Southwest Consortium for the Improvement of Mathematics and Science Teaching

Classroom Compass

Spring 1994 • Volume 1, Number 1

HIGHLIGHTS

Working for Reform

An Introduction

Charting a course through the thicket of reform in mathematics and science education is not easy. Each year seems to bring a new wave of innovation with its own set of supporters and acronyms. Systemic change, authentic assessment, whole language, constructivism—what do they mean for day-to-day instruction? For anyone interested in changing the way mathematics and science are presented in the classroom, the real work comes in translating those grand ideas into practice.

As one step in the translation, we present *Classroom Compass* bulletins—resource guides for teachers interested in ideas, information, resources, and activities for improving instruction in science and mathematics. This first issue looks at the idea of teacher as facilitator—a basic concept in the reformed classroom. In the center pages you will find two science activities that illustrate some basic characteristics of the facilitator's role. With a focus on, first, the primary grades and, then, the middle and secondary grades, the activities provide a perspective on the progression of learning that occurs as the student matures. The activities are linked to recommendations from the *Benchmarks for Science Literacy*. Future issues will examine other aspects of instructional reform and other mathematics and science content areas.

Science and mathematics offer special challenges for teachers today. The integration of content areas is emphasized even more than in the past. To make them more accessible to more students, teachers must learn to engage students in real problems and tie lessons to what students already know, while analyzing and

continued on page 2

Don't miss the pull-out science activities inside.

If you would like to receive more *Classroom Compass* bulletins, be sure to return the enclosed postcard.

measuring what they are learning. The *Classroom Compass* will examine such issues, offer suggestions, and pass on new ways of thinking about effective instruction.

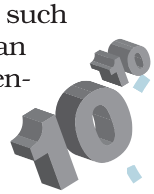
Classrooms for Tomorrow

Computers, genetic technology, global warming, population growth, space exploration...it seems clear that science and technology hold great promise and challenge for the coming generations. How will education prepare our children for their rapidly changing world?

To address such questions, various groups of scientists, mathematicians, educators, and others have been working to define educational expectations for the future. Methods of instruction are under scrutiny, standards and curriculum frameworks are emerging and a new picture of instruction is coming into focus. Successful classrooms will be based on student cooperation and interaction—communities of learners rather than groups of passive recipients of information and facts. Teachers will promote early exploration of higher level concepts and content will be selected to allow in-depth exploration of key ideas. Learning will be defined as a set of intellectual tools rather than an accumulation of data and procedures.

Benchmarks and Standards

How can teachers achieve such ideal conditions? Where can you find an outline of essential concepts, suggestions for arranging class communities, or ideas for specific instructional activities? In 1989 the National Council of Teachers of Mathematics (NCTM) published *Curriculum and Evaluation Standards for School Mathematics,* the product of three years' work by mathematics teachers, supervisors, researchers, and university mathematicians. That first book presented the fundamental content that should be included in the school mathematics curriculum. Two companion volumes, *Professional Standards for Teaching Mathematics* (1991) and *Assessment Standards* (currently in draft form), provide specific guidelines and practical examples for teaching and evaluating mathematics instruction.

