and Testing (http://www.pta.org/programs/makegrade.htm)

Some Things Parents Should Know About Testing (http://www.hbem.com/library/parents.htm)

Student Portfolios: Classroom Uses (http://www.ed.gov/pubs/OR/ConsumerGuides/classuse.html)

The State of Performance Assessments (http://www.aasa.org/SA/dec9804.htm)

What Is a Rubric?

A *rubric* is a set of scoring criteria that a teacher or other assessor uses to evaluate the responses to a performance assessment task. Since most performance assessment tasks require open-ended responses or individual initiative, a scoring rubric ensures that the responses of different students will be judged on the same merits in a fair and consistent way. This is particularly important with alternative assessment procedures, since ambiguous requirements are confounded by student differences in experiences and expectations based on their ethnicity, primary language, or gender.

As an example, here is a simple rubric for assigning points to a portfolio:

10 Portfolio well organized and documented. Format is accurate, complete, and easy to follow. Excellent quality; well-designed portfolio; indicates superior effort.

8 Portfolio fairly well organized and documented. Format is mostly accurate, complete, and easy to follow. High quality; clear design; indicates excellent effort.

6 Portions of the portfolio are poorly organized or inaccurately documented. Not complete or possibly somewhat difficult to follow. Average quality; adequate design; indicates acceptable effort.

4 Portfolio disorganized, poorly documented, significantly incomplete or inaccurate. Difficult to follow. Poor quality; little or no design; indicates insufficient effort.

2 Portfolio incomplete, incorrect, or inadequate. Work indicates little or no effort.

0 Portfolio not submitted.

Note: This is a simple example to illustrate how scoring rubrics are used. The actual rubrics used in classrooms may be considerably more detailed.

For more information about rubrics, see the following Web site hosted by The Discovery Channel: http://discoveryschool.com/schrockguide/assess.html.

National Math and Science Standards: A Primer for Parents

Wendy Sherman McCann and S. Asli Özgün-Koca

The push toward national education standards is a relatively recent development in American education—the content and skills thought to be necessary for student competency in academic subjects has historically been determined by school districts on an individual basis. Although education standards have been developed for virtually every subject, the math and science standards have drawn special attention for their potential to help U.S. students become first in the world in math and science achievement (U.S. Department of Education, 1991).

How Long Have Math and Science Standards Been Around?

On the national level, mathematics standards have been in place for some time. The National Council of Teachers of Mathematics (NCTM) published *Curriculum and Evaluation Standards for School Mathematics* in 1989, *Professional Standards for Teaching Mathematics* in 1991, and *Assessment Standards for School Mathematics* in 1995. The NCTM standards set forth five general goals for children: learning to value mathematics, becoming confident in their ability to do math, becoming mathematical problem solvers, learning to communicate mathematically, and learning to reason mathematically. NCTM endorses the idea that children who achieve these goals will be well prepared to use their mathematical knowledge and abilities in ways that will enhance their lives.

The National Research Council (NRC) developed *National Science Education Standards (NSES)* at the request of the National Science Teachers Association. These standards were published in 1996. According to *NSES*, the ideal science education would allow children to (1) experience the richness and excitement of knowing about and understanding the natural world, (2) use appropriate scientific processes and principles in making personal decisions, (3) engage intelligently in public discourse and debate about matters of scientific and technological concern, and (4) increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers.

Are Schools Required To Adopt the National Math and Science Standards?

Math and science standards are intended to *guide* schools in their efforts to help children become literate in these school subjects. Consequently, schools are not required to adopt the national standards, but professional teachers organizations have endorsed the standards as a step in the right direction toward classroom reform. Most states have established their own education standards or are in the process of developing them.

Are National Math and Science Standards Really Necessary?

Math and science standards represent a large part of the country's response to dissatisfaction with student performance in these subjects (for further discussion of national test results, see the article "A Comparison of Math and Science Education Here and Abroad" on page 26). Although setting higher expectations for student achievement seems to be a natural response to poor performance, national standards have drawn criticism for a number of reasons.

Some members of the education community have argued that tougher math and science requirements would either reduce the high school graduation rate or maintain it at the expense of education quality. Neither of these predictions has been realized. Even though many schools and teachers have not fully reformed their curricula and practices to align with the standards, they seem to be exposing their students to more credit hours of math and science instruction.

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Others have worried that standards would exist as rigid prescriptions for educational practices that could stifle the unique needs of different communities and individual children. However, at least at the national level, NCTM and NRC have emphasized that the standards are meant to be guidelines, not repressive regulations. NCTM and NRC continue to stress that curriculum decisions *should* be made at the state and local levels and that the purpose of national standards is to promote math and science literacy for students, to ensure the equity of educational experiences for all children, and to serve as a coherent vision for what a quality approach to math and science education entails.

The majority of educators believe that teachers, students, and parents benefit from having standards because they are given clear goals and explicit recommendations for the knowledge, skills, and education practices necessary for successful math and science learning.

What Is Being Done To Implement Math and Science Standards?

Although virtually all states have been involved in developing math and science standards, some organizations believe the states should work harder to ensure that standards have a positive effect on individual schools. For example, the American Federation of Teachers (AFT) (1996) has studied the development and implementation of state-level standards and has found several problems.

First, although many states plan to use assessment to determine whether children are meeting standards, the actual guidelines tend to be vague and difficult to assess. Second, most states have overlooked opportunities to make their standards internationally competitive. Third, the majority of states have not made provisions for supporting districts that will need to enact drastic reform measures to meet the goals of the standards. Overall, though, AFT is encouraged by current progress and emphasizes that states should be supported in their efforts to produce challenging educational standards for which schools are held accountable.

Control of most school policies, however, remains at the local or district level. Some schools have rushed to implement standards-based curricula and standards-based teaching and assessment practices. Other schools have been slow to introduce such changes. To encourage more rapid reform, some states have established graduation exams or differentiated diplomas based on state-level education standards. In other words, children in some states must pass proficiency exams to graduate from high school.

While disagreement exists over the extent to which children should be held accountable for meeting education standards, most educators concede that standards-based programs can be beneficial when they are not only based on current research about student learning but also established with the goal of helping all children receive the best education possible. Consequently, many school districts have chosen to write their own standards based on national or state guidelines.

How Do I Know If Standards-Based Curricula Are Being Used in My Child's School?

Ask! As a parent, you have the right to know what your school expects of its students, and teachers and administrators are pleased when parents take an interest in their child's education. Find out whether your school's teachers are aware of the national and state standards in math and science education. Most standards documents are readily available and should be easy for educators to obtain (for more information see Resources at the end of this article).

Typically, teachers and administrators are aware of education standards but have had few opportunities to implement them. Find out when your school district is planning to review its cur-

ricula and objectives for math and science education and ask whether state and national standards will be used to guide any proposed revisions.

Also, one of the goals of math and science reform is to give teachers regular opportunities for professional development. Remember, teachers who participated in certification programs many years ago may not be familiar with the more recent research findings on which the math and science standards are based. Determine how much support your district gives to teachers for taking refresher courses, attending professional conferences or workshops, or otherwise increasing their knowledge of effective teaching and assessment practices for promoting and ensuring student learning. If opportunities for teachers in your school district are limited, you may want to voice your concerns with administrators and policymakers.

Finally, realize that standards-based math and science classrooms may seem very different from the classes you participated in as a child. It is sometimes difficult for parents to understand or accept nontraditional educational practices, but you should never feel uncomfortable about asking teachers to explain how any unfamiliar strategies benefit your child. You may want to investigate some of the techniques being used in reform-minded classrooms across the country. Much of this information is readily available (see the articles "Best Practices in Science Education" on page 30 and "Promising Practices in Mathematics Education" on page 36). For example, descriptions of many grant-winning, standards-based math and science programs are available on the Internet (see Resources at the end of this article).

How Can I Help My Child Meet the Math and Science Standards?

It is widely recognized that parent and family involvement in a child's education increases student achievement and success. The research in this area is clear and convincing. The most accurate predictor of student achievement is not income or social status, but the extent to which parents are able to (1) create a home environment that encourages learning; (2) communicate high, yet reasonable, expectations for their children's achievement and future careers; and (3) involve themselves in their children's education at school and in the community (National Parent Teacher Association, 1997).

Assisting in your children's education also involves helping them strengthen their math and science skills at home. For more information, see the articles "How Can I Help My Child Become More Interested in Science?" on page 7 and "How Can I Help My Child Become More Interested in Math?" on page 9. For specific online resources that you may find helpful, see Resources at the end of this article.

You can play an important role in helping schools implement math and science standards and in helping your children become literate in science and math. With the support of all members of the education community, the standards—and the quality education they represent—are likely to be realized.

References

American Federation of Teachers. 1996. *Making Standards Matter 1996: Executive Summary.* (Available online at http://www.synecticsltd.com/AFT96Execsummary.htm)

National Council of Teachers of Mathematics. 1989. *Curriculum and Evaluation Standards for School Mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. 1991. *Professional Standards for Teaching Mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. 1995. *Assessment Standards for School Mathematics.* Reston, VA: Author.

National Parent Teacher Association. 1997. *National PTA National Standards for Parent/Family Involvement Programs.* (Available online at http://www.pta.org/programs/invstand.htm)

National Research Council. 1996. *National Science Education Standards.* Washington, DC: National Academy Press.

U.S. Department of Education. 1991. *America 2000: An Education Strategy.* Washington, DC: Author.

Resources

National Education Goals

Building a Nation of Learners (http://www.negp.gov/WEBPG10.htm)

National Standards for Parent/Family Involvement Programs

National PTA Standards (http://www.pta.org/programs/invstand.htm)

NCTM Standards for Mathematics Education

National Council of Teachers of Mathematics. 1989. *Curriculum and Evaluation Standards for School Mathematics.* Reston, VA: Author. (Available online at http://standards-e.nctm.org/1.0/89ces/Table_of_Contents.html)

National Council of Teachers of Mathematics. (To be published.) *Principles and Standards for School Mathematics: Discussion Draft.* Reston, VA: Author. (Available online at http://www.nctm.org/standards2000)

National Science Education Standards

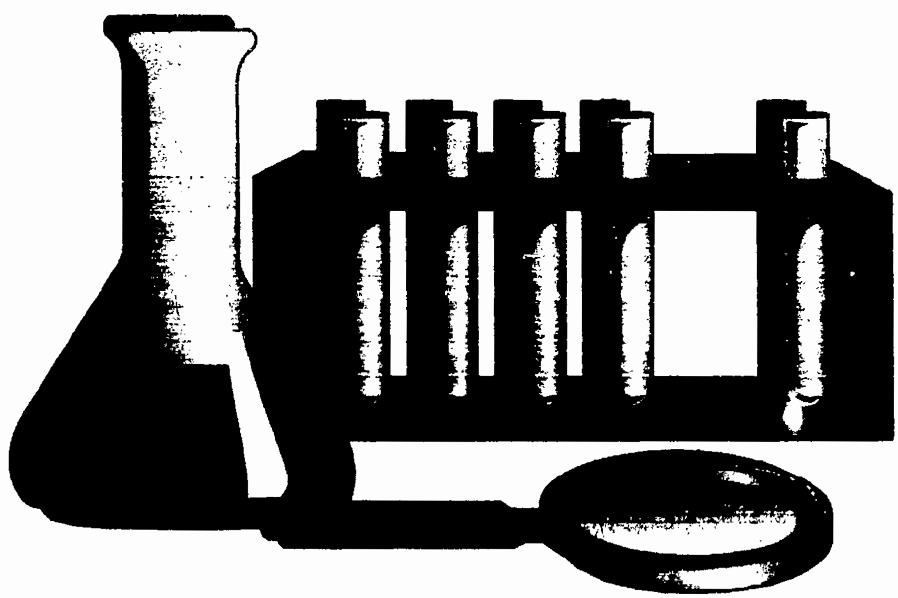
National Research Council. 1996. *National Science Education Standards.* Washington, DC: National Academy Press. ERIC Document Reproduction Service No. ED 391 690. (Available online at http://www.nap.edu/readingroom/books/nses/html)

Content Knowledge: The Mid-Continent Regional Educational Laboratory Standards Database (http://www.mcrel.org/standards-benchmarks)

Project 2061: Science Literacy for a Changing Future (http://project2061.aaas.org)

The Guide to Math and Science Reform (http://www.learner.org/theguide)

Summary of Analyzed State Curriculum Frameworks (http://www.mcrel.org/hpc/sum-cur-fram)



A Comparison of Math and Science Education Here and Abroad

S. Asli Özgün-Koca and Wendy Sherman McCann

Educators have always been interested in comparing their own policies and practices with those of others. In this age of global connectedness, international studies of educational routines and outcomes are becoming more common. For those particularly concerned with mathematics and science education, the Third International Mathematics and Science Study provides the most comprehensive look at international similarities and differences to date.

What Is TIMSS?

TIMSS (the Third International Mathematics and Science Study) is a comprehensive investigation consisting of five parts: assessments of student knowledge in math and science; analyses of curriculum guides and textbooks from participating countries; surveys of student and teacher practices and beliefs about math and science; videotape reviews of math classrooms in the United States, Germany, and Japan; and indepth investigations of classrooms and policies in the United States, Germany, and Japan.

More than half a million children from more than 15,000 schools worldwide took part in TIMSS. For comparison purposes, all of the 41 participating countries tested 13-year-old students' achievement in and attitudes toward math and science. In addition, each country could elect to test nine-year-olds and children in the last year of secondary school. Parts of the study were designed and field tested from 1991 to 1994. Materials for the curriculum study were collected in 1992 and 1993, and the assessments of student knowledge and classroom cultures took place during the 1995–96 school year.

TIMSS was designed to be as fair and accurate as possible. Each country randomly selected its students to prevent comparisons of *all* of one country's students with the *best* of another's. The tests were designed in English, then rigorously translated into 30 languages. The persons responsible for data collection and scoring were trained thoroughly.

Nonetheless, international studies such as TIMSS are often criticized on the grounds that comparisons of countries are inherently unfair. However, scholars of education policy note that, in reality, schooling practices are quite similar on a basic level around the world. Therefore, when international studies uncover great differences in student achievement, the subtle aspects of education organization and culture in various countries can be studied to explain these differences.

How Can TIMSS Results Be Interpreted?

In evaluations such as this, rankings based on raw scores (the actual percentage of correct answers) aren't particularly meaningful. As the National Science Teachers Association (NSTA) warns, TIMSS results should not be read like the outcome of a sporting event. Instead, it is more helpful to think of the results in terms of groups of countries that have similarly performing students. Therefore, TIMSS scores for each country are usually reported as being *statistically (significantly) higher than*, *lower than*, or *equivalent to* another's.

How Do U.S. Students Compare With Others?

In the United States, the TIMSS tests of student knowledge have received the most attention from the media. U.S. students were tested at grades 4, 8, and

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12. Among the 26 countries participating at the fourth-grade level, the United States performed above the international average in both science and math. In science, the United States scored significantly higher than 19 countries and equivalent to 5 others. Only Korea scored higher. In math, the United States scored significantly higher than 12 countries and equivalent to 6 countries but scored lower than 7 others.

Among the 41 countries participating at the eighth-grade level, the United States scored above the international average in science, but below the average in math. In science, the United States scored significantly higher than 16 countries and equivalent to 15 countries but scored lower than 9 others. In math, however, 20 countries outranked the United States; only 7 countries scored lower.

The U.S. results at the 12th-grade level were the most disappointing. Among 21 participating countries, the United States scored below the international average in both general science and general math knowledge. The United States was outperformed by 11 countries in science and by 14 countries in math. Only two countries scored significantly lower than the United States in both subjects. Some 12th-grade students also took tests of advanced mathematics and physics achievement; in both cases, the U.S. performance was dismal. The United States scored in the lowest performing group in both physics and advanced math achievement. For a summary of U.S. strengths and weaknesses in science and math at grades 4 and 8, see the table on this page.

How Do U.S. Textbooks and Teaching Materials Stack Up?

It has been argued that math and science curricula, textbooks, and teaching in the United States are "a mile wide and an inch deep." U.S. schools do tend to teach a little bit about many topics, rather than a great deal about relatively few topics. In both math and science, textbooks compound the problem by including many topics to cater to the broadest possible audience, and often teachers feel pressured to cover most or all of the textbook material. Nonetheless, the results from TIMSS show that, except for physical science, the U.S. science curriculum is more focused, or deeper, than the U.S. math curriculum. As a result, science topics presented at various grade levels vary widely from state to state.

Some education scholars believe that having national curriculum standards in math and science will help negate some of the emphasis on breadth rather than depth in U.S. schools. Because the mathematics standards developed by the National Council of Teachers of Mathematics had been in existence for only a few years and the national science standards had not yet been introduced at the time of the TIMSS curriculum study, professional teachers organizations are still hopeful that the standards' effects have yet to be measured. Still, they caution that standards cannot provide a "quick fix" to all the math and science education woes in the United States.

Other scholars dispute the idea that a broad, or "splintered," U.S. curriculum is the main cause of poor achievement scores. Instead, they suggest that differences in school funding and levels of child poverty across districts have a greater impact on achievement than do differences in math and science curricula. Other researchers cite parent involvement as an important variable in student success.

Still others point out that although 8 of the countries with the top 10 TIMSS scores have nationally centralized curricula, so do 8 of the 10 lowest scoring countries. They claim it would be more useful to study what other countries are doing to reform their math and science schooling practices, because achievement scores are but one aspect of the overall education picture. One such study of 13 countries (all

U.S. Students' Strengths and Weaknesses in Science and Math

Fourth Grade	
Strengths	**Weaknesses**
Earth Science Environmental Issues and the Nature of Science Life Science Physical Science	
Data Representation, Analysis, and Probability Fractions and Proportionality Geometry Patterns, Relations, and Functions Whole Numbers	Measurement, Estimation, and Number Sense
Eighth Grade	
Strengths	**Weaknesses**
Earth Science Environmental Issues and the Nature of Science Life Science	Chemistry Physics
Algebra Data Representation, Analysis, and Probability Fractions and Number Sense	Geometry Measurement Proportionality

—U.S. Department of Education, National Center for Education Statistics. 1997. *Introduction to TIMSS: The Third International Mathematics and Science Study*. Washington, DC: Office of Educational Research and Improvement. (Available online at http://nces.ed.gov/TIMSS) participants in TIMSS) found that each was engaged in serious reform efforts and that virtually all were moving toward a curriculum geared to practical application and integration of disciplinary content (Atkin and Black, 1997).

Certainly, the lack of coherence in math and science educational materials across the country concerns educators, but poor student achievement is a complex problem. The most fruitful path to reform will undoubtedly be one that takes into account many different aspects of the education system.

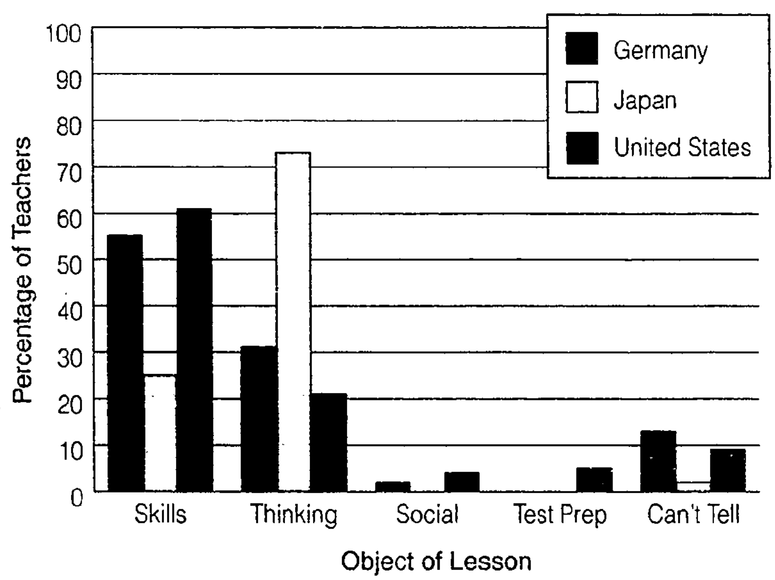
How Do U.S. Teachers Compare With Their International Counterparts?

Findings from the study of teacher beliefs and practices indicate that teacher preparation in the United States differs from that in most other countries: on a national level, U.S. teachers are not required to pass an examination to become certified to teach. Close comparison of the United States, Japan, and Germany reveals some interesting differences. Unlike U.S. teachers, teachers practicing in those countries must complete lengthy apprenticeships with mentor teachers before certification. Also, in Japan, practicing teachers have more formal and informal opportunities to interact with their colleagues than do teachers in Germany or the United States.

The TIMSS study also highlights some interesting similarities among teachers in the same countries. Teachers in the United States, Japan, and Germany all report that daily challenges include uninterested students, mixed-ability students, and overcrowded classrooms. Science teachers in all three countries report a lack of demonstration and instructional equipment.

Results From the TIMSS Videotape Classroom Study

Teachers' responses, on the questionnaire, to the question "What was the main thing you wanted students to learn from today's lesson?"



—U.S. Department of Education. National Center for Education Statistics. 1999. *The TIMSS Videotape Classroom Study. Methods and Findings From an Exploratory Research Project on Eighth-Grade Mathematics Instruction in Germany, Japan, and the United States.* National Center for Education Statistics Report No. NCES 99–074. Washington, DC: Office of Educational Research and Improvement (Available online at http://nces.ed.gov/pubs99/timssvid/index.html)

What Does the TIMSS Videotape Study Reveal?

The TIMSS videotape study of eighth-grade math classes in the United States, Japan, and Germany indicates that U.S. and German teachers emphasize skills, whereas Japanese instructors emphasize student understanding. The results of the survey of teachers reinforce this observation. Participating teachers were asked, "What was the main thing you wanted students to learn from today's lesson?" Responses are shown in the figure on this page.

The differences in teacher aims are quite apparent. While the majority of Japanese teachers mention that their main educational goal is the development of correct mathematical thinking in students, approximately half of the German teachers and 60 percent of the U.S. teachers report that skill development is their most important educational aim. Perhaps because of this, U.S. teachers do not develop concepts to the same extent that their German and Japanese counterparts do.

The Japanese emphasis on teaching children to think is reflected in the U.S. national standards for both math and science education, which emphasize teaching practices similar to those of the Japanese as part of the professional development of new teachers. Unfortunately, however, there is no systematic way in the United States to reach practicing teachers in hopes of improving their instructional effectiveness. For some time, professional education

organizations have been calling for school communities to recognize the importance of providing ongoing professional development opportunities for their teachers. Again, although addressing one aspect of education policy and practice in isolation will not produce widespread change, it is another step along the path to better math and science education for all.

What Else Does TIMSS Reveal About Education in Other Countries?

TIMSS also indicates that some of the aspects of education debated in the United States today do not seem to be problematic in relation to math or science achievement. For example, U.S. fourth- and eighth-grade children are assigned approximately the same amount of homework as are children in Japan and Germany. Moreover, fourth-grade children in the United States spend more time on math and science in school than their counterparts in Japan and Germany, and eighth graders experience more hours of math instruction. Japanese children also watch as much television as U.S. children do.

Although the TIMSS results do not provide any magical ways to decide which aspects of math or science education should be changed or replaced, they do offer a detailed picture of international educational practices from which further studies can proceed.

How Can I Get More Information?

Information on TIMSS is readily available, and more reports are scheduled for future distribution. The ERIC Clearinghouse for Science, Mathematics, and Environmental Education (http://www.ericse.org) provides links to TIMSS information on the Internet.

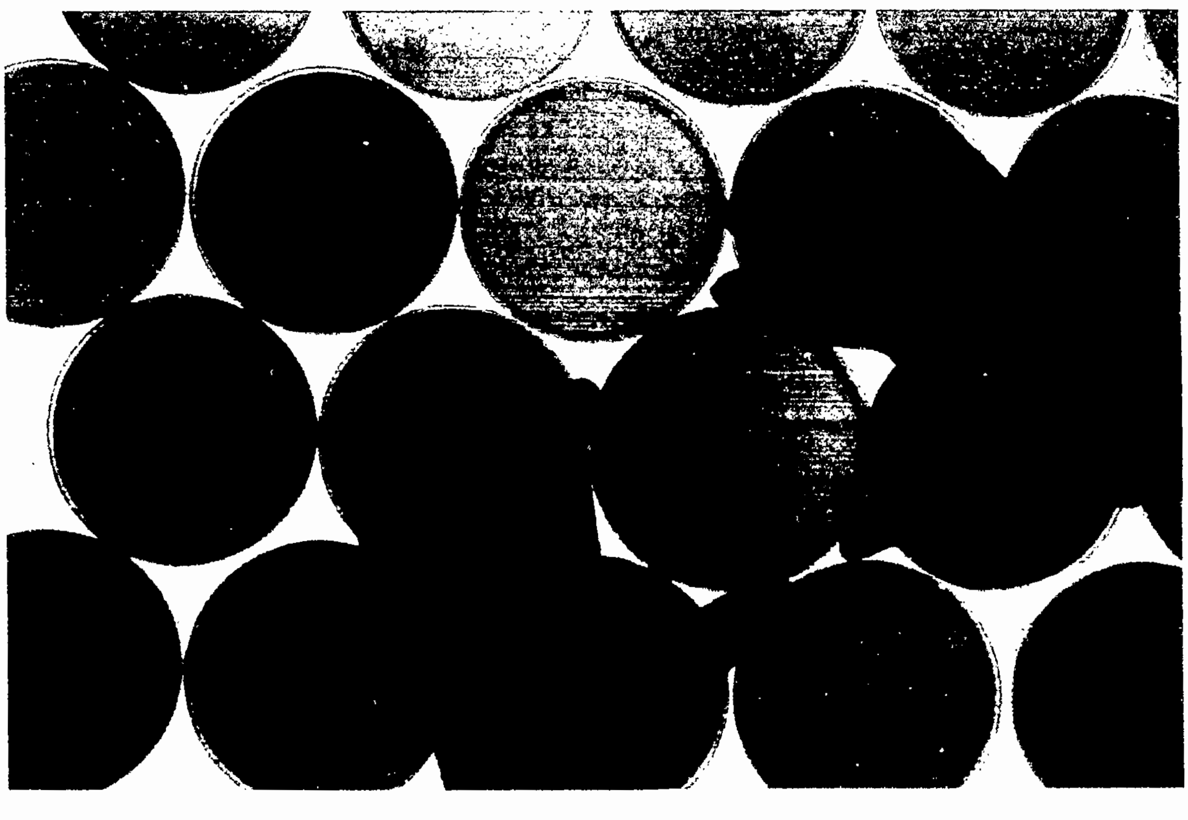
The TIMSS Resource Kit includes several publications. The textual publications of the kit, including an order form, are available for downloading at http://timss.enc.org/TIMSS/timss/index.htm. For additional information, call the TIMSS Customer Service Line at 202–219–1333 or send an e-mail message to timss@ed.gov. Information can also be obtained by writing TIMSS Project, National Center for Education Statistics, U.S. Department of Education, 555 New Jersey Avenue, NW, Washington, DC 20208–5574.

References

Atkin, J. M., and P. Black. 1997. "Policy Perils of International Comparisons: The TIMSS Case." *Phi Delta Kappan* 79 (1): 22–28.

U.S. Department of Education. National Center for Education Statistics. 1997. *Introduction to TIMSS: The Third International Mathematics and Science Study*. Washington, DC: Office of Educational Research and Improvement. (Available online at http://nces.ed.gov/TIMSS)

U.S. Department of Education. National Center for Education Statistics. 1999. *The TIMSS Videotape Classroom Study: Methods and Findings From an Exploratory Research Project on Eighth-Grade Mathematics Instruction in Germany, Japan, and the United States.* National Center for Education Statistics Report No. NCES 99–074. Washington, DC: Office of Educational Research and Improvement. (Available online at http://nces.ed.gov/pubs99/timssvid/index.html)



Best Practices in Science Education

Judith Sulkes Ridgway, Lynda Titterington, and Wendy Sherman McCann

As the new century begins, it is a good time to reflect upon the practices that will help science educators promote meaningful science learning. The entire science-learning environment and related best practices should support this goal. This article describes six classroom practices designed to help teachers engage students in science as an important, stimulating topic that affects them every day. These practices synthesize the "National Science Education Standards" (National Research Council, 1996) and the results of several national evaluations of science and math programs and curriculum materials. The evaluations were conducted by the U.S. Department of Education, the National Science Foundation, the American Association for the Advancement of Science, the Eisenhower National Consortia, the National Diffusion Network, and the Northwest Regional Educational Laboratory (see the table on pages 31–32). The best practices for science education are:

- *Student-Centered Instruction*
- *Hands-On/Minds-On Learning*
- *Authentic Problem-Based or Issue-Based Learning*
- *Inquiry Approaches*
- *Emphasis on Communication Skills*
- *Ongoing, Embedded, Authentic Assessment*

The following discussion defines the practices and provides curriculum resources that support each of the practices in the classroom setting.

Student-Centered Instruction

Student-centered instruction is at the heart of current research on how children learn. This approach allows kids to identify the paths they find most fruitful in constructing their scientific knowledge. Instruction is based on what children know and what they need to know, and children are encouraged to choose topics of study from their everyday lives, interests, and needs.

By controlling the selection of classroom topics, children realize that their thoughts are valued, feel more of an investment in the lessons, and therefore have greater motivation to learn. Student-centered instruction stimulates children's curiosity, requires them to think analytically and creatively, and requires them to use logic to make sense of the information and experimental data they gather in science class. Therefore, kids rely on their scientific reasoning to answer their own questions.

Teachers can implement student-centered instruction by relying less on lectures and computer tutorials as methods of science instruction. Instead, most of the course content should be gathered and presented by the children. Teachers can engage children by allowing them to conduct investigations, often in groups. For example, kids can gather information from the Internet or conduct their investigations within the virtual world of a simulation. Teachers can facilitate investigations by providing children with the materials they need, by asking them questions that help focus their study, and by allowing them to discuss and test their ideas.

Even though the class is student centered, the teacher is always watching, guiding, and assessing the children. The student-centered classroom can contain quite a bit of commotion, so teachers need to listen carefully to ensure that kids are discussing scientific ideas, not socializing.

Hands-On/Minds-On Learning

Many people might say, "Gee, those sound like buzzwords to me. Do they

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Promising Math and Science Practices

Evaluating Organization	Practices Derived From Program Descriptions and Evaluation Criteria
U.S. Department of Education **The Expert Panel on Mathematics and Science Education** http://www.rmcres.com/expertp/index.html	*Incorporation of:* ■ The vision outlined in national standards ■ Students' past experiences in the learning process ■ Situations or games that have real-life applications ■ Student collaboration ■ Hands-on activities, explorations, experiments, and manipulatives ■ Multiple problem-solving strategies ■ Informative and appropriate assessment techniques ■ Connection of the various topic strands within the subject ■ Connection of math and its applications to other disciplines ■ Problem-solving approach ■ Technology in the classroom ■ Attention to individual needs ■ Mathematical reasoning and communication
National Science Foundation-Funded Projects **ARC Center** http://www.comap.com/arc/index.htm **Show-Me** http://showmecenter.missouri.edu **COMPASS Center** http://www.ithaca.edu/compass/frames.htm	*Incorporation of:* ■ Discovery of mathematical ideas through investigation of structurally rich problem solving ■ Meaningful (real-world) math problems ■ Connection of math and its application to other disciplines ■ Group learning ■ Multiple representations ■ Connection of students' experiences to the study of math ■ Hands-on activities and explorations ■ Communication of mathematical ideas ■ Technology
American Association for the Advancement of Science **Project 2061** http://project2061.aaas.org	*Incorporation of:* ■ Real-world applications that engage students in mathematics through a variety of contexts ■ Students' experiences and curiosity in the learning process ■ Groups/cooperative learning ■ Projects, including clear goal-setting procedures and review/summary procedures ■ Engaging, thematic math activities and problems ■ Embedded assessment
Eisenhower National Consortia http://www.enc.org/reform/journals/enc2670/2670.htm	*Incorporation of:* ■ Cooperative learning ■ Group discussion ■ Multimedia instruction ■ Problem-solving approach ■ Multiple methods of experimentation ■ Hands-on learning ■ Individualized instruction ■ Thematic approach ■ Interdisciplinary approaches ■ Writing across the curriculum ■ Technology

continued on page 32

Promising Math and Science Practices (continued)

National Diffusion Network http://www.ed.gov/pubs/EPTW	*Incorporation of:* ■ Real-life applications ■ Hands-on experiments ■ Problem-solving approach ■ Critical thinking and reasoning ■ Technology ■ Cooperative/group learning ■ Experimentation ■ Interdisciplinary approaches ■ Manipulatives ■ Alignment with national standards
Northwest Regional Educational Laboratory http://www.nwrel.org/scpd/natspec/catalog	*Incorporation of:* ■ Problem-solving approach ■ Whole group, small group, and individual instruction ■ Investigations or explorations of rich problems that embody important math concepts ■ Connections among ideas ■ Mathematical modeling ■ Collaborative, group investigations ■ Multidimensional assessment ■ Technology ■ Communication of mathematical ideas ■ Manipulatives

have any substance?" The answer is yes. If children are generating their own ideas in a student-centered classroom, they need the freedom to be physically active in their search for scientific knowledge. How can children begin to understand the nature of the world in which they live if they experience it vicariously? For this reason, the majority of the activities that kids perform should be physical explorations. Physical explorations not only make the concepts more tangible but also appeal to children's diverse learning styles and take advantage of their multisensory strengths. If children are physically involved, they are more apt to be mentally engaged.

Depending upon the age of their students, teachers can incorporate many types of hands-on activities. For example, children can design experiments, collect data, and apply scientific reasoning to analyze and learn from their results. Computers and application software can assist children in this process. In addition, hands-on learning often leads kids out of the classroom to collect data—children are not tied to their chairs when they engage in hands-on activities.

Authentic Problem-Based or Issue-Based Learning

Neither student-centered learning nor hands-on learning is as effective when children confront concepts that are not applicable to their own lives. This supports the idea that knowing a concept is being able to apply it; indeed, scientific information and its applications do become more meaningful when children can tie them to their real-life experiences. Children engaged in authentic problem-based learning apply their science knowledge to questions they have about why things happen in their world, and they discuss the social ramifications that are often associated with scientific concepts.

Sometimes logistics prevent teachers from placing children in real-life situations to study. In these instances, kids can use computer programs, videotapes, or videodisks to study authentic problems. In addition, children can answer their questions about real-world phenomena by using the Internet to collect data. However the teacher facilitates the children's investigations, the activities should be nested in authentic, real-life problems.

Inquiry Approaches

This is the most abstract yet most scientific of all of the best practices in science. Inquiry is a method of approaching problems that is used by professional scientists but is helpful to anyone who scientifically addresses matters encountered in everyday life. Inquiry is based on the formation of hypotheses and theories and on the collection of relevant evidence. There is no set order to the steps involved in inquiry, but children need to use logic to devise their research questions, analyze their data, and make predictions. When using the inquiry methods of investigation, children learn that authorities can be wrong and that any question is reasonable.

The most abstract component of inquiry is imagination. Both students and professional scientists have to be able to look at scientific information and data in a creative way. This unconventional vision allows them to see patterns that might not otherwise be obvious.

Teachers can incorporate inquiry approaches to learning, for example, by allowing small groups of students to explore a particular natural phenomenon that might exhibit certain trends or patterns. The children can then reconvene as a class, discuss their observations, and compile a list of several different hypotheses from this discussion. Each group can choose a hypothesis to investigate. Several groups might choose to replicate the same study to reduce the bias effects of any one group's techniques. Depending on their age, children might design their own experimental apparatus, use probes attached to computers, or employ sophisticated software to analyze data or create charts and graphs. Data-based predictions can be the foundation for further investigation.

Emphasis on Communication Skills

Communication is central to any human endeavor, including science. Children learn to share ideas with members of their study group and to report the results of their investigations to the rest of the class. Communication can take the form of casual conversations or more formal presentations, such as oral reports, posters, or written reports. Using the Internet, kids also learn to exchange ideas with experts in the field or with kids in other parts of the world who may be interested in the same questions.

Children need to employ scientific language or terminology to communicate meaningfully. If they are helping each other define a problem, trying to devise the best method to test an idea, or helping each other analyze the results of an exploration, children need to use language that is scientifically appropriate. Teachers can engage children by training them to use the language of science.

The development of communication skills also entails the ability of children to relate science to other school subjects. Teachers can facilitate this process and enrich the learning experience by providing bridges from science to other disciplines, such as art, history, or language arts. This can also help children see that authentic scientific investigations are not isolated from the rest of their school subjects.

Ongoing, Embedded, Authentic Assessment

How can teachers get an idea of what students know and can do in the "best-practices" learning environment? Teachers need to assess children's knowledge and scientific reasoning skills throughout the instruction process. Teachers can gauge preexisting knowledge from the questions that children generate for investigation. This process allows teachers to decide how to help kids realign their conceptions with more scientifically accepted ideas. Similarly, as children are gathering background information and devising their experiments, the teacher is observing their techniques.

No matter how the teacher has designed the lesson, knowledge can be assessed when children are asked to communicate what they have learned. Computers can assist in this process; many simulations have questions or journals embedded in them. Teachers can see student responses to questions or prompts in the program. Teachers also can evaluate children who are using presentation software to communicate their understanding.

Other Practices

All best practices are meant to support the development of scientific reasoning skills in children, and the use of technology can enhance this process. In addition, it is important that all children—including girls, minorities, and children with special needs, who are typically underrepresented in science study—participate in the various aspects of science learning and assessment. Finally, best practices should lead to children's understanding of the nature of science as a human enterprise.

Conclusion

The teacher's role is to ensure that students achieve their primary goal: meaningful understanding of scientific concepts. The practices described in this article help bring this about in several ways. When instruction centers on students and focuses on hands-on experience with scientific phenomena, science class becomes an exciting place. When instruction concentrates on the investigation of current problems and issues through scientific inquiry, science class becomes a relevant and meaningful place. When instruction emphasizes the development of communication skills, science class becomes an invaluable place for preparing children to tackle the challenges of adulthood. And the education community owes it to its students to assess their academic progress fairly and accurately.

Reference

National Research Council. 1996. *National Science Education Standards*. Washington, DC: National Academy Press. ERIC Document Reproduction Service No. ED 391 690.

Selected Resources From the Eisenhower National Clearinghouse

For more information on the following resources, readers can visit the Eisenhower National Clearinghouse (ENC) Web site and use the Resource Finder at http://www.enc.org/rf/index.htm to search ENC's online catalog. Visitors can search the catalog by ENC number, key word, cost, or grade level. Search results include a detailed abstract, price, and ordering information. Readers who do not have access to the Internet can call ENC at 1–800–621–5785.

Student-Centered Learning

- *Thinking Fountain.* This Web site, developed by the Science Museum of Minnesota, is a living card file of ideas and activities that offer surprising, gross, funny, and personal connections to science. (http://www.sci.mus.mn.us/sln/tf)
- *Science 2000.* These curriculum kits constitute a multimedia middle school curriculum that uses constructivist strategies, activities, experiments, and software simulations to help children develop a conceptual understanding of science. [Grades 6–8] ENC–013498
- *Amusement Park Physics: A Teacher's Guide.* This teacher's guide, developed for middle school grades, provides materials to implement an amusement park study program in the classroom. [Grades 6–8] ENC–006302
- *Exploring the Nardoo.* This CD-ROM and classroom guide provides an interactive multimedia tool that allows students to perform virtual field work on a complex, changing river environment. [Grades 7–12] ENC–014195

Hands-On/Minds-On Learning

- *From Butterflies to Thunderbolts: Discovering Science With Books Kids Love.* This book provides students with the opportunity to learn about science through a hands-on, minds-on approach with activities that are coupled to children's literature. [Grades K–6] ENC–014140
- *Creepy Crawlies.* This activity book introduces young children to insects. The book is part of a series that encourages children to explore science concepts and skills and learn about the world around them through hands-on learning. [Grades K–2] ENC–006102

Problem-Based Learning

- *Odyssey of the Mind.* This Web site provides information about the annual Odyssey of the Mind competition to promote creative, team-based problem solving for students in grades K through 12 and in college. The competition challenges students to solve problems in a variety of areas, from building mechanical devices such as spring-driven vehicles to giving their own interpretation of literary classics. (http://www.odyssey.org)
- *The Cat on the Chimney.* This big book kit, part of the Realization Technology Series, presents a series of dilemmas designed to help children develop basic science concepts. In a sample scenario, students design a rescue device to get a frightened cat down from a chimney. The colorful illustrations depict a 15-pound cat trapped on a 3-story chimney, a tree that can bear a maximum of 40 pounds, and approximately 20 tools that include 100 feet of rope, an aluminum can of sardines, a 6-foot ladder, and a magnet. [Grades 4–7] ENC–013420
- *Wreck of the Fortuna Dourada.* This CD-ROM is part of the Science Sleuths Elementary Series, which uses humorous science mysteries to integrate life, earth, and physical science concepts with a variety of problem-solving techniques. In this episode, children help an archaeologist decide which of three treasure hunters has found the correct location of the wreck of the Fortuna Dourada. [Grade 4] ENC–008501
- *Volcano!* This middle school unit, based on media reports of volcanic activity, challenges children to develop a public information campaign to inform other kids about volcanoes and about hazards related to living in the shadow of Mount Rainier. Children obtain background information through science activities, discovery files, and stories in the module as well as through independent research. [Grades 6–9] ENC–005155

Selected Resources From the Eisenhower National Clearinghouse (continued)

Inquiry Approach

- *Hello, Dolly: A WebQuest.* This Web site offers an inquiry-oriented activity that helps children learn about the implications of cloning. (http://powayusd.sdcoe.k12.ca.us/dolly/default.htm)
- *Thrill Ride!* This curriculum kit, developed for grades 5 through 9 as part of the Event-Based Science Series, uses the opening of a new thrill ride at an amusement park as the focus of a five-week study of Newton's laws of motion. [Grades 5–9] ENC–012797
- *NGS Works.* This CD-ROM, developed by the National Geographic Society (NGS) Kids Network, contains a suite of data analysis, word-processing, and telecommunications software designed specifically for children in grades 3 through 9. The NGS Kids Network is a telecommunications-based, interdisciplinary curriculum in which children collaborate as research scientists by conducting original research. [Grades 3–9] ENC–014298

Communication Skills

- *Seasons.* This interactive group software, developed for grades 4 through 6 and part of the Science Court Series, involves children in an animated courtroom drama in which the cause of seasons on Earth is explored to find the answer to why there won't be a summer. [Grades 4–6] ENC–013710

Assessment

- *Amazing Me: Understanding How the Body Works.* This program is a multisensory curriculum kit developed for kindergarten students. The assessment component includes portfolios, interviews, and role-play and teacher-observation activities designed to measure each child's degree of independence, contribution to group projects, and ability to interact in small groups. [Grade K] ENC–006421
- *Puddle Questions for Science: Performance Assessment Investigations.* This book, developed for grade 6 as part of a series of performance assessment books, provides open-ended activities designed to assess how students work through a complex investigation. It includes detailed teacher support to help prepare, implement, and evaluate alternative performance assessments, and provides holistic scoring rubrics for each investigation. [Grade 6] ENC–003330

Promising Practices in Mathematics Education

Terese A. Herrera and S. Asli Özgün-Koca

This discussion of promising practices in mathematics education synthesizes the results of several national evaluations of science and math programs and curriculum materials. The evaluations were conducted by the U.S. Department of Education, the National Science Foundation, the American Association for the Advancement of Science, the Eisenhower National Consortia, the National Diffusion Network, and the Northwest Regional Educational Laboratory (see the table on pages 31–32).