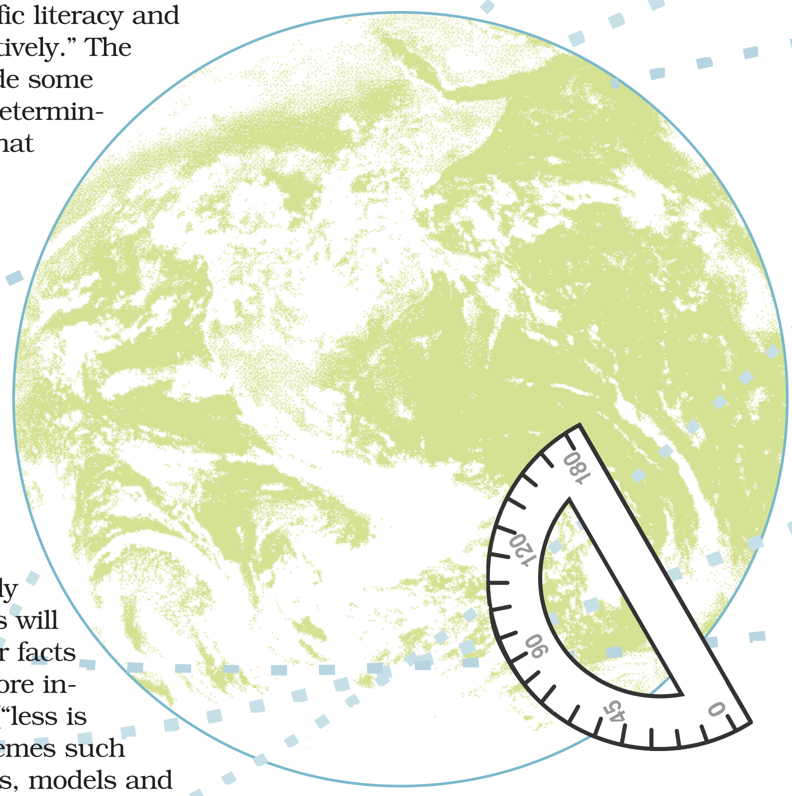


Reform in science instruction has taken a similar path. Project 2061, a diverse group of teachers, administrators, scientists, mathematicians, historians, engineers, and learning specialists gathered by the American Association for the Advancement of Science (AAAS) has produced two books (*Science for all Americans,* 1989, and *Benchmarks for Science Literacy,* 1993) that present expectations for general science understanding and the specific skills students must master to achieve it. In *Science for All Americans,* the authors note: "...schools do not need to be asked to teach more and more content, but rather to focus on what is essential to scientific literacy and teach it more effectively." The *Benchmarks* provide some practical ways of determining and teaching that essential content.

Images for the Future

Schools, teachers, and the community must be willing to accept new standards that address the need for long-term intellectual growth in a world that is rapidly changing. Teachers will be presenting fewer facts and figures and more in-depth exploration ("less is more") of larger themes such as change, patterns, models and systems. Emphasis will be less on definitions and classification skills and more on student-directed exploration and theorizing ("hands-on/minds-on" approaches). New knowledge will be built on the experiences and understanding that students bring to the classroom ("constructivism"). The role of the teacher will become less that of an expert and more a facilitator, a guide to student exploration.

These changes are not easy. Teachers may find it difficult to place the responsibility for learning in the hands of students. Using the learner's, rather than the teacher's, knowledge is an unsettling, and for some, counterintuitive idea. However, we need only think about the influence of the outside world—television, computers, the marketplace—to realize that no one comes to the classroom empty of experience and knowledge, be it formal or informal. Students can take their current conceptions and build on them with new experiences from the classroom to produce a powerful and lasting understanding.



Publications

The mathematics publications at right are available from:
National Council of Teachers of Mathematics (NCTM)
1906 Association Drive
Reston, Virginia 22091

Assessment Standards for School Mathematics. (In production)

Still in its review stage, this volume will provide standards for effective mathematics assessment systems.

Curriculum and Evaluation Standards: The Addenda Series. 1991. (Prices vary by title from $9.50 to $17.00)

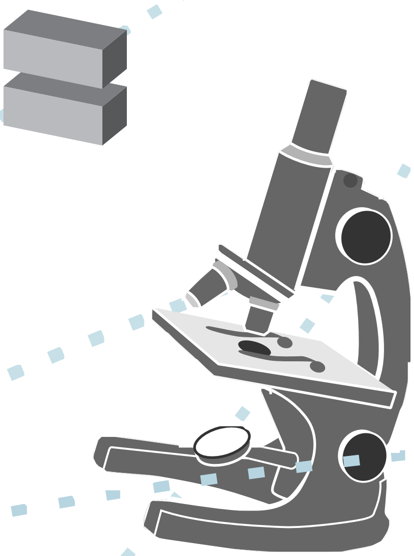
This series of short books provides instructional examples and illustrations to enhance the *Curriculum* and *Professional* standards. The practical applications are presented in three grade-level segments (Grades K–6; Grades 5–8; Grades 9–12) and address a variety of mathematical topics (e. g., number sense, patterns, rational numbers, proportions, statistics, data analysis).