Identified practices focus on those that have direct instructional impact and therefore immediate relevance for K–12 teachers who are looking for effective ways to improve classroom learning. The classroom practices that follow are derived from the criteria used in the national evaluations and from descriptions of exemplary programs:

- *Problem-Solving Approach*
- *Experimental Approach*
- *Development of Mathematical Reasoning*
- *Cooperative/Group Learning*
- *Illustration of Mathematical Connections*
- *Use of Technology*
- *Communication of Mathematical Ideas*

The following discussion defines the practices and provides curriculum resources that support each of the practices in the classroom setting.

Problem-Solving Approach

Teachers introduce content by presenting a problem. As children grapple with making sense of the problem, they are taught to model the situation mathematically, to formulate processes to deal with that model, and finally, to generalize those processes into useful algorithms. It is critical that teachers:

- Engage children in problems that embody significant mathematical concepts.
- Create and sustain a classroom environment that supports problem solving—for example, help children cope with frustration and honor all their attempts to work through the problem.
- Assist children in seeing the mathematics embedded in the problem and in creating models that represent the mathematical situation.
- Assist children as they move from the concrete model to the more abstract formulation of their problem-solving processes into algorithms.
- Teach children to constantly monitor and reflect on their strategies.

Children engaged in a problem-based curriculum build mathematical knowledge through their work with and discussion of problems. Children explore, report on their findings, explain and talk about their varied solutions, invent ways to represent their thinking, and generalize their solutions to other areas.

Experimental Approach

The experimental approach owes much to the scientific method: forming a hypothesis, collecting data to test it, analyzing the data, and reaching a conclusion. In the math classroom, experimentation begins with an open-ended question. Children then make predictions, plan strategies to explore the question, and collect and compare data. What counts is for kids to get their hands on the problem, either literally, by using manipulatives or some other concrete model, or figuratively. There is a real spirit of play involved in such investigation, but also purpose. Teachers direct experimentation as they:

- Set out the question to be investigated, or recognize and accept one from the class.

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- Motivate children to engage in the investigation.
- Teach children methods of collecting data, representing data (tables, charts, graphs, algebraic expressions), and drawing conclusions.
- Provide children with tools for exploring (manipulatives, calculators, graphing software, microworlds).
- Help children see the significance of their work.

The environment described here is supported in research by constructivist learning theory, which states that children actively construct knowledge from their experiences.

Development of Mathematical Reasoning

Mathematical reasoning can be defined as "a part of mathematical thinking that involves forming generalizations and drawing valid conclusions about ideas and how they are related" (O'Daffer and Thornquist, 1993, p. 43). Such thinking occurs not only in the high school geometry classroom, but also in all math classrooms, regardless of topic and age level.

Teachers foster mathematical reasoning in the classroom when they:

- Encourage questions, even doubt. This is the opposite of the children's usual acceptance of the teacher or the printed word as the arbiter of "right or wrong" in a mathematical argument.
- Expect children to explain and justify their answers.
- Assist children in considering and evaluating several solutions to a problem.
- Teach high school students formal methods of proof (that is, deductive reasoning) as well as statistical arguments, and the difference between the two.
- Above all, create "a classroom environment where students feel comfortable questioning, challenging, suspending judgment, and demanding reasons and justification as they deal with mathematical and real-world content" (O'Daffer and Thornquist, 1993, p. 42).

The habit of reasoning does not develop in a specific math course but instead throughout the school curriculum. As stated in *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989), "Mathematical reasoning cannot develop in isolation. . . . [T]he ability to reason is a process that grows out of many experiences that convince children that mathematics makes sense" (p. 31).

Cooperative/Group Learning

When kids work in small groups to solve a problem, they have the opportunity to give and receive help in a comfortable, nonthreatening environment. The difference between the teacher-centered classroom and the cooperative learning classroom can be visualized as pictured in the figure on this page.

Although research has documented positive results for cooperative learning strategies in all grade levels and all subjects (Artzt and Newman, 1997), several elements are required for this approach to be an effective classroom practice: positive interdependence (children's sense of sinking or swimming together), individual accountability (each child has to contribute and learn), interpersonal skills (communication, trust, decision making), and willingness to reflect on the team process (for more information, see the Cooperative Learning Center at the University of Minnesota at http://www.clcrc.com).

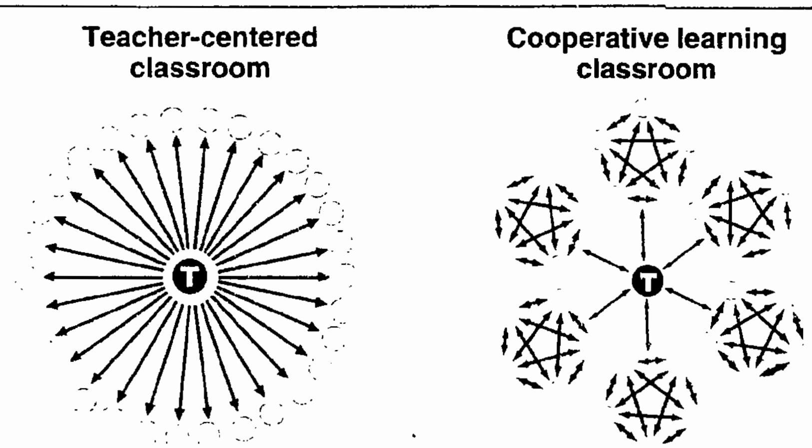
The teacher, then, is essential in making this approach productive. It is the teacher who:

- Assigns students to groups, deciding the appropriate number and mix of children and then monitoring group interaction.
- Designs problems that require the input of each group member.
- Motivates children to collaborate, in part through well-designed incentives.
- Holds children accountable, individually and as a group, through varied assessments.

Illustration of Mathematical Connections

The aim of this practice is to illustrate the relationships and interconnections among different math topics in such a way that children see math not as a set of isolated topics but as a "coherent whole." Moreover, by incorporating everyday experiences or real-world situations into the curriculum, math teachers can show

Classroom Instruction Models



—Reprinted with permission from Artzt, A. F., and C. M. Newman. 1997. *How To Use Cooperative Learning in the Mathematics Class.* Reston, VA: National Council of Teachers of Mathematics. Copyright 1997 by the National Council of Teachers of Mathematics.

kids real-world applications of math and can help them use it in context.

To implement this practice, teachers can:

- Refer to and build on children's previous experiences, bringing their world into the math classroom.
- Create opportunities to relate the current topic to other math topics.
- Use multiple representations such as tables, graphs, and equations for a given function to build bridges among different mathematical ideas.
- Collaborate with teachers of other school subjects, such as art and biology.
- Design environments that require children to apply math in a real-world scenario.

Use of Technology

The use of technology in the classroom not only prepares children to live and work in a high-tech society but also helps them understand mathematical concepts in powerful ways. For instance, many graphing tools decrease the drudgery of graphing and save time for children to focus on the interpretation of graphs and give meaning to them. Scientific or graphing calculators, computer software, spreadsheets, the Internet, or calculator-based or microcomputer-based laboratories—even videotapes—are examples of technological tools used in math classrooms.

Teachers successfully incorporate technology into the classroom when they:

- Continually improve their own command of the available technology, including its use in mathematics education.
- Facilitate exploration of mathematical ideas through technological means; this teaches children that the teacher is not the only source of information in the classroom.
- Focus the class on the mathematical concepts rather than on the technological tools themselves.
- Expose children to those mathematical representations available through technology, such as online manipulatives, graphing software, and spreadsheets.
- Make use of multimedia in their lessons to support the multiple intelligences of students; for example, teachers can show videos that involve children in real-world scenarios.

Communication of Mathematical Ideas

Communicating mathematically through oral or written tasks is another way for children to engage in the learning process. In classrooms where communication is active, children rationalize and justify their thinking through discussion. Teachers create environments in which children have opportunities to discuss, write, and listen to one another in the classroom. Role playing, drawing pictures, and presenting information to the class are activities that may encourage kids to communicate mathematically. Teachers can incorporate this practice by:

- Asking questions that clarify and extend children's ideas.
- Assisting children as they try to model mathematical situations and develop multiple representations (oral, written, pictorial, graphical, algebraic, or physical).
- Exploring and utilizing mathematical language and notation with children.
- Encouraging children to listen and to share their mental concepts of mathematical ideas.

References

Artzt, A. F., and C. M. Newman. 1997. *How To Use Cooperative Learning in the Mathematics Class.* Reston, VA: National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics. 1989. *Curriculum and Evaluation Standards for School Mathematics.* Reston, VA: Author.

O'Daffer, P. G., and B. A. Thornquist. 1993. "Critical Thinking, Mathematical Reasoning, and Proof." In P. S. Wilson, ed., *Research Ideas for the Classroom: High School Mathematics* (pp. 39–56). New York: Macmillan Publishing Company.

Selected Classroom Resources From the Eisenhower National Clearinghouse

For more information on the following resources, readers can visit the Eisenhower National Clearinghouse (ENC) Web site and use the Resource Finder at http://www.enc.org/rf/index.htm to search ENC's online catalog. Visitors can search the catalog by ENC number, key word, cost, or grade level. Search results include a detailed abstract, price, and ordering information. Readers who do not have access to the Internet can call ENC at 1–800–621–5785.

Problem-Solving Approach

- *Super Problems.* This kit contains a collection of 16 sets of exercises designed to develop problem-solving skills [Grades 7–9] ENC–011447
- *The Factory Deluxe.* This CD-ROM features five factory-based activities designed to help children expand their problem-solving strategies in geometry, sequencing, and other areas. [Grades 4–8] ENC–011765
- *Here's the Scoop: Follow an Ice Cream Cone Around the World.* This unit, the second in the One and Only Common Sense (Cents) Series for primary grade children, provides 22 activities that address consumer awareness, money transactions, identification of coins and bills, and decision making about money. [Grades K–3] ENC–008006

Selected Classroom Resources From the Eisenhower National Clearinghouse (continued)

- *Journey to Cedar Creek.* This is the first episode in the Jasper Woodbury Series, which is produced in accordance with the National Council of Teachers of Mathematics standards. Each episode contains a teacher's manual, student materials, a videodisk, and optional computer software. The series is intended to develop problem-solving skills and to integrate math with other curriculum areas. [Grades 5–8] ENC–000379

Experimental Approach

- *Making Sense: Teaching and Learning Mathematics With Understanding.* This book, written for teachers and future teachers of mathematics at all levels and for teacher educators, presents current research-based ideas on how to design classrooms that help children learn mathematics with understanding. ENC–011845
- *The Geometric SuperSUPPOSER.* This software encourages kids to draw, study, explore, construct, and solve geometry problems. Includes a teacher's guide. [Grades 6–12] ENC–013545

Mathematical Reasoning

- *Logical Journey of the Zoombinis.* This CD-ROM with teacher's guide, part of the Active Mind Series, contains 12 interactive activities designed to help children explore and apply fundamental principles of logic, problem solving, and data analysis in an adventure story context. [Grades 3–7] ENC–014513
- *Set Enterprises Homepage.* This Web site explains, through a Java tutorial, how to play a family or classroom card game that is designed to engage the player's whole brain in a logical, spatial-thinking activity. [Grades 3 and up] (http://setgame.com)

Cooperative/Group Learning

- *Group Solutions, Too! More Cooperative Logic Activities for Grades K–4.* This teacher-activity guide, the second volume of logic activities from the Great Explorations in Mathematics and Science (GEMS) Series, challenges children to reason, make deductions, and form conclusions with 70 cooperative problem-solving activities. [Grades K–4] ENC–011642
- *The Right Angle.* This laserdisc with teacher's manual, part of the New Adventures of Jasper Woodbury Mathematics Series, tells the story of a young Native American who is challenged by her grandfather to find the cave where a family heirloom is hidden. [Grades 5–8] ENC–013834

Math Connections

- *EnviroNet Monitoring Projects.* This Web site lists a wide variety of environmental monitoring projects. EnviroNet is a network of teachers, scientists, environmental educators, and others who utilize telecommunications to enhance environmental science education. (http://earth.simmons.edu/monitoring_projects/index.html)
- *Emergency.* This CD-ROM, one of three interactive software products available in the Prime Time Math Series for middle school grades, presents the story of the dramatic work of a medical team treating a 15-year-old patient in an emergency room. [Grades 6–8] ENC–011939
- *Math in Daily Life.* This Web site, part of the Annenberg/CPB Project Exhibits Collection, explores how math principles can be helpful when following a recipe, decorating a home, or deciding whether to buy or lease a car. [Grades 6–12] (http://www.learner.org/exhibits/dailymath)

Use of Technology

- *Tabletop, Jr.* This software introduces children to basic math concepts, including data visualization, grouping, sorting, classifying, graphing, interpreting data, logical reasoning, and patterns. [Grades 3–6] ENC–005157
- *Geometry Activities for Middle School Students with the Geometer's Sketchpad.* This text and the accompanying software for Macintosh and PC computers provide middle school mathematics teachers with engaging student activities using the Geometer's Sketchpad. The materials may be used as the basis for an independent geometry unit or as activities to reinforce and enrich children's understanding of geometric concepts. [Grades 6–8] ENC–012572

Communication of Mathematical Ideas

- *Language and Communication in the Mathematics Classroom.* This book is an edited collection of essays about communication as it pertains to teachers and students in the classroom. [Grades K–12] ENC–013132
- *Communicating Mathematics With Geoboards.* This booklet provides activities to help students in the intermediate grades develop the language of mathematics. Children use geoboards to develop skill with shapes and patterns, numeration, addition and subtraction, measurement, geometry, and spatial sense. [Grades 4–6] ENC–011024

Minorities in Science and Mathematics: A Challenge for Change

Julia V. Clark

While the United States is concerned about the current shortage of K–12 teachers, especially in science and math, it is equally concerned about the challenge of attracting more students to these subjects and related careers. Looking to the year 2000 and beyond, the country faces a serious shortage of scientists and mathematicians. To remain economically competitive, the United States must educate and advance minority students in science and math.

Why Minorities?

Minority children represent the most rapidly growing part of the school-age population. Differing fertility rates, immigration patterns, and age distributions among population subgroups suggest that by 2030, the elementary school population could be divided equally between white children and children of all other racial and ethnic groups combined. This minority subgroup is expected to outnumber the white subgroup by 2050 (Hodgkinson, 1992).

The projected composition of the resultant workforce causes great concern in the science and math communities, because minorities—with the exception of Asian Americans—are underrepresented in these occupations. In 1990, for example, African Americans, Hispanics, and Native Americans constituted 19 percent of the total labor force, but only 8 percent of the science, math, engineering, and technology (SMET) labor force (National Science Foundation, 1994). In addition, women made up 46 percent of the total labor force, but only 22 percent of the SMET labor force. Projections for the year 2000 indicate that 85 percent of new entrants to the U.S. workforce will be women and members of minority groups (for a discussion of women as a minority group in math and science, see the article "Encouraging Girls in Science and Math" on page 45). The presence of women and minorities in the science and technology professions should reflect their presence in the population as a whole.

As the nation's economic base shifts increasingly toward technology, the participation and achievement of minorities and women in the SMET labor force become increasingly important. The United States can meet the projected shortage of scientists, mathematicians, engineers, and technology professionals only by attracting underrepresented minorities to these occupations. Unfortunately, underrepresented minorities, on average, are the children most left behind in science and math education.

Minority Achievement

Although science and math achievement test scores have increased for all ethnic/racial groups between 1978 and 1996, gaps in proficiency between white children and minority children remain. Among 4th-, 8th-, and 12th-grade students who participated in the National Assessment of Educational Progress (NAEP) in 1996, more than 20 percent of white children—but less than 10 percent of black, Hispanic, and Native American children—scored at or above the proficient level in math; half of black and Hispanic children—but only about one-fourth of white children—scored below the basic proficiency level in mathematics (National Science Foundation, 1998). In science, 1996 NAEP results showed that white children scored substantially higher than black and Hispanic children at all three grade levels (National Science Foundation, 1998).

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Barriers to Success

Many factors contribute to unequal participation of minorities in science and mathematics education. These include understaffed and underequipped schools, which are usually found in minority communities, judgments about ability, tracking, number and quality of science and mathematics courses offered, access to qualified teachers, access to resources, and curriculum emphasis (National Science Foundation, 1996).

Inequities in school funding can also highlight the social context of schooling. Urban schools with a high proportion of economically disadvantaged or minority children typically offer less access to science and math education (Oakes, 1990).

Ability grouping also affects achievement: science and math classes with a higher proportion of minority children are more likely to be labeled "low-ability" than those with a low proportion of minority children (National Science Foundation, 1996). For example, in grades 9 through 12, 29 percent of the classes with a low proportion of minority children are labeled "low-ability," but 42 percent of the classes with at least 40 percent minority children are so labeled (National Science Foundation, 1996).

Being labeled by ability is very important to student achievement because teachers tend to have different expectations of students in the various groups (National Science Foundation, 1996). Teachers in "high-ability" classes are more likely than those in "low-ability" classes to emphasize the development of reasoning and inquiry skills. As a result, children in high-ability classes are more likely to participate in hands-on science activities and more likely to be asked to explain their reasoning processes. Children in low-ability classes are more likely to read from a textbook and spend time doing worksheet problems.

Minority children typically have less access to qualified teachers. For example, math classes with a high proportion of minorities are less likely than those with a low proportion of minorities to have teachers who majored in mathematics (National Science Foundation, 1996).

The instructional emphasis in minority-predominant classes is likely to differ as well. The teachers in science and math classes having a high minority enrollment are more likely to emphasize preparing children for standardized tests. In contrast, teachers in classes having fewer minority children are more likely to emphasize the preparation of students for further study in science or math (National Science Foundation, 1996).

Finally, many children—especially minority children—learn to dislike or fear science and math classes by the time they reach middle school. As a result, many of them take only the minimum number of math and science courses required for graduation from high school. The damage done is incalculable: minorities emerge from elementary and secondary schools often without an adequate grounding in science and math. Even if they become interested in the subjects in later grades, it is often too late to take the college courses necessary to pursue related careers. Attitude also acts as a barrier for girls (see the article "Encouraging Girls in Science and Math" on page 45).

Transforming Teaching and Learning

To ensure that all children receive an appropriate, high-quality science and math education, educators should provide underrepresented minorities with better opportunities and greater encouragement to participate fully in science and math education. Educators need to reform curricula and implement innovative teaching methods that incorporate cooperative learning and alternative learning styles. High-quality programs should foster student interest and competence in science and math and enthusiasm for pursuing related careers.

Teachers and parents can do several things to attract and retain more minority students in science and math.

Suggestions for Teachers

- Set and maintain high expectations in science and math for minority children.
- Encourage minority children to develop an interest in science and math by providing them with challenging intellectual experiences.
- Involve minority children in classroom activities and discussions. Present science as a subject they can learn. This will help them develop the positive attitudes and self-confidence necessary to become high achievers in science and math.
- Create classroom activities that allow minority children to apply classroom learning experiences to practical situations. Also, permit them to bring their life experiences into the classroom. This helps them see that science and math are applicable to daily living and valuable to future education and employment.
- Provide minority children with access to minority role models and mentors. Involve role models in career exploration activities.
- Employ a variety of teaching styles and strategies. Modify and adapt materials so that minority children can participate fully in science and math education.

Suggestions for Parents

The family is the country's most important social unit, and parental influence on children should be the most profound. Given parental support and encouragement, minority children can perform well in science and math. Parents of minority children can do several things to guide their children toward excellence in these subjects.

- Help your child develop positive attitudes toward science and math, and help him or her see that early involvement with these subjects can open career doors in the future.
- Involve your child in "hands-on" science and math activities. Many books and Internet resources include math activities or easy-to-do science projects that parents can help with at

home (see "Books" on page 60 and "Internet Resources" on page 66).