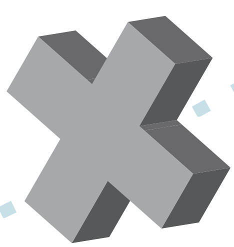
Curriculum and Evaluation Standards for School Mathematics. 1989. ($25.00)

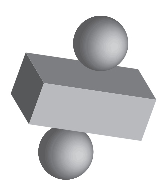
Curriculum standards for grades K-12 are outlined with accompanying overview discussion and teaching suggestions. The last third of the book is dedicated to evaluation as a tool to implement reform.

Professional Standards for Teaching Mathematics. 1991. ($25.00)

Issued as a companion to the *Curriculum Standards*, this book includes teaching, evaluation, and professional development standards for reformed mathematics instruction.







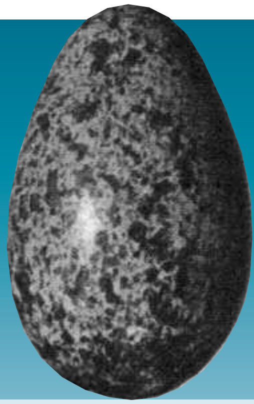
The science publications at right, developed by the American Association for the Advancement of Science (AAAS), are available from:
Oxford University Press
200 Madison Avenue
New York, NY 10016

Benchmarks for Science Literacy. 1993. ($19.95)

A collection of specific instructional goals, organized by topic, that concentrate on a common core of science learning.

Science for All Americans. 1989. ($10.95)

A thoughtful examination of the basic knowledge, skills, and attitudes all students should acquire from kindergarten through high school in order to achieve science literacy.



THE PHYSICAL SETTING:

Teaching in the Early Grades

The following synopses (pages 4 and 5), based on *Benchmarks for Science Literacy*, outline curricular milestones for teaching about the earth's physical setting. The accompanying instructional activities, "Mud Slide" and "Stream Works," provide practical examples for translating the *Benchmarks* recommendations to the classroom. In these activities we take a close look at the teacher as facilitator—a basic concept in the reformed classroom.

It's all connected: the earth, the stars, the weather, the elements. All the pieces of nature work together to form our physical surroundings. Teaching young children about that interconnectedness stretches their imagination and understanding. The child's knowledge of nature's relationships will develop over many years. Ideas will be visited again and again in new contexts and with greater detail. Such concepts as energy transfer, gravitation, photosynthesis, and the water cycle will build slowly as children mature and learn in different contexts.

In **the early years** the curriculum should focus on experiences and ideas that are accessible to children—for example, how planets differ from the earth or the variety of materials found in nature. The curriculum should build on the first steps to understanding, using what children can observe—the movement of the sun and moon, the patterns of seasonal change and changes in the earth's crust that are evident to anyone who looks for them.

Young children are especially curious about how the world works. In the **early grades,** young students can start with the ways organisms, themselves included, modify their surroundings. Encourage young children (**grades K-2**) to look at what things change and what causes change around them. For example, as people have used the earth's resources, they have altered some earth systems. By the end of **2nd grade**, students should realize that some events in nature have repeating patterns. They should be aware that chunks of rocks come in many sizes and shapes from boulders to grains of sand and even smaller.

As students progress (**grades 3-5**), they will accumulate more information about the physical environment, becoming familiar with the details of geological features, observing and mapping locations of hills, valleys, and rivers. Students should learn what causes earthquakes, volcanos and floods and how these forces shape the earth's surface. Since children may show more interest in the phenomenon itself than the role it plays in sculpting the earth, teachers should start with immediate interests and work toward the science.

Students at this stage should observe elementary processes of the rock cycle: erosion, transport, deposition. Water and sand boxes and rock tumblers can provide firsthand examples. They should learn to use magnifiers to inspect rocks and soils. They can build devices that demonstrate how wind and water shape the land and how forces can make wrinkles, folds, and faults in the earth's crust. Remember: elaborate classification is not necessary. The point is not to classify rigorously, but to notice the different pieces of the big picture and to examine the processes involved.