- Find out if local colleges and universities offer summer science and math enrichment programs for school-age children.
- Make sure your child takes science and math courses throughout high school.

For more parent and teacher tips, see the articles "How Can I Help My Child Become More Interested in Science?" on page 7, "How Can I Help My Child Become More Interested in Math?" on page 9, and "Putting It All Together: An Action Plan" on page 70.

The Challenge

Education is facing new challenges. Teachers are called on to provide quality education to all children and to prepare them to live and work in a world transformed not only by increasingly common demographic changes but also by rapid growth in new technologies, international competitiveness, and economic globalization. Raising the science and math achievement of all groups is important in meeting the challenges of the next century. Future shortfalls of scientists, mathematicians, engineers, and other technology professionals can be met only by bringing minorities into the pool of science and mathematics majors. As a new century approaches, the promise made by America and articulated by Franklin D. Roosevelt more than a half century ago must be reclaimed: "We seek to build an America where no one is left out." America must ensure that all children receive a quality education and have access to economic opportunities (Quality Education for Minorities Project, 1990).

References

Hodgkinson, H. L. 1992. *A Demographic Look at Tomorrow*. Washington, DC: Institute for Educational Leadership, Center for Demographic Policy.

National Science Foundation. 1994. *Women, Minorities, and Persons With Disabilities in Science and Engineering*. Washington, DC: Author. (Available online at http://www.nsf.gov/sbe/srs/wmpdse94/start.htm)

National Science Foundation. 1996. *Women, Minorities, and Persons With Disabilities in Science and Engineering*. Washington, DC: Author. (Available online at http://www.nsf.gov/sbe/srs/nsf96311/htmpdf.htm)

National Science Foundation. 1998. *Women, Minorities, and Persons With Disabilities in Science and Engineering*. Washington, DC: Author. (Available online at http://www.nsf.gov/sbe/srs/nsf99338/start.htm)

Oakes, J. 1990. *Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities To Learn Mathematics and Science*. Santa Monica, CA: The RAND Corporation.

Quality Education for Minorities (QEM) Project. 1990. *Education That Works: An Action Plan for the Education of Minorities*. Cambridge: Massachusetts Institute of Technology, QEM Project.

Science and Mathematics Classes for Children With Special Needs

Wendy Sherman McCann

The total number of students with recognized disabilities in the United States has risen steadily over the past two decades. According to the report "Women, Minorities, and Persons With Disabilities in Science and Engineering: 1998," approximately 10 percent of children in the United States participated in federally funded special education programs during the 1994–95 school year (National Science Foundation, 1999). The occurrence of particular disabilities varies widely among children with special needs, but more than half of the identified disabilities are learning disabilities. Other disabilities include speech and language difficulties, mental retardation, and serious emotional difficulties. Physical disabilities are relatively rare, accounting for less than three percent of those students identified as having disabilities.

During the past few years, legal resolutions, parental concerns, and new research on learning and socialization have led to widespread efforts to place children with special needs in regular classrooms, a practice known as inclusion. According to one report, the number of children with special needs included in general education classrooms has risen by 10 percent during the period from 1992 to 1997. Still, "Women, Minorities, and Persons With Disabilities in Science and Engineering: 1998" concludes that special needs students take fewer science and math classes, have lower grades, and have lower achievement scores than general education students.

What Are Effective Policies for Inclusion?

Many parents are understandably interested in determining what kinds of education practices are most beneficial to their children with special needs. The Consortium on Inclusive Schooling Practices (1996) has developed a framework for evaluating state and local policies for inclusion to assist parents in this process. According to the framework, effective inclusion policies have six characteristics: (1) use of curricula that allow for the maximum development of individual students; (2) implementation of measurable, alternative, appropriate assessment practices; (3) accountability for all members of the education community; (4) commitment to professional development; (5) sufficient and responsible funding for educational programs; and (6) governance that allows central support of local control.

On the school level, the policies that best serve children with special needs often parallel those that are recognized as sound in general education. For example, schools that use block scheduling, interdisciplinary instruction, and team teaching are often better prepared to educate children with special needs in inclusive settings.

Can My Child Benefit From Being in a General Education Class in Science or Math?

General education classes in science and math provide opportunities that children with special needs may not get anywhere else. For example, special education teachers who lack the expertise to comfortably teach science or math may neglect to cover these subjects in depth. Also, special education programs often lack the supplies and equipment necessary for science laboratory work, so children may miss many opportunities to perform scientific experiments.

In addition, the structure and practices of general education classes in science and math—for example, hands-on activities, group work, and exciting experiments—make ideal inclusion situations. Participation in these classes can not only improve the self-esteem of children with special needs but also further develop the empathy, understanding, and leadership potential of children without special needs.

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How Can Science and Math Teachers Adapt Their Classrooms?

Including children with special needs in general education classrooms may require modification of the physical environment. For example, lab benches, storage spaces, sinks, and first aid stations are often inaccessible to children with physical disabilities. Because of their limited mobility, these children may also require additional aisle space both within classrooms and along any corridors that are part of emergency escape routes.

Children with special needs may also benefit from assistive technology. However, general education teachers may not be aware of assistive technology resources, or they may be unfamiliar with how to choose such devices. Special education experts recommend that teachers follow three procedures when considering assistive technology in the inclusive classroom: (1) allow the child, his or her family, and classmates to help select assistive technology devices; (2) have a specific activity in mind when looking for a device, rather than simply purchasing an available device and then trying to figure out what to do with it; and (3) seek help and advice from experts outside the field of education, including, for example, engineers, carpenters, and computer experts (for more information, see *Assistive Technology and Inclusion* online at http://www.asri.edu/CFSP/brochure/asstech.htm).

How Can Science and Math Teachers Adapt Curriculum and Assessment?

In general, the strategies involved in adapting curriculum for inclusive situations will depend upon the needs of the individual children in a particular classroom. For example, teachers can often help children with learning disabilities by making increased use of lesson summaries and other organizational techniques, such as providing children with organizing notebooks, translating complicated directions or procedures into small blocks of information, distributing copies or outlines of class lecture notes, and posting weekly assignments in convenient places for students to examine. Teachers can help children with physical disabilities by positioning them near the front of the classroom or by developing special signals to indicate the need for communication.

In science classes, teachers may have to modify laboratory instruction significantly for children with special needs. Children with learning disabilities may require more organized information in smaller increments. Children with physical disabilities often require modified equipment to complete lab exercises. For example, Braille rulers can be adapted or made, and instruments that normally have visual output can be modified to have audio output. For children with hearing impairments, lab equipment with sound signals can be wired to include a light or other visible signal as well. Microscopes that do not require fine motor skills can be purchased, or projection scopes can be used for children with visual disabilities.

Science teachers may also modify some procedures to make the lab more accessible to children with special needs. Pairing a general education student as a "lab buddy" with a student with special needs is often successful. The lab buddy should understand his or her partner's limitations and be able to work within those limitations to do lab activities *with* the special needs child, rather than *for* him or her. Finally, no child in science class should be exempt from safety rules, so teachers may need to model appropriate safety behavior frequently and give children several chances to practice reacting to staged "crises."

In math classes, teachers may also have to modify the curriculum to accommodate children with special needs. The National Council of Teachers of Mathematics standards encourage math teachers to use manipulatives and physical models to help children develop number sense and understanding of mathematical operations. Working with partners is also a successful strategy in mathematics learning. And children with special needs should be given multiple opportunities to interact with technology, especially calculators and computers.

Assessment options for the inclusive classroom should reflect the diverse skills and goals of the children in the class. Teachers may find that frequent checks of student progress are helpful. Teachers should accept that children will solve math problems in many different ways and that alternative problem-solving methods are equally valid in most situations. In addition, unit projects that allow children to focus on their own science or math interests and to showcase their individual talents are extremely beneficial.

How Can Parents and Teachers Work Together?

Partnerships between science or math teachers, special education teachers, and parents are key in determining effective educational strategies for children with special needs. These partnerships can also include other children; teachers with experience in inclusive classrooms claim that children often devise strikingly successful ways to adapt educational strategies for their classmates with special needs.

One of the most important ways that parents and teachers can work together to help children with special needs is to develop an Individualized Education Plan, or IEP. According to the Individuals with Disabilities Education Act of 1991 (IDEA), IEPs must include (1) a description of the student's present level of performance; (2) short-term and annual goals for student progress; and (3) the educational services to be provided to the student in support of these performance goals. Some states also specify additional requirements for IEPs. Professionals and parents should work together to develop the IEP, review it frequently, and revise it if necessary. Parents have the right to be active advocates for their special needs child in today's schools.

Parents and teachers should realize the important role they play in developing the attitudes of children with special needs toward science and math. For example, one study of adults with disabilities shows teacher behavior to be the most frequently cited reason for choosing a career in science (Weisgerber, 1990).

Finally, all children can participate in some way in the science or math classroom, even if it is not the same way. But parents and teachers should remember that inclusive classroom techniques—organizing topics around central themes and allowing children to demonstrate their knowledge in a variety of ways—are helpful to and appropriate for every child in the classroom, not just those with special needs. To be sure, maintaining an inclusive science or math classroom involves a commitment to the needs of all children, and all children can benefit from the process.

References

Consortium on Inclusive Schooling Practices. 1996. *A Framework for Evaluating State and Local Policies for Inclusion.* Consortium on Inclusive Schooling Practices Issue Brief. (Available online at http://www.asri.edu/CFSP/brochure/framewrk.htm)

National Science Foundation. 1999. *Women, Minorities, and Persons With Disabilities in Science and Engineering: 1998.* Arlington, VA: Author. (Available online at http://www.nsf.gov/sbe/srs/nsf99338/start.htm)

Weisgerber, R. A. 1990. "Encouraging Scientific Talent." *The Science Teacher* 57 (8): 38–39.

Resources

Circle of Inclusion (http://circleofinclusion.org)

Consortium on Inclusive Schooling Practices (http://www.asri.edu/cfsp/brochure/abtcons.htm)

ERIC Clearinghouse on Disabilities and Gifted Education (http://www.cec.sped.org/ericec.htm)

The National Information Center for Children and Youth with Disabilities (http://www.nichcy.org)

Encouraging Girls in Science and Math

Linda A. Milbourne

While jobs requiring advanced degrees in science and math continue to increase, women remain underrepresented in these careers, particularly in engineering. In 1995, women constituted about 46 percent of the U.S. labor force, but only about 22 percent of the scientists and engineers in the labor force (National Science Foundation, 1999). Many other career paths also require advanced education in science and math, so today more than ever before, all students must be included in the national priority to make U.S. students first in the world in science and mathematics achievement (Goal Five of the National Education Goals). Girls, in particular, need to be shown the options open to them by continuing to study science and math.

Gender Differences in Science and Math Enrollment

In 1992, the American Association of University Women reported that girls did not take as many advanced science and math courses in high school as boys. Since then, the gap in math has decreased, but girls still lag behind in physics and computer science: although girls and boys essentially take the same amount of science and math course work in high school, girls are less likely to take physics; Advanced Placement (AP) chemistry or AP physics; or the sequence of biology, chemistry, and physics generally taken by students planning to major in science or math in college (see the table on page 46). As shown in the table, significantly more girls than boys take clerical and data entry computer courses, but more boys than girls take computer application and computer science courses.

The most recent National Assessment of Educational Progress (NAEP) in science shows a similar pattern of course work: although 71 percent of girls and 66 percent of boys in grade 12 reported taking biology and chemistry, only 29 percent of girls and 34 percent of boys reported taking biology, chemistry, and physics (O'Sullivan, Weiss, and Askew, 1998). It appears that girls often do not realize that higher-level science and math courses are prerequisites for some college majors.

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Gender Differences in Science and Math Proficiency

It comes as no surprise that enrollment in advanced science and math courses in high school is related to proficiency in these subjects (Madigan, 1997). Because the gender gap in math enrollment has been closing, gender differences in math proficiency scores have decreased accordingly. NAEP results for 1994 show no gap in math proficiency scores between boys and girls at ages 9 and 13, and the gap in scores that existed from 1973 to 1986 between 17-year-old boys and girls has practically disappeared [National Center for Education Statistics (NCES), 1997]. However, the gender gap in science proficiency persists. In 1994, science proficiency scores were similar for girls and boys at age 9, but clearly lower for girls at age 13—and the gap is growing (NCES, 1997).

Though girls begin to fall behind boys on standardized science exams by grade 7, they do not fall behind in math until grade 10. By the time students take the Scholastic Assessment Tests (SAT) and the AP exams in science and math, boys outscore girls in both science and math. It is critical to remember that gender differences in science and math proficiency scores become apparent when girls either stop taking advanced courses or enroll in fewer science and math courses than boys their age.

Percentage of High School Graduates in 1994 Earning Credits for the Indicated Courses

Courses Taken	Females	Males
Any Mathematics (1.0)*	99.91	99.91
Algebra II (1.0)	61.00	54.39
Calculus (1.0)	9.15	9.45
AP Calculus (1.0)	6.81	7.17
Any Science (1.0)	99.78	99.50
AP/Honors Biology (1.0)	12.81	10.92
Chemistry	58.59	52.90
AP Chemistry (1.0)	3.73	4.08
Physics (1.0)	22.28	27.19
AP/Honors Physics (1.0)	2.02	3.45
Biology + Chemistry + Physics (3.0)	19.80	23.24
Clerical & Data Entry (1.0)	24.40	16.42
Computer Applications (1.0)	1.14	6.08
Computer Science (0.5)	26.53	29.83
Computer Science (1.0)	10.96	13.85

*Carnegie Units

—U.S. Department of Education. National Center for Education Statistics. 1997. *The 1994 High School Transcript Study Tabulations: Comparative Data on Credits Earned and Demographics for 1994, 1990, 1987, and 1982 High School Graduates, Revised.* National Center for Education Statistics Report No. NCES 98–532. Washington, DC: Author.

Factors That Influence the Underachievement of Girls in Science and Math

Beginning at a young age, many girls and boys receive different messages from parents, peers, teachers, and the media. Young girls are taught to be nurturing while boys are encouraged to play with toys they can tinker with or manipulate, such as construction sets, Legos, building blocks, and tool kits. Playing with these toys provides opportunities to develop the problem-solving and independent-thinking skills inherent to success in science and math. Girls who lack these skill-building experiences often enter science and math classes feeling insecure about their abilities.

Self-perceptions play an important role in science and math achievement, especially for girls. Research shows that self-esteem and academic achievement among girls begin to decline during middle school (Backes, 1994) and that girls often exhibit a loss of self-confidence by age 12 (Orenstein, 1994). This lack of self-confidence is also reflected in the fact that boys are more likely to attribute personal success to effort, whereas girls tend to attribute it to luck. As a result, many girls underachieve in science and math simply because they choose to participate in activities in which success is almost assured.

Attitudes also contribute to the underachievement of girls in science and math. Although middle school girls take more high-ability courses than boys and make comparable or higher grades, their attitudes toward science and math are less positive, and they are less likely to participate in related extracurricular activities.

Unfortunately, research shows that social attitudes tend to become fixed during middle school and early in high school (Heller and Martin, 1992). So girls who develop negative attitudes toward science and math during this period of development are unlikely to acquire the academic background necessary for careers in science, math, or engineering. As a result, by grade 12, more girls than boys say they chose not to take more science or math courses because they either disliked the subject matter or didn't do well in those subjects (NCES, 1997). And as the table on page 47 shows, few girls entering college see themselves as future engineers.

In essence, girls' and boys' abilities are the same; their self-perceptions and attitudes are different. Even girls who have course backgrounds and achievement levels similar to those of boys have less confidence in their abilities and less interest in studying science and math. Consequently, girls are less likely than boys to pursue related careers (NCES, 1997).

Finally, some girls underachieve in science and math because they are discouraged from studying these subjects. One study shows that higher percentages of girls than boys are advised not to take senior science or math (National Science Foundation, 1994).

What Can Parents Do?

Parents are most influential in giving their daughters the confidence necessary to succeed in science and math courses and in related careers. Here are several ways that parents can help girls succeed in science and math:

- Maintain high expectations and encourage high achievement and career aspirations. Make sure girls take Algebra I in eighth grade. Encourage girls to take science and math every year throughout high school. This will keep their career options open.
- Encourage girls to become involved in science, math, or computer clubs in school, or to join other extracurricular activities, enrichment programs, or summer programs in science and math.
- Show that science and math are important parts of daily life. Involve girls in home activities, such as cooking, paying bills, balancing checkbooks, fixing appliances, and assembling things.
- Reinforce positive attitudes toward science and math. Avoid perpetuating any negative feelings you may have had as a student. Negative comments imply that it is okay not to do well.
- Visit classrooms occasionally and observe the learning environment. Does the teacher call on boys and girls equally to answer questions? Urge teachers to encourage girls to take advanced and higher-level science and math courses.
- Express confidence in girls' abilities, and let them know that they can become anything they want to be. Without this encouragement, girls find it difficult to believe in their own abilities.

What Can Teachers Do?

- Have high expectations for girls. Advise them to take science and math courses, especially advanced courses.
- Help girls develop positive attitudes toward science and math. This is especially important in middle school, when girls are in their early teens.
- Develop a classroom atmosphere that encourages participation. Boys call out answers more often than girls, yet teachers continue to encourage boys more than girls.
- Encourage girls to participate in class discussions, projects, and experiments, and provide opportunities for cooperative learning. All children learn more and show greater interest when allowed to "do" science and math. Girls generally prefer to work in groups because it reduces feelings of competitiveness.
- Provide girls with access to women mentors and role models by forming partnerships with local businesses and community organizations. This helps girls learn about various career options available to them and reinforces the idea that they can succeed in science- and math-related careers.

For more parent and teacher tips, see the articles "How Can I Help My Child Become More Interested in Science?" on page 7, "How Can I Help My Child Become More Interested in Math?" on page 9, and "Putting It All Together: An Action Plan" on page 70.

Percentage Distribution of Probable Fields of Study Among First-Time College Freshmen, by Sex: Fall 1996

Probable Major Field of Study	Females	Males
Arts and Humanities	10.5	9.4
Biology	7.4	6.5
Business	13.8	18.1
Computer Sciences	1.2	4.3
Education	14.2	6.3
Engineering	2.6	15.2
Physical Sciences[a]	2.0	2.7
Professional[b]	20.2	9.8
Social Sciences	11.7	6.1
Technical	1.4	3.7
Other	6.5	10.5
Undecided	8.8	7.4

[a]Includes fields such as astronomy, chemistry, earth science, mathematics, and physics.
[b]Includes fields such as architecture and health technologies.

—Astin, A. W., W. S. Korn, and K. M. Mahoney. 1996. *The American Freshman: National Norms for Fall 1996.* Los Angeles, CA: Higher Education Research Institute, Graduate School of Education and Information Studies, University of California at Los Angeles.

References

American Association of University Women. 1992. *How Schools Shortchange Girls.* AAUW Report. Washington: Author.

Backes, J. S. 1994. "Bridging the Gender Gap: Self-Concept in the Middle Grades." *Schools in the Middle* (3): 19–23.

Heller, R. S., and C. D. Martin. 1992. *Bringing Young Minority Women to the Threshold of Science.* National Science Foundation Report.

Madigan, T. 1997. *Science Proficiency and Course Taking in High School: The Relationship of Science Course-Taking Patterns to Increases in Science Proficiency Between 8th and 12th Grades.* National Center for Education Statistics Report No. NCES 97–838. Washington, DC: U.S. Department of Education.

National Center for Education Statistics (NCES). 1997. *Findings From the Condition of Education 1997: Women in Mathematics and Science.* Washington, DC: U.S. Department of Education. (Available online at http://nces.ed.gov/pubs97/97982.html)

National Science Foundation. 1994. *Women, Minorities, and Persons With Disabilities in Science and Engineering: 1994.* Arlington, VA: Author. (Available online at http://www.nsf.gov/sbe/srs/wmpdse94)

National Science Foundation. 1999. *Women, Minorities, and Persons With Disabilities in Science and Engineering: 1998.* Arlington, VA: Author. (Available online at http://www.nsf.gov/sbe/srs/nsf99338)

O'Sullivan, C. Y., A. R. Weiss, and J. M. Askew. 1998. *Students Learning Science: A Report on Policies and Practices in U.S. Schools.* National Center for Education Statistics Report No. NCES 98–493. Washington, DC: U.S. Department of Education.

Orenstein, P. 1994. *Schoolgirls: Young Women, Self-Esteem, and the Confidence Gap.* New York: Doubleday.

Mathematics Education for Gifted and Talented Children

David L. Haury

Within the diverse student population in the United States are children who are fascinated with numbers, quick to see patterns, adept at solving math problems, or who otherwise show a strong aptitude for or interest in mathematics. These gifted and talented children (herein, gifted) present a unique challenge as educators pursue the national goal to meet the needs of all children in math: How can teachers nurture the ongoing academic development of gifted children within the context of the mixed-ability math classroom?

This question causes great concern among many parents, teachers, and other members of the education community, who believe that gifted children may not be challenged sufficiently in a mixed-ability setting. Like other children, gifted children develop their math skills by struggling with challenging mathematical ideas and procedures. Simply doing more problems than the other children or covering more of the same material in less time will only increase the likelihood that math class will become tedious or boring. If gifted children reach the limit of what they can do with minimal effort, they may ultimately give up on themselves and quit the study of mathematics (Lappan, 1999).