This synthesis is based on several portions of "Processes that Shape the Earth," a chapter in *Benchmarks for Science Literacy* by the American Association for the Advancement of Science (AAAS).

The Teacher as Facilitator

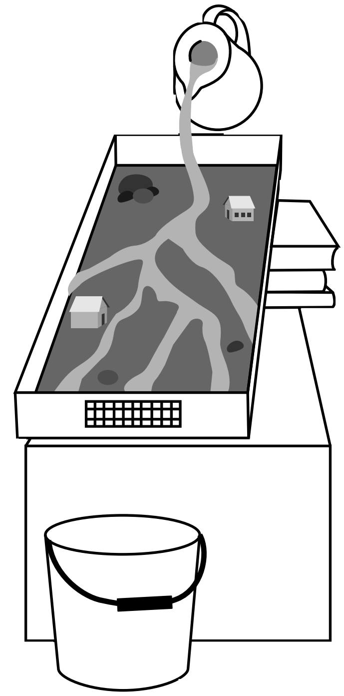
Even the youngest children have observed and experienced enough of the world around them to discuss erosion and deposition processes. By tapping into their prior knowledge through guided instruction, you can encourage thoughtfulness and speculation.

Begin by asking for their previous experiences. Such questions as, "What have you observed during thunderstorms? What washes down driveways and streets?" strengthen children's confidence in their own abilities to observe and learn. Start with local conditions and expand to predictions of what would happen in different seasons, in different terrains. Open-ended questions encourage higher level thinking and help avoid the "guess what the teacher wants" game. The facilitating teacher places the student in the role of a scientist who uses knowledge, observation, and prediction to draw a conclusion about an event.

Let the students use their own words. Learning such terms as erosion and deposition is not a prerequisite for the experience. Vocabulary introduced at appropriate times will take on meaning in the context of its use.

The facilitator should elicit a variety of views from the students—there may be different explanations from the group about the reasons and results of erosion and deposition. Allow those variations to surface, guiding the discussion with questions and invitations to speculate. Continue to refer back to what the students observed in the activity and the conclusions they can draw from what they saw.

Mud Slide



No matter how familiar a teaching activity is, looking at what occurs when learning takes place can make us see it anew. This well-known erosion activity for early grades provides a clear picture of a powerful physical phenomenon.

As a way to examine the processes of erosion, transport, and deposition, this activity lets students build a model terrain and observe the effects of moving water on it. To engage student interest, you might try an introductory walk around the schoolyard or neighborhood, read from a children's story concerning a flood or a mud slide, or show a film about the effects of water and weather (avalanches, flooding, mud slides).

You will need:

- Erosion trays: shallow trays with small drainholes or screen across one end
- Plastic tubs for catching drainage (1 per work group)
- Sprinkling jars—jars with holes in lids or pitchers
- Several books or bricks for support
- Paper towels or coffee filters
- Soil/Clay/Sand
- Debris (small sticks, stones, leaves)
- Small toy houses, cars, etc. (optional)

Organize the students into groups of three. Each group is assigned the task of developing a model of an area that is rained on and reporting back to the class on the terrain and the group's observations. Each tray should use approximately 1 cup of soil and water.

A combination of the materials listed above can be used to simulate terrain conditions. Some ideas include stacking the books to provide elevation, comparing trays with or without debris, measuring debris runoff with filter paper, or varying the force of water sprinkled or poured over the trays.

After the activity is completed, bring the groups back together to discuss their observations and findings. Ask them to compare their activities, looking for variations or discrepancies. How do the findings from the mini-terrains translate to what they have observed in their communities? You might have them make a mural showing the types of results they saw, letting them name each resulting landform. Then go outside and look for similar features, or look at other visual evidence such as posters or pictures.