How To Recognize Giftedness in Mathematics

Not all high achievers in math are gifted. Some children may be high achievers simply because they have good memories or have learned to apply rules and procedures to standard math problems in predictable ways. Differentiating gifted children from other high achievers may require some careful probing and observation. The characteristics and behaviors of gifted math students—the top 2 to 3 percent of students—are as follows (Miller, 1990):

- An unusually keen awareness of and intense curiosity about numeric information.

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- An unusual quickness in learning, understanding, and applying mathematical ideas.
- A high ability to think and work abstractly and the ability to see mathematical patterns and relationships.
- An unusual ability to think and work with mathematical problems in flexible, creative ways rather than in a stereotypic fashion.
- An unusual ability to transfer learning to new mathematical situations.

Because math giftedness refers to an unusually high ability to understand mathematical ideas and to reason mathematically, it is important not to confuse the ability to do arithmetic computations or get good grades in math with being gifted.

Classrooms That Nurture Gifted Math Students

Like all students, gifted math students have a variety of interests, learning styles, and preferences; there is no single instructional approach that is best suited for all of them. There is, however, an array of program features that respond to the needs of this special population. Some of the most essential elements are as follows (Miller, 1990).

First, gifted math students should have the opportunity to work with one another when possible "Pull-out" programs and separate classes for gifted children are increasingly uncommon, so the desired grouping of gifted children may be restricted to clustering them within the mixed-ability classroom. In the resulting *differentiated* classroom, the teacher recognizes the differing readiness levels, interests, and learning profiles of the children and offers them, accordingly, a variety of ways to (1) explore topics, (2) come to understand and "own" information and ideas, and (3) demonstrate or exhibit what they have learned (Tomlinson, 1995).

Second, the program should stress mathematical reasoning, rather than computation, and develop independent exploratory behavior. Gifted children in such a program are actively engaged in learning, solving problems, discovering formulas, completing special projects, organizing data to find relationships, and looking for patterns and underlying principles.

Third, less emphasis should be given to repetitious computations and cyclical reviews. Such work should be minimal for gifted math students.

Fourth, the breadth of the math curriculum should be increased to provide an adequate foundation for gifted children who may want to pursue math-related careers.

Finally, the math program should be structured for flexibility, enabling teachers to place gifted children at an appropriate instructional level based on an assessment of knowledge and skill. Flexible pacing can be achieved in a variety of ways. For example, *continuous progress* allows gifted children to receive appropriate daily instruction and move ahead as they master content and skill. Or gifted children may take a *compacted course*, in which they complete two or more courses in an abbreviated time, or an *advanced-level course*, in which they learn course content normally taught in a higher grade. Through *concurrent* or *dual enrollment*, gifted children at one grade level take some courses at another grade level. Flexible pacing of gifted children can also occur through *grade skipping*, *credit by examination*, or *early entrance* to elementary school, middle school, high school, or college.

Recommendations for Teachers of Gifted Math Students

The following teacher activities can help gifted math students reach their potential (Sheffield, 1994):

- Use a variety of measures to identify gifted math students, tapping skills beyond computation. These children need to have a wide range of exciting math classes, math clubs, and contests in which they can demonstrate and hone their math abilities.
- Use a wide variety of assessments beyond standardized achievement tests, which measure low-level computation only. Teachers can expect gifted math students, unlike other high achievers in math, to attain the highest levels of achievement on several types of assessments.
- Provide all children with a wide variety of rich, inviting tasks that require spatial as well as analytical skills. Gifted children should explore topics in more depth, draw more generalizations, and create new problems and solutions related to the topic.
- Encourage children to persist in solving math problems. Fewer problems need to be tackled, but in far greater depth. Gifted children need the challenge of new and more complex problems. They need to experience the joy of solving difficult problems, and they should have the opportunity to share that joy with others.
- Encourage children to construct their own mathematical understanding, and encourage gifted children to reach the highest levels of construction.
- Engage all children in the use of technology and manipulatives to aid in their construction of mathematical concepts. Gifted children should use these materials to explore even further and to create and display quality mathematics.
- Show gifted children examples of advanced student work to challenge them to ever-increasing levels of mathematical achievement.

Finally, teachers should ask administrators for their support and assistance in obtaining the materials, technology, and training necessary to educate gifted math students.

References

Lappan, G. March 1999. "'Mathematics for All' Must Include High-Ability and Highly Motivated Students." *NCTM News Bulletin* 35 (8): 3. (Available online at http://www.nctm.org/news-bulletin/1999/03/1999-03.president.html)

Miller, R. C. 1990. *Discovering Mathematical Talent.* Reston, VA: ERIC Clearinghouse on Disabilities and Gifted Education, and The Council for Exceptional Children. ERIC Document Reproduction Service No. ED 321 487. (Available online at http://www.cec.sped.org/digests/e482.htm)

Sheffield, J. N. 1994. *The Development of Gifted and Talented Mathematics Students and the National Council of Teachers of Mathematics Standards.* (Available online at http://www.gifted.uconn.edu/sheffiel.html)

Tomlinson, C. A. 1995. *Differentiating Instruction for Advanced Learners in the Mixed-Ability Middle School Classroom.* Reston, VA: ERIC Clearinghouse on Disabilities and Gifted Education, and The Council for Exceptional Children. ERIC Document Reproduction Service No. ED 389 141. (Available online at http://www.cec.sped.org/digests/e536.htm)

Science Education for Gifted and Talented Children

Joyce VanTassel-Baska

This is a time of great concern about the continuation and continuity of programs for gifted and talented children (herein, gifted) in many parts of the United States. It is relatively uncommon to find pull-out science programs at the elementary level and also somewhat rare to find separate science programs for gifted children in middle schools. So perhaps it is appropriate to focus on how gifted children participate and learn in mixed-ability science classrooms.

What Should a Science Curriculum for Gifted Students Include?

Researchers at the Center for Gifted Education at The College of William and Mary have spent the past six years identifying elements of appropriate science curriculum and instruction for gifted children and melding those elements to the template of science curriculum reform for all children. Consequently, the elements essential to the education of gifted children apply to other children as well. The most important elements are described below.

An Emphasis on Teaching Concepts

By restructuring the science curriculum to emphasize those ideas deemed most appropriate for children to know and grounded in the view of practicing scientists, teachers allow children to learn at deeper levels the fundamental ideas central to understanding and doing science in the real world. Concepts such as *systems, change reductionism,* and *scale* all provide an important scaffold for learning about the core ideas of science. These core ideas do not change, but their specific applications do.

An Emphasis on Higher-Level Thinking

Just as children need to learn about important science concepts, they also need to manipulate those concepts in complex ways. Having children analyze the relationship between a real-world problem, such as an acid spill on the highway, and its implications for understanding science and for seeing its relationship to society provides children with opportunities to think critically and creatively. Such an emphasis is crucial in a science curriculum that claims to be engaging children in "minds-on" experiences.

An Emphasis on Inquiry Approaches, Especially Problem-Based Learning

The more that children can construct an understanding of science for themselves, the better able they will be to employ appropriate scientific processes when they encounter new situations. Through guided questions by the teacher, through collaborative dialog and discussion with peers, and through individual exploration of key questions, children can grow in the

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development of the valuable habits of mind—such as skepticism, objectivity, and curiosity—found among scientists (VanTassel-Baska, Gallagher, Bailey, and Sher, 1993).

An Emphasis on the Use of Technology as a Teaching Tool

The use of technology to teach science offers children some exciting opportunities to connect with real-world problems. Access to the world of scientific papers through CD-ROM databases offers new avenues for exploration. Moreover, the Internet provides teachers with access to well-constructed units of study in science as well as ideas for teaching key concepts. In addition, e-mail allows children to communicate directly with scientists and students around the world regarding questions related to their research projects.

An Emphasis on Teaching the Scientific Method and Using Experiments

Many children know very little about experimental design and its related processes. Typically, basal science texts offer "canned" experiments in which children follow steps that lead to a preordained conclusion. Rarely are children encouraged to read and discuss a particular topic of interest, come up with a problem related to the topic of interest, or follow through in a reiterative fashion with appropriate procedures, further discussion, reanalysis of the problem, or communication of findings.

What Can Teachers Do To Make These Reform Efforts Successful?

While the inclusion of the elements cited above will go a long way toward enhancing science education in U.S. schools, especially for gifted students, it is folly to think that these major emphases can be effected without the appropriate support structures in place to nurture them. To ensure that science reform has a chance to succeed, administrators, teachers, and parents need to consider a variety of resource tools. Some of these are described below.

Select Modular Materials Rather Than Basal Texts

Excellent science materials designed to promote the curriculum elements previously described are now available (Johnson, Boyce, and VanTassel-Baska, 1995). However, districts must be willing to use these materials rather than insisting on the purchase of basals, which do little to promote the desired kind of science learning. Moreover, excellent supplementary materials, also attuned to science reform, are available to augment any school science program.

Train Teachers in Content-Based Pedagogy

Research suggests that to improve teaching and focus on learning, teachers need help in teaching for understanding (Cohen, McLaughlin, and Talbert, 1993). Teacher training programs can provide the necessary help by emphasizing classroom strategies and instructional approaches in the context of content, rather than separate from it. One good way to ensure the integration of content and pedagogy is to use high-quality materials as the basis for teacher training sessions.

Monitor Curriculum

No matter what new emphasis schools wish to implement, they need to ensure that it is implemented faithfully. Research on staff development and effective instruction demonstrates the need for systematic followup procedures to ensure teacher action (Guskey, 1996; Showers, Joyce, and Bennett, 1987). Whether such monitoring occurs through peers, administrators, or curriculum specialists is not as important as the fact that it does take place.

Conclusion

An appropriate science curriculum for gifted children emphasizes some elements at the expense of others. It focuses on a few concepts that are taught deeply and well. It concentrates on the real-world act of doing science. It incorporates technology as a resource. It makes the experience in science classrooms learner centered and dynamic. If the education community can accomplish such an integrated set of goals, children will be far more likely to function at higher levels of scientific literacy than is currently the case.

References

Cohen, D., M. McLaughlin, and J. Talbert. 1993. *Teaching for Understanding.* San Francisco: Jossey Bass.

Guskey, T. R. 1996. "Exploring the Relationship Between Staff Development and Student Learning." *Journal of Staff Development* 17 (4): 34–38.

Johnson, D., L. Boyce, and J. VanTassel-Baska. 1995. "Evaluating Curriculum Materials in Science." *Gifted Child Quarterly* 89 (1): 35–43.

Showers, B., B. Joyce, and B. Bennett. 1987. "Synthesis of Research on Staff Development: A Framework for Future Study and State of the Art Analysis." *Educational Leadership* 45 (3): 77–87.

VanTassel-Baska, J., S. Gallagher, J. Bailey, and B. Sher. 1993. "Scientific Experimentation." *Gifted Child Today* 16 (5): 42–46.

Resources

The Center for Gifted Education at The College of William and Mary offers a catalog of math and science publications, including seven curriculum units containing different real-world situations and a related guide to curriculum use. Visit the center online at http://www.wm.edu/education/gifted.html.

Addressing the Needs of English-Language Learners in Science and Math Classrooms

Cathleen McCargo

In recent years, national reform efforts in education have advocated higher academic standards for all children in science and math. Rigorous standards have been mandated by legislation such as the Goals 2000: Educate America Act. In its recent proposal for reauthorization of the Elementary and Secondary Education Act, the Department of Education emphasized the importance of standards in all academic areas. Professional organizations such as the National Council of Teachers of Mathematics, the National Science Teachers Association, the National Science Foundation, and the American Association for the Advancement of Science have all proposed standards. In response to these national movements, states and local school districts across the country have developed standardized tests to assess children's knowledge in various content-specific disciplines.

Although implementing higher standards challenges teachers to rethink the ways in which they help children build subject knowledge and critical thinking skills, these reform efforts have serious implications for schools that serve large populations of English learners. English learners enrolled in science and math classes face a double challenge in that they are learning English while simultaneously learning content. Factors such as age of entry into the United States, age of entry into school, previous educational background, and type of program in which they are enrolled all influence English learners' ability to succeed in these classes.

Questions and Issues

Why Is It Important for Science and Math Teachers To Consider Children's English Proficiency?

Science and math teachers often find that English proficiency varies widely among English learners. For this reason, the question of what and how to teach becomes critical. Depending on the English skill level of the class, instructors may need to teach in their students' native language or use a sheltered instructional approach in which they help children acquire content and develop English language skills at the same time.

How Does an Understanding of *Social Language* and *Academic Language* Help Teachers in Their Instruction of English Learners?

Science and math teachers need to be aware that much of the language used in interpersonal communication differs from the language used in education and that children may be more proficient in one than the other. *Social language* is the language used to converse with a friend or to complete routine tasks. In contrast, *academic language* is the language of subject-matter discussions and textbooks. Although children may appear proficient in their ability to engage in daily conversations in English, they may have difficulty understanding or using English when reading textbooks, writing papers, or engaging in other academic learning activities.

The *ESL Standards for Pre-K–12 Students*, developed by the Teachers of English to Speakers of Other Languages Association (TESOL), identify goals for English learners. These standards are designed for use with existing content area standards to help teachers develop children's proficiency in social language skills

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(for example, requesting information) and in academic language skills (for example, representing information graphically). Research shows that the development of academic language skills may require five to nine years of instruction (Cummins, 1980). Science and math teachers should understand that it may be a long time before the English learners perform on a par with the native English speakers in their classes.

The development of academic language skills is further complicated by the specialized language or *register* characteristic of science and math disciplines. Teachers should familiarize children with this specialized language so that they can recognize and use it successfully in science and math courses.

What Effect Does Previous Schooling Have on Achievement in Science and Math Classes?

An awareness of children's cultural backgrounds, particularly the level of schooling attained prior to arrival in the United States, helps teachers get a clearer picture of their students' needs. For example, English learners in science and math classes may be on different educational levels from those of their same-age peers as a result of limited or interrupted schooling.

Educational level has important implications for the selection of instructional strategies, including decisions about the language of instruction. By understanding children's educational backgrounds and cultures, teachers gain invaluable insights into what has already been learned with respect to the curriculum, allowing them to tap into their students' abilities instead of highlighting their deficits (see, for example, Secada, 1983). Having this awareness helps teachers understand how children comprehend, for example, procedures for solving math problems. Teachers should be familiar with the various ways that children may approach mathematical operations—that is, the teacher's usual method may differ from the one children initially learned in their native country. Allowing children to express their comprehension of particular operations helps teachers understand their thinking processes and assess their content knowledge. It also provides valuable language practice.

The approaches described in this section involve instruction in English. However, many researchers cite that teaching English learners in their native language, particularly when new concepts are being taught, facilitates understanding of the content (Buchanan and Helman, 1993).

Should Children Learning English Take Science and Math Courses?

Yes. Although children may lack the English proficiency and educational background to fully communicate their ideas and understandings in a science or math class, many have some math knowledge that teachers can build on, and most can participate in science experiments in ways that do not demand high levels of language use. Exposure to science and math concepts helps facilitate the acquisition of language and the development of cognitive skills.

Implications for Practice

Because of the growing numbers of English learners in school districts across the country and the wide range of needs that these learners bring to the classroom, schools might consider the following suggestions, grouped into four broad categories: curriculum and materials, instruction, assessment, and professional development.

Curriculum and Materials

Curriculum and materials appropriate for English learners are often lacking. Thus, these children are often excluded from science and math classes, or they take the classes without fully benefiting from them. Given the wide range of English proficiency levels and developmental levels that can exist within a classroom, teachers should use appropriate curricula to address the needs of all children.

Teachers can adapt the curriculum to meet the needs of English learners, particularly those with low levels of literacy, by identifying and *clustering* similar learning objectives across grade levels. Clustering should also take into account factors such as student age, educational background, and level of English proficiency (Buchanan and Helman, 1993). For children who have had gaps in their educational experience, clustering has several benefits. First, it allows teachers to move children along as quickly as possible and revisit objectives if necessary. Second, clustering learning objectives allows teachers to integrate a variety of math strands into one lesson.

Instruction

Appropriate instructional strategies are needed to make academic material accessible. For example, children who have had minimal or interrupted schooling may benefit from instruction in science and math in their native language. Children with low native literacy skills will benefit from instruction focused on literacy development. Children who have had previous schooling will do well with a "sheltered" approach to learning science and math, in which teachers make extensive use of supplementary materials and provide multiple opportunities for interaction to make academic content accessible in English. Sheltered content classes are often organized around themes that tap into children's life experiences while addressing curricular objectives.

Assessment

Because English learners have the dual challenge of learning language and academic content simultaneously, teachers need to implement a variety of assessment procedures that allow children to successfully demonstrate what they know and can do.

Several assessment techniques proposed by the National Council of Teachers of Mathematics are essential for teachers who work with English learners, particularly those with low levels of literacy. These techniques can be divided into three categories: those that are a part of instruction, such as spot checks, checklists, and anecdotal records of student progress over time; those that include multiple assessment methods that target what children know, such as rating scales/rubrics and portfolios; and those that holistically assess children's language skills—listening, speaking, reading, and writing—in an integrated math and language course (Buchanan and Helman, 1993).

Professional Development

Collaboration between English as a second language (ESL) teachers and content teachers is essential and can be advantageous for both groups. Because content teachers are already familiar with the curriculum and materials, ESL teachers can benefit from their knowledge and expertise in solving problems. At the same time, ESL teachers can make science and math teachers more aware of the types of language activities that can be built into the content area classroom to promote children's language development. Language teachers should be trained to integrate language and content instruction, and content teachers should be trained in ESL methodologies.

Conclusion

To prepare English learners to meet high academic standards at all grade levels, educators have to consider many factors. Science and math teachers need to develop children's language and academic skills as well as teach content material. In addition to general language proficiency, children need to learn the special variety or language register of the discipline. Knowledge about factors such as age, language proficiency, and developmental levels related to children's formal schooling can help science and math teachers adapt curricular objectives, identify appropriate materials and instructional strategies, and determine whether native language support should be provided.

Because the structure and content of programs vary from district to district, program staff should determine the amount of support necessary for science and math teachers who instruct English learners. Whether a program uses a sheltered approach with ESL staff, or a native language approach, or depends on interdisciplinary planning and teaching among content and language teachers, collaboration and professional development are clearly needed to help English learners meet high standards in science and math.

References

Buchanan, K., and M. Helman. 1993. *Reforming Mathematics Instruction for ESL Literacy Students.* Washington, DC: National Clearinghouse for Bilingual Education.

Cummins, J. 1980. "The Cross-Lingual Dimensions of Language Proficiency: Implications for Bilingual Education and the Optimal Age Issue." *TESOL Quarterly* 14: 175–87.

Secada, W. 1983. *The Educational Background of Limited English Proficient Students: Implications for the Arithmetic Classroom.* Arlington Heights, IL: Bilingual Education Service Center.

Federal Support for Science and Mathematics Education

Kevin Mitchell

The federal government continues to show strong support for K–12 science and math education. The U.S. Department of Education has identified seven priorities based on President Clinton's 1997 "Call to Action" to provide American students with the best education in the world. Several of these priorities now play a major part in guiding the Department's activities related to boosting academic achievement in science and math:

- *All students will master challenging mathematics, including the foundations of algebra and geometry, by the end of eighth grade.*
- *All states and schools will have challenging and clear standards of achievement and accountability for all children and effective strategies for reaching those standards.*
- *There will be a talented, dedicated, and well-prepared teacher in every classroom.*
- *Every classroom will be connected to the Internet by the year 2000, and all students will be technologically literate.*

The information that follows provides a brief overview of federal programs and initiatives related to improving science and math education. Although this information appears in discrete groups, many of the programs include elements that necessarily overlap.

Curriculum and Materials

The *America Counts Challenge* (http://www.ed.gov/inits/Math) is a six-point initiative designed to help all students master advanced skills in math by the end of eighth grade. In addition, President Clinton has urged the states to adopt Voluntary National Tests (VNT) to determine whether students are meeting the national standards for eighth-grade mathematics achievement (for more information, see the article "National Math and Science Standards: A Primer for Parents" on page 23).

The Department of Education has granted the National Assessment Governing Board exclusive authority over the development of the proposed VNT, which would be based on the same content and performance standards as the National Assessment of Educational Progress (NAEP). But unlike NAEP, VNT would be given to individual students and yield individual student scores.

Support for, as well as opposition to, VNT has been bipartisan, so its future is unclear. Depending on legislative activity in 1999, pilot testing of VNT may begin in 2000 or 2001, with subsequent implementation in 2002 or 2003.

The Department and the National Science Foundation have issued *An Action Strategy for Improving Achievement in Mathematics and Science* (http://www.ed.gov/pubs/12TIMSS), an outline for using federal resources to help states, local school districts, and schools improve teaching, upgrade curricula, and integrate technology and high-quality teaching materials into the classroom.

The Department's Office of Educational Research and Improvement (OERI) funds the National Center for Improving Student Learning & Achievement in Mathematics & Science. The center conducts research and publishes materials that educators can request or view on its Web site (http://www.wcer.wisc.edu/NCISLA).

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The Department also funds the Eisenhower National Clearinghouse for Mathematics and Science Education (ENC), which collects a wide range of math and science curriculum materials and makes them available online (http://www.enc.org) and on CD-ROM. The ENC network includes regional consortia, demonstration sites, and access centers, which provide educators with technical assistance and professional development opportunities on topics important to their regions and to the nation.

In addition, the Department funds the Educational Resources Information Center (ERIC), through OERI and the National Library of Education. The ERIC Clearinghouse for Science, Mathematics, and Environmental Education provides a wealth of online resources for teachers, parents, and students. Visitors to the Web site (http://www.ericse.org) will find links to lesson plans, journals, books, digests, and related organizations. Science teachers will find an entire section devoted to science fairs, including links to several "idea generators."

The Gateway to Educational Materials (GEM) Web site (http://thegateway.org), a special project of the ERIC Clearinghouse on Information & Technology, provides one-stop access to thousands of lesson plans, curriculum units, and other education resources found on federal, state, university, nonprofit, and commercial Web sites. Visitors can search the database—including extensive math and science resources—by key word and grade level, or browse the subject index.

The Department's current, free publications and products are available through ED Pubs, the Education Publications Center. Visitors to the Web site (http://www.ed.gov/pubs/edpubs.html) can search the catalog by title or browse by subject. All items can also be ordered by toll-free telephone at 1-877-433-7827.

Teachers can also access many other online resources devoted to math and science education. *The Guidebook of Federal Resources for K-12 Mathematics and Science* (http://www.enc.org/guidebook), published by the Eisenhower National Clearinghouse, is a comprehensive national directory of federal offices, programs, and facilities that support math and science education.

Educators can learn more about available education resources by visiting the Teachers Web Page (http://www.ed.gov/inits/teachers/teach.html) on the Department's Web site. This page provides links to teacher guides, education research, and information on professional development, leadership, and recruitment.

Professional Development

The Department sponsors several programs designed to improve science and math achievement through advancements in teacher training. For example, Eisenhower Professional Development State Grants support professional development activities in the core academic subjects. At least $250 million of the currently funded $310 million must be spent on professional development in math and science.

The Eisenhower Professional Development Federal Activities Program supports national professional development initiatives, such as the National Board for Professional Teaching Standards (NBPTS). NBPTS establishes national standards of excellence in teaching and recognizes attainment of those standards through a rigorous assessment process.

Title II of the Higher Education Amendments of 1998 created three Teacher-Quality Enhancement Grants: State Grants to support comprehensive statewide reforms to improve teacher quality; Partnership Grants to bring about fundamental change and improvement in traditional teacher education programs; and Teacher Recruitment Grants to reduce shortages of qualified teachers in high-need school districts. Currently funded at $75 million, these grants will facilitate recruitment, preparation, and induction of the estimated 2.2 million new teachers to be hired over the next decade. For more information, visit the Department's Web site at http://www.ed.gov/offices/OPE/heatqp.

Teachers interested in learning more about these and other programs sponsored by the Department should consult *The New Teacher's Guide to the U.S. Department of Education* (http://www.ed.gov/pubs/TeachersGuide), *What Should I Know About ED Grants?* (http://www.ed.gov/pubs/KnowAbtGrants), *Guide to U.S. Department of Education Programs and Resources* (http://web99.ed.gov/GTEP/Program2.nsf), and *Excelling in Math and Science* (http://www.ed.gov/pubs/Excelling/excelling.html).

Technology

The Department's Office of Educational Technology sponsors several programs that support the development of technologically literate students, classrooms, and teachers. These programs can contribute significantly to the professional development of science and math teachers. The Technology Innovation Challenge Grant Program provides grants to consortia that work to improve and expand new applications of technology. Currently funded at $22 million, the grants help strengthen school reform, improve student achievement, and provide sustained professional development for teachers, administrators, and school library media personnel.

Preparing New Teachers To Use Tomorrow's Technology is a grant program that prepares teachers to integrate new technologies into the classroom. Currently funded at $75 million, the program provides three levels of support: Capacity-Building Grants, Implementation Grants, and Catalyst Grants. For more information on these and other programs sponsored by the Office of Educational Technology, visit the Department's Web site at http://www.ed.gov/Technology/inititiv.html.

Teachers can find out more about integrating technology into the classroom through the Network of Regional Technology in Education Consortia (http://www.rtec.org). Funded through

OERI, each of the six regional consortia establishes and conducts regional activities that address professional development, technical assistance, and information dissemination to promote the effective use of technology in education. The ERIC Clearinghouse on Teaching and Teacher Education (http://www.ericsp.org) and the ERIC Clearinghouse on Information & Technology (http://ericir.syr.edu/ithome) are also valuable sources of related information.

Other Resources

Although most of the federal funding for improving K–12 science and math education flows from programs of the Department of Education and the National Science Foundation, other federal agencies also play a part. For example, the U.S. Environmental Protection Agency awards grants to schools, state agencies, nonprofit organizations, and others to support environmental education programs. Other agencies that promote K–12 science and math education include the National Institutes of Health; the Smithsonian Institution; and the Departments of Agriculture, Commerce, Defense, Energy, the Interior, and Transportation.

Readers can access hundreds of federally funded, Internet-based education resources compiled by these and many other federal agencies by visiting the U.S. Department of Education's Federal Resources for Education Excellence Web site at http://www.ed.gov/free.

Math and Science Resource Organizations

Linda A. Milbourne

American Association for the Advancement of Science (AAAS)
1200 New York Avenue, NW
Washington, DC 20005–3920
Phone: 202–326–6440
Fax: 202–789–0455
E-mail: media@aaas.org
Web: http://www.aaas.org

AAAS is dedicated to promoting and advancing science and technology across all disciplines throughout the United States by expanding public understanding and appreciation of science through improved education in schools and in society. AAAS sponsors several programs that seek to promote or improve scientific endeavors around the world, including science education in schools nationwide.

Association for Multicultural Science Education (AMSE)
University of Houston
Department of Urban Education
One Main Street, Suite 601 South
Houston, TX 77002–1001
Phone: 713–221–8109
Fax: 281–438–5087
E-mail: key@dt.uh.edu

AMSE works to explore and promote improvements in science curricula and teaching methods, and to encourage students from culturally diverse backgrounds to consider science-related careers. In addition, AMSE recruits science teachers of diverse cultural backgrounds and supports initiatives and programs that improve the science education of culturally diverse students. AMSE focuses on urban and rural populations and African-American, Hispanic, and other students of color. AMSE works to meet the needs of all students and defines multicultural education as providing equal access to successful science experiences for all students.

Association for Women in Mathematics (AWM)
University of Maryland
4114 Computer & Space Sciences Building
College Park, MD 20742–2461
Phone: 301–405–7892
Fax: 301–314–9363
E-mail: awm@math.umd.edu
Web: http://www.awm-math.org

AWM's goal is to encourage women in the mathematical sciences and to improve mathematics and science education in the nation's schools and universities through the development of hands-on, constructivist curricula and computer-based learning tools. Other initiatives involve research on learning theories, evaluation of effective teaching methods, and development of strategies to improve the instruction of underserved students. AWM also publishes reports and papers describing the effects of computer-based learning.

Association for Women in Science (AWIS)
1200 New York Avenue, NW, Suite 650
Washington, DC 20005
Phone: 202–326–8940
Fax: 202–326–8960
E-mail: awis@awis.org
Web: http://www.awis.org

Linda A. Milbourne is Associate Director of the ERIC Clearinghouse for Science, Mathematics, and Environmental Education at The Ohio State University in Columbus, Ohio. She is also the AskERIC Coordinator for the clearinghouse.

AWIS seeks to achieve equity for and full participation of women in science, mathematics, engineering, and technology. As part of its efforts to promote the entrance and advancement of women in science, AWIS has a long-standing commitment to fostering the careers of women science professionals. AWIS chapters encourage the participation of girls and women in science by sponsoring educational activities in schools and communities. At the national level, AWIS publishes a variety of materials to inform girls and women about science programs and women's issues.

Center for Chemical Education (CCE)
Miami University—Middletown
4200 East University Boulevard
Middletown, OH 45042
Phone: 513–727–3421
Fax: 513–727–3223
E-mail: hoguelm@muohio.edu
Web: http://miavx1.muohio.edu/~cceewis

CCE promotes quality, hands-on chemical education that encourages teachers and students to work together to solve scientific challenges, think critically, and develop their observation skills. The organization coordinates teacher programs, student programs, materials development, and networking between industry and academia. The organization coordinates several student programs, including science camps, science carnivals, Super Saturday Science Sessions, and the PACT Ambassador Program, which offers high school and two-year college students practical experiences outside the classroom through mentoring relationships with retired chemists, chemical technicians, and engineers.

Center of Excellence for Science and Mathematics Education (CESME)
University of Tennessee at Martin
145 Gooch Hall
Martin, TN 38238
Phone: 901–587–7166
Fax: 901–587–7206
E-mail: jpprather@utm.edu
Web: http://cesme.utm.edu

The mission of CESME is to encourage and support the improvement of science and mathematics education at all levels. The center is widely known for leadership and initiative in the development and dissemination of materials for learner-centered instruction in science, mathematics, and environmental education. Focus areas include improvement of science and mathematics education throughout the K–12 and college arenas, effective use of technology in science and mathematics education, and promotion of women and minorities in science and mathematics.

Council for Exceptional Children (CEC)
1920 Association Drive
Reston, VA 20191–1589
Phone: 703–620–3660
Fax: 703–264–9494
E-mail: service@cec.sped.org
Web: http://www.cec.sped.org

CEC is the largest international professional organization dedicated to improving educational outcomes for individuals with exceptionalities, including students with disabilities and gifted students. CEC advocates for appropriate governmental policies, sets professional standards, provides continual professional development, advocates for underserved individuals with exceptionalities, and helps professionals obtain conditions and resources necessary for effective professional practice.

Educational Equity Concepts, Inc. (EEC)
114 East 32nd Street, Suite 701
New York, NY 10016
Phone: 212–725–1803
Fax: 212–725–0947
E-mail: information@edequity.org
Web: http://www.edequity.org/welcome.htm

EEC creates programs and materials to assist pre-K–12 educators in providing bias-free learning environments and positive adult role models. Its mission is to decrease discrimination based on gender, race, ethnicity, and disability through the creation of equity-based programs and materials. The organization conducts training and research and provides publications and hands-on materials for use in and outside the classroom for teachers, administrators, parents, students, and advocacy groups.

Eisenhower National Clearinghouse for Mathematics and Science Education (ENC)
The Ohio State University
1929 Kenny Road
Columbus, OH 43210–1079
Toll Free: 800–621–5785
Phone: 614–292–7784
Fax: 614–292–2066
E-mail: info@enc.org
Web: http://www.enc.org

Supported by the U.S. Department of Education, ENC offers curriculum resources in support of math and science reform. The clearinghouse identifies effective curriculum resources, creates professional development materials, and disseminates information and products to improve mathematics and science education in kindergarten through grade 12. ENC also produces print and CD-ROM publications.

ERIC Clearinghouse for Science, Mathematics, and Environmental Education (ERIC/CSMEE)
The Ohio State University
1929 Kenny Road
Columbus, OH 43210–1080
Toll Free: 800–276–0462
Phone: 614–292–6717
Fax: 614–292–0263
E-mail: ericse@osu.edu
Web: http://www.ericse.org

ERIC/CSMEE acquires, selects, and processes high-quality materials in science, mathematics, and environmental education, and it provides a variety of services and products to help educators, administrators, parents, researchers, and others stay current on a broad range of issues. The clearinghouse produces publications, bibliographies, ERIC Digests—syntheses and summaries of mathematics and science topics—and compilations of promising programs and practices. ERIC/CSMEE hopes to facilitate improved teaching, learning, and scholarship in science, mathematics, and environmental education through the active exchange of information and services.

Girls Incorporated
National Resource Center
441 West Michigan Street
Indianapolis, IN 46202–3287

Phone: 317–634–7546
Fax: 317–634–3024
Web: http://www.girlsinc.org

Girls Incorporated develops informal education programs designed to encourage girls, particularly those from low-income and single-parent families, to take risks and master physical, intellectual, and emotional challenges. Girls Incorporated designed and developed Operation SMART (Science, Math, and Relevant Technology), which builds girls' skills in mathematics, science, and technology by providing hands-on activities led by trained specialists, usually in informal education settings.

Math/Science Network
5000 MacArthur Boulevard
Oakland, CA 94613
Phone: 510–430–2222
Fax: 510–430–2090
E-mail: msneyh@mills.edu
Web: http://www.elstad.com/msngoal.html

An organization of educators, scientists, mathematicians, parents, and community leaders, the Math/Science Network aims to promote the continuing advancement of all people in mathematics and science education, with an emphasis on women and girls. Specifically, it seeks to increase the participation, retention, and advancement of women and girls in mathematics, science, and technology education and careers.

Mathematical Sciences Education Board (MSEB)
National Research Council
2101 Constitution Avenue, NW (HA 450)
Washington, DC 20418
Phone: 202–334–3294
Fax: 202–334–1453
E-mail: mseb@nas.edu
Web: http://www4.nationalacademies.org/csmee/mseb.nsf

MSEB, located within the National Research Council's Center for Science, Mathematics, and Engineering Education, seeks to provide national leadership and guidance for policies, programs, and practices supporting the improvement of mathematics education at all levels and for all members of society.

National Association for Gifted Children (NAGC)
1707 L Street, NW, Suite 550
Washington, DC 20036
Phone: 202–785–4268
Fax: 202–785–4248
E-mail: nagc@nagc.org
Web: http://www.nagc.org

NAGC is an organization of parents, educators, other professionals, and community leaders who unite to address the unique needs of children and youth who have demonstrated gifts and talents or who may be able to develop their talent potential with appropriate educational experiences.

National Council of Teachers of Mathematics (NCTM)
1906 Association Drive
Reston, VA 20191–1593
Phone: 703–620–9840
Fax: 703–476–2970
E-mail: infocentral@nctm.org
Web: http://www.nctm.org

NCTM is dedicated to improving mathematics education at all levels, meeting the needs of mathematics educators, and providing leadership in the improvement of mathematics teaching and learning. Serving as a major communications center for the mathematics education community, NCTM provides information on curriculum trends, equity issues, instructional aids, professional development, technology, and careers in mathematics.

National Parent Teacher Association (PTA)
330 North Wabash Avenue, Suite 2100
Chicago, IL 60611–3690
Toll Free: 800–307–4782
Phone: 312–670–6782
Fax: 312–670–6783
E-mail: info@pta.org
Web: http://www.pta.org

PTA advocates for children and families in schools, in the community, and before government agencies and other organizations that make decisions affecting children. PTA encourages parent and public involvement in the public schools and assists parents in developing the skills necessary to raise and protect their children.

National Science Foundation (NSF)
4201 Wilson Boulevard
Arlington, VA 22230
Phone: 703–306–1234
Web: http://www.nsf.gov

NSF promotes science and engineering through programs that invest more than $3.3 billion per year in almost 20,000 related research and education projects. NSF initiates and supports grants and contracts, awards graduate fellowships in science and engineering, fosters the exchange of information between U.S. scientists and those in other countries, and engages in a number of other activities in support of its mission.

National Science Teachers Association (NSTA)
1840 Wilson Boulevard
Arlington VA 22201–3000
Phone: 703–243–7100
Fax: 703–243–7177
E-mail: publicinfo@nsta.org
Web: http://www.nsta.org

NSTA serves as an advocate for science educators by keeping its members and the public informed of national issues and trends in science education. NSTA offers professional certification for science teachers in eight teaching-level and discipline-area categories.

Quality Education for Minorities (QEM) Network
1818 N Street, NW, Suite 350
Washington, DC 20036
Phone: 202–659–1818
Fax: 202–659–5408
E-mail: qemnetwork@qem.org
Web: http://qemnetwork.qem.org

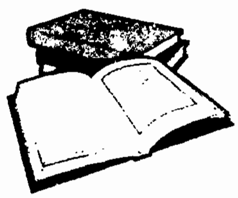
QEM serves as a national information and communications network that collects and disseminates information on issues, policies, programs, and resources related to the education of minorities. The network also disseminates information on exemplary or promising education strategies and research findings relevant to the education of minorities and evaluates educational programs and projects.

Science Service
1719 N Street, NW
Washington, DC 20036
Phone: 202–785–2255
Fax: 202–785–1243
E-mail: webmaster@sciserv.org
Web: http://www.sciserv.org

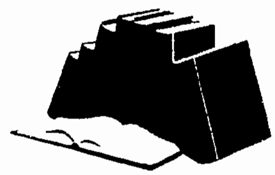
Science Service encourages students, parents, teachers, and communities to explore the vast world of science. Through publications and programs, science fairs and scholarship competitions, Science Service helps young people utilize and strengthen their knowledge in science, math, and engineering.

Society for Advancement of Chicanos and Native Americans in Science (SACNAS)
1156 High Street
Santa Cruz, CA 95064
Phone: 408–459–4272
Fax: 408–459–3156
E-mail: sacnas@cats.ucsc.edu
Web: http://www.sacnas.org

SACNAS encourages Chicano, Latino, and Native American students to pursue graduate education and the advanced degrees necessary for careers in science research and teaching. Its membership includes faculty and scientists from universities, corporations, and federal agencies who are dedicated to increasing the number of Chicano, Latino, and Native American students entering science-related professions.



Books



Niqui Beckrum

75 Easy Physics Demonstrations. T. Kardos, 1996, 110 pp.

This book is a collection of classroom demonstrations in physics that present basic scientific ideas on a concrete level. Topics covered include physical change and properties of matter; energy waves and energy forms; absorption of heat; radiant energy; vacuum bottles; kinetic molecular theory; states of matter; pressure of air; work from air pressure; properties of light; pinhole cameras; angles of incidence and reflection; mirror images; laws of refraction; motion picture effect; electromagnetic spectrum; frequency, wavelength, and amplitude; the light spectrum and color of objects; laser light; lenses; potential energy; speed, velocity, and friction; acceleration; Bernoulli's principle; Newton's third law of motion; and magnets and poles. $9.95. J. Weston Walch, Publisher, P.O. Box 658, Portland, ME 04104–0658; 1–800–341–6094.

474 Science Activities for Young Children. M. D. Green, 1996, 458 pp.

This book uses a child-initiated approach to help children have fun while exploring the world of science. Activities are divided into 23 units. Each unit begins with an Attention-Getter, which stimulates children's interest and creates excitement about the discoveries they will be making. Activities in this book range across the curriculum and include science, math, music, movement, language arts, multicultural diversity, dramatic play, social studies, and motor and cognitive development. $53.95. Delmar Publishers, 3 Columbia Circle, Albany, NY 12212; 1–800–865–5840.

Active Learning with Hands-On Resources. T. Crow, editor, 1996, 30 pp.

This document is the fourth issue in a series of print catalogs that provide educators with information about curriculum resources for K–12 science and math education. This issue features materials that encourage active learning through the use of hands-on materials. Includes information about a cross-section of materials in different media or formats and at various grade levels, along with ordering and price information. Free. Eisenhower National Clearinghouse, The Ohio State University, 1929 Kenny Road, Columbus, OH 43210; 1–800–621–5785.

Activities for Science: Cooperative Learning Lessons (Challenging). G. Jasmine and J. Jasmine, 1996, 144 pp.

This book helps advanced elementary students learn science skills through cooperative learning activities based on the earth sciences and natural disasters. The first section explains how to make cooperative learning a part of the curriculum and includes activities, instructions, guidelines for setting up groups, ideas for an activity center, and suggestions for assessment and portfolios. This book also provides a wide range of cooperative activities that develop skills in observing, making and reading scientific instruments, doing research, recording information, constructing charts and graphs, and presenting information. $12.95. Teacher Created Materials, Inc., P.O. Box 1040, Huntington Beach, CA 92647; 1–800–662–4321.

Niqui Beckrum is the Database Coordinator at the ERIC Clearinghouse for Science, Mathematics, and Environmental Education at The Ohio State University in Columbus, Ohio. She also serves as Acquisitions Coordinator for the clearinghouse.

Ben Franklin Book of Easy and Incredible Experiments, Activities, Projects, and Science Fun: A Franklin Institute Science Museum Book. L. J. Rudy, editor, 1995, 131 pp.

Benjamin Franklin was the first great American scientist. This book contains activities organized into six subjects that Benjamin Franklin investigated. Subjects include observation and experimentation, meteorology, electricity, sound and music, paper and printing, and lenses and vision. At the end of each chapter is a list of further resources and ideas. A timeline of the life of Benjamin Franklin is also presented. $12.95. John Wiley and Sons, Inc., Department 713, 1 Wiley Drive, Somerset, NJ 08875–1272; 1-800-225-5945.

Breaking Away From the Math Book II: More Creative Projects for Grade K–8. P. Baggett and A. Ehrenfeucht, 1998, 272 pp.

While calculators are more readily available in classrooms today than they were a few years ago, the recommendation to use them is rarely followed in elementary grades. One reason is the lack of appropriate classroom materials. This book provides tested lessons in which calculators act as tools to help solve math problems. Contents include measuring, money, science, counting and numbers, puzzles and games, and geometric concepts and constructions. $34. Technomic Publishing Co., Inc., 851 New Holland Avenue, Box 3535, Lancaster, PA 17604; 1-800-233-9936.

Energy: Simple Experiments for Young Scientists. L. White, 1995, 48 pp.

This book contains simple experiments through which students can learn about the properties of energy. Topics include energy and work, fossil fuels, solar energy, kinetic energy, potential energy, mechanical energy, heat energy, sound energy, electric energy, and atomic energy. $6.95. Millbrook Press, Inc., 2 Old New Milford Road, Brookfield, CT 06804; 203-740-2220.

Engaging Families in Mathematics and Science Education: It's Just Good Teaching. J. Stepanek, 1998, 41 pp.

This booklet offers teachers a variety of ideas and resources to strengthen partnerships with parents. Reasons and challenges for involving families are discussed. Various ways of doing activities and homework with children are offered. Contains 16 references. Free. Northwest Regional Educational Laboratory, 101 SW Main Street, Suite 500, Portland, OR 97204–3297; 503–275–9500.

Equity in the Classroom: Mathematics and Science Materials and Resources for Elementary Teachers. T. Crow, editor, 1994, 26 pp.

This document is the fourth issue in a series of print catalogs that provide educators with information about curriculum resources for K–12 math and science education. This issue offers a sampling of useful teaching materials and other resources that promote equity in math and science education. Each entry contains the resource's title, author, publication date, publisher, grade level, target audience, material type, language, subjects, abstract, evaluation, and ordering information. Free. Eisenhower National Clearinghouse, The Ohio State University, 1929 Kenny Road, Columbus, OH 43210; 1-800-621-5785.

Every Child a Scientist: Achieving Scientific Literacy for All. Center for Science, Mathematics, and Engineering Education Staff, 1998, 32 pp.

In a rapidly changing, increasingly technological world, all students need to understand science and technology. This booklet helps parents and other adults who want to take an active role in improving the science program in their schools. The authors outline how the national science standards can help improve the quality of science education and suggest some ways to become a partner in improving science teaching and learning in schools. $10. National Academy Press, 2101 Constitution Avenue, NW, Lock Box 285, Washington, DC 20055; 1-888-624-8373.

Everyday Science: Fun and Easy Projects for Making Practical Things. S. Levine and L. Johnstone, 1995, 101 pp.

This book contains 25 experiments that help students understand how science is used every day. Each experiment includes a list of materials, a series of easy-to-follow steps, an explanation of the scientific principle demonstrated, and additional scientific facts and information. Experiments are organized into the following categories: light and optics, heat, earth science, chemistry, and electricity and magnetism. Also includes a glossary of terms and a reader-reply form for suggesting experiments. $9.95. John Wiley and Sons, Inc., Department 713, 1 Wiley Drive, Somerset, NJ 08875–1272; 1-800-225-5945.

Family Involvement in Education. J. L. Harris, editor, 1998, 61 pp.

This document is one in a series of print catalogs that provide educators with information about curriculum resources for K–12 science and math education. A one-page description of each resource includes the contents; subjects addressed; grade level; publication date; and ordering information including price, authors, and related resources. Free. Eisenhower National Clearinghouse, The Ohio State University, 1929 Kenny Road, Columbus, OH 43210–1079; 1-800-621-5785.

Girls Can Succeed in Science! Antidotes for Science Phobia in Boys and Girls. L. S. Samuels, 1998, 240 pp.

This book provides teachers with effective strategies to help all students, especially girls, overcome their apprehensions about science. Class and laboratory activities, tailored for life science, biology, and advanced biology, demonstrate how to implement the new philosophy of science education to create independent and self-assured problem solvers. $29.95. Corwin Press, Inc., 2455 Teller Road, Thousand Oaks, CA 91320–2218; 805–499–9774.

High School Mathematics at Work: Essays and Examples for the Education of All Students. Mathematical Sciences Education Board, 1998, 177 pp.

This book illuminates the interplay between vocational mathematics and precollege mathematics, subjects traditionally separated in high schools. A collection of essays by mathematicians, educators, and other experts is enhanced with real-world tasks that suggest ways to strengthen high school math education. $27.95. National Academy Press, 2101 Constitution Avenue, NW, Lock Box 285, Washington, DC 20418; 1–888–624–8373.

Insights & Outcomes: Assessments for Great Explorations in Math and Science. J. Barber, 1995, 273 pp.

This handbook contains ready-made assessments for teachers to integrate into their presentation of activity-based mathematics and science units. An overview of assessment issues as well as ideas about how to use this book are provided. This handbook also includes descriptions of 13 major assessment strategies, actual student work, analysis of the insights gained from case studies, and a list of other opportunities in the Great Explorations in Math and Science (GEMS) series for using each strategy. $31.50. University of California, Attention LHS Store, Lawrence Hall of Science #5200, Berkeley, CA 94720–5200; 510–642–1016.

Janice VanCleave's 201 Awesome, Magical, Bizarre, and Incredible Experiments. J. VanCleave, 1994, 118 pp.

This book is a collection of 201 science experiments designed to be fun and to show that science is more than a list of facts—it is a way of solving problems and discovering why things happen the way they do. Activities cover five different fields of science: astronomy, biology, chemistry, earth science, and physics. Each experiment contains a description of its purpose, necessary materials, procedure, and results. An explanation of the results is also included. $12.95. John Wiley and Sons, Inc., Department 713, 1 Wiley Drive, Somerset, NJ 08875–1272; 1–800–225–5945.

Math Ties: Problem Solving, Logic Teasers, and Math Puzzles All "Tied" to the Math Curriculum. Book A1. T. Santi, 1998, 84 pp.

This book describes a classroom-tested approach to help teach problem solving to students in grades 4–6, regardless of ability. Information about problem solving in general is provided, and mathematical problems in logic, numbers, fractions, decimals, geometry, ratio, proportion, percent, probability, sets, and pre-algebra are featured. Includes answers to all problems. $14.95. Critical Thinking Books and Software, P.O. Box 448, Pacific Grove, CA 93950–0448; 1–800–458–4849.

Math Ties: Problem Solving, Logic Teasers, and Math Puzzles All "Tied" to the Math Curriculum. Book B1. T. Santi, 1998, 79 pp.

This book describes a classroom-tested approach to help teach problem solving to students in grades 6–8, regardless of ability. Information about problem solving in general is provided, and mathematical problems in logic, exponents, algebra, geometry, number theory, set theory, ratio, proportion, percent, probability, and topology are featured. Includes answers to all problems. $14.95. Critical Thinking Books and Software, P.O. Box 448, Pacific Grove, CA 93950–0448; 1–800–458–4849.

Mission Mathematics: Linking Aerospace and the NCTM Standards. Grades 5–8. V. F. O'Connor and M. C. Hynes, 1997, 136 pp.

A collaborative project of the National Aeronautics and Space Administration (NASA) and the National Council of Teachers of Mathematics (NCTM), this book provides classroom-tested lessons that effectively model the vision of the NCTM standards and focuses on the exciting problems that arise out of NASA's activities. The lessons in this document are couched in an aerospace setting that motivates students to become involved with and connected to mathematical concepts, skills, and applications. Many lessons are linked to form indepth investigations that can be used flexibly to replace parts of the present school curriculum. $19.95. NCTM, 1906 Association Drive, Reston, VA 20191–1593; 1–800–235–7566.

Resources for Computation: The Math Rescue Series. Book 1, Grades K–6. L. Bradsby and S. Bradsby, 1998, 622 pp.

This book, the first in the Math Rescue Series, provides general education and special education teachers with alternative, individualized methods of teaching math computation skills. Activities are designed to appeal to auditory, visual, and kinesthetic learning styles. The six math topics addressed are modeling of addition and subtraction, basic facts for addition and subtraction, addition and subtraction with regrouping, modeling of multiplication and division, basic facts of multiplication and division, and algorithms for multiplication and division. Activities are identified by appropriate grade level and include assessments. $75. Sopris West, 4093 Specialty Place, Longmont, CO 80504; 1–800–547–6747.

Science for All Children: A Guide to Improving Elementary Science Education in Your School District. Center for Science, Mathematics, and Engineering Education, 1997, 225 pp.

This book presents the National Science Resources Center's (NSRC's) strategic planning model for bringing about districtwide elementary science reform in accordance with the national science standards. The NSRC model views the elementary science program as a cohesive system that includes a research-based, inquiry-centered science curriculum; professional development; materials support; appropriate assessment strategies; and community and administrative support. The system can be modified to meet the needs of large or small, urban or rural school districts.

Includes exemplary elementary science curriculum materials and a list of professional associations and government agencies involved in science education reform. $17.95. National Academy Press, 2101 Constitution Avenue, NW, Lock Box 285, Washington, DC 20418; 1-888-624-8373.

Teaching the Majority: Breaking the Gender Barrier in Science, Mathematics, and Engineering.
S. V. Rosser, editor, 1995, 272 pp.

This book presents pioneering work by scientists, mathematicians, and engineers on the topic of attracting women to, and retaining them in, these fields. Each chapter in this volume is written by a teacher who has transformed his or her course to appeal successfully to women students, in particular, while retaining its appeal for male students. Transformed curricula, successful teaching techniques, and expanded problem sets and laboratory exercises are presented to assist teachers in breaking the gender barrier in science and technology. $22.95. Teachers College Press, P.O. Box 20, Williston, VT 05495-0020; 1-800-575-6566.

That Can't Be Right! Using Counterintuitive Math Problems.
N. J. Maylone, 1999, 131 pp.

This book provides middle school mathematics teachers with ideas for enlivening instruction to help students acquire a sense of numbers. Features guided classroom discussions and writing opportunities centered on the theme of problem solving. Problems, puzzles, investigations, and demonstrations are also presented. $34.95. Technomic Publishing Company, Inc., 851 New Holland Avenue, Box 3535, Lancaster, PA 17604; 1-800-233-9936.

Using the Learning Cycle To Teach Physical Science: A Hands-On Approach for the Middle Grades.
P. Beisenherz and M. Dantonio, 1996, 145 pp.

The Learning Cycle Strategy, which includes an exploration phase, introduction phase, and application phase, enables students to construct discrete science concepts themselves. This book focuses on the use of the Learning Cycle to teach physical sciences. Each Learning Cycle centers on a single concept or idea and contains a num of sequenced, hands-on activities. opportunity for teachers to develop their own Learning Cycle sequence is provided. $26.50. Heinemann, 361 Hanover Street, Portsmouth, N 03801-3912; 1-800-793-2154.

The Wonderful World of Mathema
D. Thiessen, M. Matthias, and J. Sn 1998, 355 pp.

Children's literature in mathemat a valuable tool for developing po attitudes toward mathematics as as for exploring mathematics. Th book provides annotated bibliogı phies of children's literature boo that emphasize mathematics edu tion. Each review describes the b content and accuracy, its illustrat and their appropriateness, and th author's writing style, and indica whether activities for the reader a included. $17.95. National Counc of Teachers of Mathematics, 1906 Association Drive, Reston, VA 20191-1593; 1-800-235-7566.

Journals and Newsletters

Linda A. Milbourne and Susan Eshbaugh

The American Biology Teacher
National Association of
Biology Teachers
11250 Roger Bacon Drive, #19
Reston, VA 20190–5202
Toll Free: 800–406–0775
Phone: 703–471–1134
Fax: 703–435–5582
E-mail: nabter@aol.com
Web: http://www.nabt.org

This journal provides lessons, activities, and ideas related to biology teaching and presents developments in the field. Published nine times per year. Cost of subscription: $75 per year for nonmembers in the United States, $90 international.

Association for Women in Science Magazine
Association for Women in Science (AWIS)
1200 New York Avenue, NW, Suite 650
Washington, DC 20005
Toll Free: 800–886–AWIS (2947)
Fax: 202–326–8960
E-mail: awis@awis.org
Web: http://www.awis.org

Each issue of this journal for AWIS members has a theme related to women in science, such as Dual Careers, Education, or Computer Science. It also contains news, jobs, and more. Published quarterly. Cost of membership: Dues are dependent upon income.

Hands On!
Technical and Educational Research Center (TERC)
2067 Massachusetts Avenue
Cambridge, MA 02140
Phone: 617–547–0430
Fax: 617–349–3535
E-mail: info@terc.edu
Web: http://www.terc.edu

Published semiannually, this magazine reports on TERC's work in curriculum and teacher development, research on teaching and learning in math and science, and progress in developing technology tools. Cost of subscription: Free.

Journal of Research in Science Teaching
National Association for Research in Science Teaching (NARST)
Dr. Arthur L. White
NARST Executive Secretary
The Ohio State University
1929 Kenny Road, Room 200E
Columbus, OH 43210
Phone: 614–292–3339
Fax: 614–292–1595
Web: http://science.coe.uwf.edu/NARST/NARST.html

This journal for NARST members contains reports for science education researchers and practitioners on issues of science teaching and learning and science education policy. Published 10 times per year. Cost of membership: $80 per year in the United States.

Journal of Science Education and Technology
Plenum Publishing Corporation
233 Spring Street
New York, NY 10013
Phone: 212–620–8000
Fax: 212–807–1047
E-mail: info@plenum.com
Web: http://www.plenum.com

This journal is an interdisciplinary forum for original, peer-reviewed articles about improving or enhancing science education at all levels worldwide. Published quarterly. Cost of subscription: $62 per year in the United States; $73 international.

Journal of Women and Minorities in Science and Engineering
Virginia Polytechnic Institute and State University
Center for Interdisciplinary Studies, Lane Hall
Blacksburg, VA 24061–0227
Phone: 540–231–6296
Fax: 540–231–7013
E-mail: jrlwmse@vt.edu

This journal publishes original, peer-reviewed papers on innovative ideas, studies, and programs related to the recruitment and education of underrepresented groups in science and engineering. Published quarterly. Cost of subscription: $47.50 per year for individuals, $95 for institutions.

Mathematics Magazine
Mathematical Association of America
1529 18th Street, NW
Washington, DC 20036
Toll Free: 800–741–9415
Phone: 202–387–5200
Fax: 202–265–2384
Web: http://www.maa.org

This magazine provides lively and appealing mathematical exposition. Published bimonthly except July/August. Cost of subscription: $16 per year for members; $68 per year for nonmembers and libraries.

Mathematics Teacher* and *NCTM News Bulletin
National Council of Teachers of Mathematics (NCTM)
1906 Association Drive
Reston, VA 20191–1593
Toll Free: 800–235–7566
Fax: 703–476–2970
E-mail: nctm@nctm.org
Web: http://www.nctm.org

These two publications are available to members of NCTM. *Mathematics Teacher* focuses on mathematics instruction in secondary schools, two-year colleges, and teacher education

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colleges. Highlights include practical ideas for more effective teaching and motivation of students, book reviews, technology tips, and research studies. Published monthly, September through May. *NCTM News Bulletin* focuses on events and issues affecting math teachers. Published 10 times per year. Cost of membership: $62 per year in the United States, $70 international: $75 per year for institutions.

Mathematics Teaching in the Middle School
National Council of Teachers of Mathematics (NCTM)
1906 Association Drive
Reston, VA 20191-1593
Toll Free: 800-235-7566
Fax: 703-476-2970
E-mail: nctm@nctm.org
Web: http://www.nctm.org

This journal for NCTM members focuses on investigations that help students develop the conceptual basis for greater mathematical abstractions. Published monthly, September through May. Cost of membership: $62 per year in the United States, $70 international.

Quantum
National Science Teachers Association (NSTA)
1840 Wilson Boulevard
Arlington, VA 22201-3000
Phone: 703-243-7100
Fax: 703-243-7177
E-mail: quantum@nsta.org
Web: http://www.nsta.org

This bimonthly magazine for teachers and advanced students promotes excellence and innovation in science teaching and learning. Cost of subscription: $25 per year for individuals, $18 for students, $45 for institutions.

School Science and Mathematics
Oregon State University
Science and Mathematics Education
237 Weniger Hall
Corvallis, OR 97331-6508
Phone: 541-737-2545
Fax: 541-737-1817
E-mail: ssm@ucs.orst.edu
Web: http://osu.orst.edu/pubs/ssm

This journal focuses on the improvement of K-12 science and math instruction and integration. Published monthly, October through May. Cost of subscription: $35 for individuals, $58 for institutions.

Science and Children
National Science Teachers Association (NSTA)
1840 Wilson Boulevard
Arlington, VA 22201-3000
Phone: 703-243-7100
Fax: 703-243-7177
E-mail: publicinfo@nsta.org
Web: http://www.nsta.org

This journal for NSTA members presents peer-reviewed articles that describe activities and instructional approaches appropriate for preschool, elementary school, and middle school students. Published eight times during the school year. Cost of membership: $62 per year for individuals, $72 for institutions.

Science News
Science Service
1719 N Street, NW
Washington, DC 20036
Phone: 202-785-2255
Fax: 202-785-1243
E-mail: scinews@sciserv.org
Web: http://www.sciserv.org

This magazine provides brief science news summaries. Published weekly on Saturday, except for the last week in December. Cost of subscription: $49.50 for 1 year, $88 for 2 years.

Science Scope
National Science Teachers Association (NSTA)
1840 Wilson Boulevard
Arlington, VA 22201-3000
Phone: 703-243-7100
Fax: 703-243-7177
E-mail: sciencescope@nsta.org
Web: http://www.nsta.org/

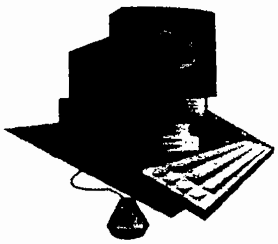
This journal for NSTA members provides ideas for creative, well-designed, and safe science activities designed to meet the unique needs of middle school students. Published eight times during the school year. Cost of membership: $62 per year for individuals, $72 for institutions.

The Science Teacher
National Science Teachers Association (NSTA)
1840 Wilson Boulevard
Arlington, VA 22201-3000
Phone: 703-243-7100
Fax: 703-243-7177
E-mail: publicinfo@nsta.org
Web: http://www.nsta.org

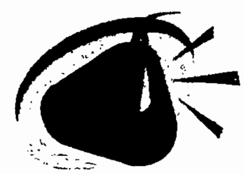
This journal for NSTA members focuses on the latest trends in teaching strategies, technology, and research related to secondary school science education. Published monthly, September through May. Cost of membership: $62 per year for individuals, $72 for institutions.

Teaching Children Mathematics
National Council of Teachers of Mathematics (NCTM)
1906 Association Drive
Reston, VA 20191-1593
Toll Free: 800-235-7566
Fax: 703-476-2970
E-mail: nctm@nctm.org
Web: http://www.nctm.org

This journal for NCTM members is a forum for the exchange of ideas, activities, research findings, and teaching strategies for pre-K-6 mathematics. Published monthly, September through May. Cost of membership: $62 per year in the United States, $70 international.



Internet Resources



David L. Haury and Linda A. Milbourne

Teachers are continually seeking new ways to create active learning environments that capture children's attention, engage their minds, and nurture their interests. The Internet is a powerful tool for engaging minds: school groups and individual students can become involved in authentic, collaborative projects; children can pursue individual interests as never before, allowing them to take responsibility for managing their own projects; and everyone benefits from greater opportunities to find timely information and communicate with peers and experts worldwide. In essence, the Internet provides kids with a way to break through school walls so they can engage people and access resources around the world.

Parents, too, are seeking ways to enhance, as well as play a more active part in, their children's education. The Internet contains many resources designed to help parents assist their children with homework, learn more about various topics of study with their children, and find engaging educational activities that effectively extend their children's learning environment from the school to the home.

Teachers and parents can use the following Internet resources as a starting point for further exploration of the many math- and science-related Web sites. The resources are grouped to reflect some of the roles that the Internet plays in science and math education today.

Activities

Math in Daily Life
http://www.learner.org/exhibits/dailymath

Math in Daily Life offers a number of exhibits that connect math concepts with everyday situations and tasks. The site also includes an extensive list of math-related print and electronic resources.

Odyssey of the Mind
http://www.odyssey.org

Odyssey of the Mind is a worldwide program that promotes creative, team-based problem solving for K–12 kids and college students. The program helps students learn divergent-thinking and problem-solving skills while they participate in a series of challenging and motivating activities.

Whelmers
http://www.mcrel.org/whelmers

Instead of overwhelming students with science, teachers can "whelm" them with whelmers—classroom activities designed to capture the attention of even the most indifferent students. Whelmers are the perfect complement to a comprehensive science program.

Career Information

Mathematical Sciences Career Information
http://www.ams.org/careers

This Web site includes a bulletin board that features descriptions of nonacademic math careers through profiles of mathematicians working in industry and government. Visitors can query the currently featured mathematicians or search the archive of profiles by key word, employment sector, or level of education.

Real Science!
http://www.realscience.org

Associated with San Jose's public television station KTEH, Real Science! provides visitors with information on many science-related careers, including profiles of people working in the field and links to related resources.

Collaborative Projects

The GLOBE Program
http://www.globe.gov

Global Learning and Observations to Benefit the Environment (GLOBE) is a worldwide network of students, teachers, and scientists working together to study and understand the global environment. GLOBE students make environmental observations at or near their schools and report their data using the Internet. Scientists use GLOBE data in their research and provide feedback to the students to enrich their science education.

Houghton Mifflin Project Center
http://www.eduplace.com/projects/index.html

Designed for teachers, the Houghton Mifflin Project Center Web site lists

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collaborative classroom projects in a variety of categories, including math and science. Teachers can also post their own online projects on this site, which is updated weekly.

The Mars Millennium Project
http://www.mars2030.net

The Mars Millennium Project, an official White House Millennium Council Youth Initiative, challenges K–12 students across the country to design a community for the planet Mars. The project is intended to get kids thinking about what makes their own community work as they create a living environment from the ground up.

Family Learning Experiences

Helping Your Child Learn Math
http://www.ed.gov/pubs/parents/Math/index.html

This online booklet presents basic math concepts through a number of everyday activities that parents and children can do together. An extensive list of print and electronic resources is also included.

Helping Your Child Learn Science
http://www.ed.gov/pubs/parents/Science/index.html

This online brochure describes a variety of everyday science-related activities that parents can do with their children at home and in the community. An extensive list of print resources is also included.

Homework Help and Tutoring

The ERIC Clearinghouse for Science, Mathematics, and Environmental Education (ERIC/CSMEE) Homework Companion
http://www.ericse.org/homework.html

The Homework Companion section of the ERIC/CSMEE Web site contains links to online resources related to math and science homework, parent guidelines for helping children with homework, and related resources.

Math for Morons Like Us
http://library.advanced.org/20991/home.html

Designed for students, Math for Morons Like Us presents tutorials, sample problems, and quizzes that cover a range of math topics from pre-algebra to calculus. The site also includes links to other math resources and a message board where kids can ask questions and post answers.

Online Learning Centers

A+ Math
http://www.aplusmath.com

Designed to help students improve their math skills interactively, the A+ Math Web site features problems, games, and a bulletin board where students can post questions and answers.

The Learning Studio @ The Exploratorium
http://www.exploratorium.edu/learning_studio

The Exploratorium's Learning Studio Web site provides visitors with reviews of Web sites in 23 topic areas, access to online exhibits, many science-related activities for students, and more.

The Math Forum
http://forum.swarthmore.edu

The Math Forum is an online community of teachers, students, researchers, parents, educators, and citizens at all levels who have an interest in math and math education. The site features online math resources by subject and grade level, information on new methods and issues in math education, and timely discussions of math education and associated source materials.

Online Magazines

Science News Online
http://www.sciencenews.org

This Web site features selected full-text articles from current and past issues of the print version of *Science News Online*, which covers all aspects of science and remains the only weekly newsmagazine of science published in the United States.

Scientific American Explorations
http://www.explorations.org

This Web site features selected stories from Scientific American's new quarterly magazine, *Scientific American Explorations*, which is designed to make learning about science and technology fun for the entire family. Each issue includes museum and exhibit updates, family vacation planners, inhome experiments for kids, and reports about what's new on the Web for families.

Question-Answering Services

Ask Dr. Math
http://forum.swarthmore.edu/dr.math

Ask Dr. Math is a question-answering service for K–12 math students and their teachers. The site includes a list of frequently asked questions, a searchable archive of previously asked questions, and many links to other math-related Web sites.

KidsConnect
http://www.ala.org/ICONN/AskKC.html

KidsConnect is an online question-answering service for kids in grades K–12. The site is sponsored by the American Association of School Librarians—a division of the American Library Association—with support from Microsoft.

The Mad Scientist Network
http://www.madsci.org

The Mad Scientist Network provides answers to science-related questions and links to related sites. Visitors can search the entire network, including its links, archives, and library.

Scientific American: Ask the Experts
http://www.sciam.com/askexpert/index.html

Ask the Experts features answers to readers' questions about astronomy, biology, chemistry, computers, math, physics, and other topics related to science and technology.

Virtual Field Trips, Museums, and Nature Centers

Science Adventures
http://www.scienceadventures.org

Science Adventures makes it easy to find informal science education centers throughout the United States that offer students, teachers, and parents the opportunity to participate in science education experiences.

Smithsonian Museums
http://www.si.edu/organiza

This Web site provides visitors with links to the Smithsonian network of museums, events, activities, resources, tours, and more.

Virtual Tours
http://www.dreamscape.com/frankvad/museums.html

The Virtual Tours Web site contains links to more than 300 museums, exhibits, and points of special interest that offer online multimedia guided tours.

Virtual Libraries and Reference Sources

700+ Great Sites for Children: Science and Technology
http://www.ala.org/parentspage/greatsites/sciencew.html

The largest juried collection of children's Web sites on the Internet, this site includes links to online resources related to general science, chemistry and physics, biology, mathematics, computers and technology, and science experiments. The sites are recommended for children in grades pre-K–9 and their parents. The list of sites was compiled by the Children and Technology Committee of the Association for Library Service to Children, a division of the American Library Association.

The Virtual Library
http://www.vlib.org

Run by a confederation of topic-area experts, the Virtual Library is recognized as one of the highest quality guides to specific sections of the Internet. The science category provides links to sites related to biology, chemistry, earth science, physics, science fairs, and more. The science category also includes a link to math-related topics.

Note: The information presented in this article was adapted from two books—*The Connected Family's Companion to Science Education* and *The Connected Family's Companion to Math Education*—that are being published by the ERIC Clearinghouse for Science, Mathematics, and Environmental Education.

Searching the ERIC Database on Science and Mathematics Topics

Niqui Beckrum

The ERIC database is the world's largest education database. It is an excellent resource for anyone seeking information on teaching and learning in science and mathematics. ERIC features abstracts of nearly 1 million research reports, curriculum and teaching guides, conference papers, and journal articles dating from 1966 to the present. You can search the ERIC database online at http://www.accesseric.org or through print indexes and CD-ROMs at hundreds of libraries, colleges and universities, and state and local education offices.

The result of an ERIC search is an annotated bibliography of document and journal literature on the topic that you have specified. You can then review the bibliography to determine which listings are most helpful to you and select those citations to get an abstract of each document. To get the full text of a journal article (shown as EJ followed by six digits), you can visit a university library or a large public library, or you can contact a journal article reprint service, such as The UnCover Company (1-800-787-7979) or the Institute for Scientific Information (1-800-336-4474).

To get the full text of a document (shown as ED followed by six digits), you can visit one of the more than 1,000 libraries around the world that maintain an ERIC microfiche collection. There you can view or print the document. You can also order a print copy from the ERIC Document Reproduction Service (1-800-443-3742) or from the document's distributor. Many documents published after 1992 may be ordered and delivered via the Internet at http://edrs.com.

Niqui Beckrum is the Database Coordinator at the ERIC Clearinghouse for Science, Mathematics, and Environmental Education at The Ohio State University in Columbus, Ohio. She also serves as Acquisitions Coordinator for the clearinghouse.

All entries in the ERIC database have been indexed with key words called *descriptors*. These words describe the most important concepts contained in a journal article or document. Although it is certainly possible to search the database using common words and phrases, your search will be far more effective if you use ERIC terminology.

When searching the database for information on science education, begin with the following descriptors:

- *Science Education*
- *Science Instruction*
- *Science Activities*
- *Sciences*

When searching the database for information on mathematics education, begin with the following descriptors:

- *Mathematics Education*
- *Mathematics Instruction*
- *Mathematics Achievement*
- *Mathematics*

Other commonly used descriptors that may also be useful when searching the ERIC database are listed in the box on this page.

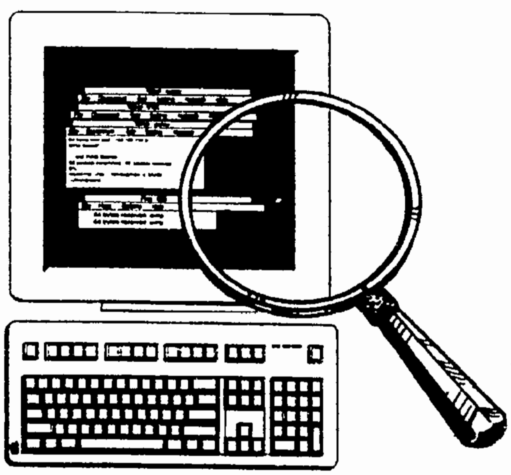
To perform an effective ERIC search, use the descriptor that is most specific to your topic. For example, if you are looking for information on teaching mathematics, use the descriptor *Mathematics Instruction* instead of the broader term *Teaching Methods*. If you are looking for documents on the specific subject of biology, use the descriptor *Biology* instead of the broader term *Sciences*.

If you require assistance in searching the ERIC database on a science or mathematics topic, call the ERIC Clearinghouse for Science, Mathematics, and Environmental Education at 1–800–276–0462. If you find yourself doing extensive searching, you may find the *Thesaurus of ERIC Descriptors* helpful. The *Thesaurus* is available from Oryx Press (1–800–279–6799) and at most places that offer access to the ERIC database. For general information about accessing the database or for a free copy of the brochure *All About ERIC*, call ACCESS ERIC at 1–800–LET–ERIC (538–3742).

Other Descriptors Commonly Used in Searching the ERIC Database

Science Terms:

College Science
Demonstrations (Science)
Elementary School Science
General Science
Science and Society
Science Careers
Science Clubs
Science Course Improvement Projects
Science Curriculum
Science Education History
Science Experiments
Science Process Skills
Science Programs
Science Projects
Science Teachers
Scientific Literacy
Scientific Methodology
Secondary School Science



Mathematics Terms:

College Mathematics
Elementary School Mathematics
General Mathematics
Mathematical Applications
Mathematical Concepts
Mathematical Models
Mathematics Curriculum
Mathematics Skills
Mathematics Teachers
Numbers
Numeracy
Secondary School Mathematics
Word Problems (Mathematics)

Putting It All Together: An Action Plan

Linda A. Milbourne, David L. Haury, and Susan Eshbaugh

The articles in this publication highlight the need for all students to graduate from high school with sufficient mastery of science and mathematics to function effectively in today's technologically oriented society or to pursue further study in these fields. The following action plan summarizes the steps that parents, teachers, school administrators, and community members can take toward achieving this goal.

Parents

- Encourage curiosity, questioning, exploration, and investigation; these are the paths to learning in science and math.
- Have high expectations and a positive attitude. Expect your child to do well in math and science.
- Help your children develop an interest in math and science. Talk to them about math and science, and listen to what they say.
- Attend parent-teacher conferences to learn about your child's progress. Get extra support from the school if your child needs to improve in math and science.
- Maintain contact with teachers and guidance counselors; let them know that you are involved in your child's education.
- Find out what your child is doing in science and math class by checking and discussing homework.
- Be involved in course scheduling decisions. Make sure that your child takes four years of math and science in high school (see the box on page 71 for a list of recommended courses).
- Give your child a quiet place to do homework every night. Check over assignments, and offer appropriate assistance, as needed.
- Encourage your children to think about careers in math and science. Urge them to go to college or technical school.
- Visit science museums together, and participate in family math and science activities.
- If your child is having trouble with math or science, let the teacher and counselor know that he or she needs extra help.
- Become familiar with national science and math standards, and question how they are being used to

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David L. Haury is Director of the ERIC Clearinghouse for Science, Mathematics, and Environmental Education and Associate Professor of Mathematics, Science, and Technology Education at The Ohio State University in Columbus, Ohio.

Susan Eshbaugh is the User Services Coordinator at the ERIC Clearinghouse for Science, Mathematics, and Environmental Education at The Ohio State University in Columbus, Ohio.

Recommended Math and Science Course Work for High School Students

Most math- and science-related careers require a bachelor's degree from a college or university. Some require more advanced training. Because science and math courses build on prior knowledge, students can make a smoother transition to college if they complete the following courses in high school.

High school students can also take Advanced Placement (AP) and honors courses in math and science. Students who score high enough on the AP exams can obtain college credit or advanced placement in college.

Mathematics:

- Algebra I (preferably in eighth grade)
- Geometry
- Algebra II
- Trigonometry
- Pre-Calculus or Calculus

Science:

- Biology
- Earth Science
- Chemistry
- Physics

Resources

College Board Online (http://www.collegeboard.org/features/parentgd/html/academic.html)

College Entrance Examination Board. 1997. *Going Right On.* (Available online at http://www.collegeboard.com/pubaff/gronline/html/class.html)

guide teaching and learning in your child's school.

- Become familiar with the specific concepts and skills that students should be learning at each grade level in elementary school, and be ready to help them learn and practice.
- Join your child in using a computer and the Internet as learning tools for science and math: explore the many Web sites that bring an element of fun and excitement to learning science and math (see "Internet Resources" on page 66).
- Watch educational television programs with your child, such as *National Geographic, NOVA, Nature,* and *Bill Nye—the Science Guy.*
- Become familiar with the forms of assessment being used in science and math, and be alert to struggles that your child may be having with the forms of assessment being used. Let teachers know if you think your child is having a hard time demonstrating what he or she knows or is able to do.

Teachers

- Have high expectations for *all* students. Encourage them to take challenging math and science courses.
- Provide opportunities for hands-on and cooperative learning experiences. Allow children to explore, investigate, estimate, question, predict, and test their ideas about math and science.
- Emphasize inquiry, problem solving, and using information to make decisions.
- Try to individualize assignments to allow students to progress at their own rate so that all students will be challenged.
- When assessing students, use multiple sources of information. Consider alternatives to traditional assessment.
- Encourage the use of technology, including but not limited to calculators and computers, as tools for learning math and science.
- Look for opportunities to showcase women, minorities, and other underrepresented groups in scientific and technical fields as role models. Establish a mentor program.
- Show students how math and science relate to everyday life.
- Take advantage of professional development opportunities.
- Find local businesses where students can talk to owners and employees to learn how science and math are part of their workplaces.
- Parents are your instructional partners; keep them informed of the concepts and skills their children are learning. Provide feedback about how performance is being assessed and how parents can help.

School Administrators

- Require all students to take algebra in eighth or ninth grade.
- Be aware of how children in your school district are doing in relation to national standards and international benchmarks.
- Reexamine grouping practices, and consider ending traditional tracking. Support flexible grouping that encourages frequent collaboration by students of diverse ability, age, gender, socioeconomic status, and cultural background. Promote differentiated instruction to meet individual needs within all classrooms.
- Regularly review education research and implement the changes necessary for creating coherent, well-aligned science and math curricula, instruction, and assessment.
- Provide leadership in supporting equity and excellence through policy and staffing practices, curriculum

development, implementation of new standards and assessment practices, professional development, and participatory decision making.

- Communicate a renewed vision of math and science education that is consistent with a schoolwide view of engaged, active learning. Garner the support and involvement of parents and community leaders in pursuing this vision.

Community Members

- Serve as mentors or role models to students by providing support and encouraging all students to investigate various career opportunities. (See the box on this page for a list of math- and science-related careers.)
- Volunteer to work in the library, help with afterschool activities, or provide personal expertise by serving as career speakers, tutors, or teacher aides.
- Establish partnerships with local businesses ("adopt a class") or create "school-to-work" programs.
- Support family involvement in education by allowing employees to stay in touch with teachers and attend school programs.

Math- and Science-Related Careers

The following list is offered as a sampling of the many careers that require advanced training in science, mathematics, or both. To find out more about these and other careers, consult the *1998–99 Occupational Outlook Handbook* at your local library or online at http://stats.bls.gov/ocohome.htm. Readers can also obtain career information from many of the science and math resource organizations listed on pages 57–60.

Accounting
Anthropology
Architecture
Astronomy
Biology
Botany
Cartography
Chemistry
Computer Science
Dentistry
Dietetics
Drafting
Ecology
Economics
Education
Engineering
Entomology
Finance
Forestry
Genetics
Geography
Geology
Immunology
Information Systems Management
Management Science
Mathematics
Medical Technology
Medicine
Meteorology
Navigation
Oceanography
Operations Research
Optometry
Paleontology
Pharmacy
Physics
Seismology
Speech-Language Pathology
Statistics
Surveying
Veterinary Medicine
Zoology

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ERIC Directory

Educational Resources Information Center (ERIC)
National Library of Education
Office of Educational Research and Improvement (OERI)
U.S. Department of Education
Toll Free: (800) 424–1616
TTY/TDD: (800) 437–0833
Web: http://www.ed.gov

Clearinghouses

Adult, Career, and Vocational Education
Ohio State University
Toll Free: (800) 848–4815, ext. 2–8625
Phone: (614) 292–7069
TTY/TDD: (614) 688–8734
Web: http://ericacve.org

Assessment and Evaluation
University of Maryland, College Park
Toll Free: (800) GO4–ERIC (464–3742)
Phone: (301) 405–7449
Web: http://ericae.net

Community Colleges
University of California at Los Angeles
Toll Free: (800) 832–8256
Phone: (310) 825–3931
Web: http://www.gseis.ucla.edu/ERIC/eric.html

Counseling and Student Services
University of North Carolina at Greensboro
Toll Free: (800) 414–9769
Phone: (336) 334–4114
Web: http://www.uncg.edu/edu/ericcass

Disabilities and Gifted Education
Council for Exceptional Children
Toll Free: (800) 328–0272
Phone: (703) 264–9475
TTY/TDD: (800) 328–0272
Web: http://ericec.org

Educational Management
University of Oregon
Toll Free: (800) 438–8841
Phone: (541) 346–1684
Web: http://eric.uoregon.edu

Elementary and Early Childhood Education
University of Illinois at Urbana—Champaign
Toll Free: (800) 583–4135
Phone: (217) 333–1386
TTY/TDD: (800) 583–4135
Web: http://ericeece.org
National Parent Information Network Web: http://npin.org

Higher Education
George Washington University
Toll Free: (800) 773–ERIC (3742)
Phone: (202) 296–2597
Web: http://www.eriche.org

Information & Technology
Syracuse University
Toll Free: (800) 464–9107
Phone: (315) 443–3640
Web: http://ericir.syr.edu/ithome
AskERIC Web: http://www.askeric.org

Languages and Linguistics
Center for Applied Linguistics
Toll Free: (800) 276–9834
Phone: (202) 362–0700
Web: http://www.cal.org/ericcll

Reading, English, and Communication
Indiana University
Toll Free: (800) 759–4723
Phone: (812) 855–5847
Web: http://www.indiana.edu/~eric_rec

Rural Education and Small Schools
Appalachia Educational Laboratory
Toll Free: (800) 624–9120
Phone: (304) 347–0400
TTY/TDD: (304) 347–0448
Web: http://www.ael.org/eric

Science, Mathematics, and Environmental Education
Ohio State University
Toll Free: (800) 276–0462
Phone: (614) 292–6717
Web: http://www.ericse.org

Social Studies/Social Science Education
Indiana University
Toll Free: (800) 266–3815
Phone: (812) 855–3838
Web: http://www.indiana.edu/~ssdc/eric_chess.htm

Teaching and Teacher Education
American Association of Colleges for Teacher Education
Toll Free: (800) 822–9229
Phone: (202) 293–2450
Web: http://www.ericsp.org

Urban Education
Teachers College, Columbia University
Toll Free: (800) 601–4868
Phone: (212) 678–3433
Web: http://eric-web.tc.columbia.edu

Adjunct Clearinghouses

Child Care
National Child Care Information Center
Toll Free: (800) 616–2242
TTY/TDD: (800) 516–2242
Web: http://nccic.org

Clinical Schools
American Association of Colleges for Teacher Education
Toll Free: (800) 822–9229
Phone: (202) 293–2450
Web: http://www.aacte.org/menu2.html

Consumer Education
National Institute for Consumer Education
Phone: (734) 487–2292
Web: http://www.nice.emich.edu

Educational Opportunity
National TRIO Clearinghouse
Council for Opportunity in Education
Phone: (202) 347–2218
Web: http://www.trioprograms.org

Entrepreneurship Education
Center for Entrepreneurial Leadership
Toll Free: (888) 4–CELCEE (423–5233)
Phone: (310) 206–9549
Web: http://www.celcee.edu

ESL Literacy Education
Center for Applied Linguistics
Phone: (202) 362–0700, ext. 200
Web: http://www.cal.org/ncle

International Civic Education
Indiana University
Toll Free: (800) 266–3815
Phone: (812) 855–3838

Law-Related Education
Indiana University
Toll Free: (800) 266–3815
Phone: (812) 855–3838

Postsecondary Education and the Internet
University of Virginia
Phone: (804) 924–3880
Web: http://highered.org

School Counseling Services
University of North Texas
Phone: (940) 565–2910
Web: http://www.coe.unt.edu/cdhe/eric.htm

Service Learning
University of Minnesota
Toll Free: (800) 808–SERVe (7378)
Phone: (612) 625–6276
Web: http://umn.edu/~serve

Test Collection
Educational Testing Service
Phone: (609) 734–5689
Web: http://ericae.net/testcol.htm

U.S.–Japan Studies
Indiana University
Toll Free: (800) 266–3815
Phone: (812) 855–3838
Web: http://www.indiana.edu/~japan

Affiliate Clearinghouse

National Clearinghouse for Educational Facilities
National Institute of Building Sciences
Toll Free: (888) 552–0624
Phone: (202) 289–7800
Web: http://www.edfacilities.org

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Web: http://edrs.com

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Phone: (301) 497–4080
Web: http://ericfac.piccard.csc.com

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