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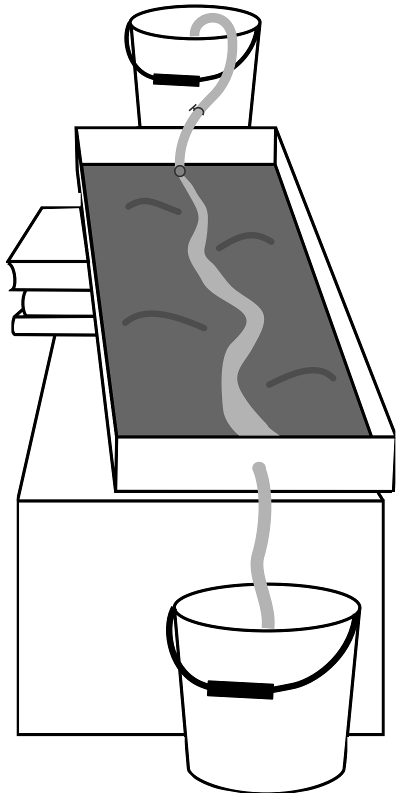
Stream Works



By the time students reach the higher grades they should be developing some understanding of the explanations that underlie the phenomena they have been describing. While this activity has many surface similarities to "Mud Slide," it should be presented in ways that allow students to develop and test more sophisticated understandings of the process and to test explanations for the events they observe. Students will again build their own terrain and will control various factors involving erosion, sedimentation, and change in the landscape. In their investigation they will observe how a stream's ability to erode and deposit earth material is affected by a change in its flow.

You will need:

- Stream pan, 2cm x 50cm x 10cm with drain hole at one end of the pan (1 per working group)
- Rubber tubing, 1 cm in diameter (2 lengths per group, approx. 25 cm each)
- Buckets (2 per group)
- Sand
- Books or bricks for support
- Screw clamp (1 per group)

Each group will develop a model of a landscape. Have each group set up a stream table with the pan holding the sand and the books or bricks producing a slight elevation to the landscape. Water, which is siphoned from the bucket placed above the stream table, is regulated by the screw clamp around the tubing. The water drains through the stream pan and out the pan hole into the second bucket.

With this basic setup, the students can construct several variations that reflect actual drainage situations. They can measure the amount of material moved through the model and devise explanations and predictions regarding the forces at work. Debris might be added for blockage. Lakes, hills, plants and other additions will alter the water's flow. To make connections between mathematics and science, measure the amount of water released, the incline of the slope, the amount of sand moved, the velocity of the water, and the stream volume.

To translate the model into a real event, the students might be asked to develop plans to prevent or manage the devastation of flooding in a local situation or an area reported in a news event, such as the Mississippi River.

Adapted from *Earth Science* by Charles Coble, Elaine Murray, Dale Rice (Englewood Cliffs, NJ: Prentice-Hall), 1987.

The Teacher as Facilitator

While it may be tempting to start this activity with a brisk overview of basic facts and definitions of erosion and deposition, the lesson's content should be embedded in the context of the classroom discussion and the performance of the activity itself. This approach places the student in charge of discovering and examining more complex aspects of this physical phenomenon.

Students will probably have a rich variety of personal anecdotes if they are guided to relate the lesson idea to their neighborhood, local recreational areas, the community's business concerns or terrain they have seen on vacation trips. They can reproduce their experiences in the model and draw conclusions from the activities they perform.

To help students explore the variety of mathematical measurements that are part of water technology, have measuring devices available. Do not direct them to use these devices but advise them when they begin to turn to these tools on their own. Other resources such as charts, tables, or formulas can also be available to evaluate water's effect on the terrain. Work with the students to apply these abstract tools to the practical situation in the activity.

Resources from outside the classroom can enrich the students' understanding. Invite community planners, builders, farmers, or engineers who deal with erosion as part of their work and can provide insight to real world situations.

THE PHYSICAL SETTING:

Teaching in the Middle and Secondary Grades

By the middle grades students should be able to understand most of the main features of the physical and biological factors that shape the face of the earth. It is especially important that they understand how sedimentary rocks formed periodically, embedding plant and animal remains and leaving a record of the sequence in which the plants and animals appeared and disappeared. Besides the relative age of the rock layers, the absolute age of those remains is central to the argument that there has been enough time for evolution of species. While the process of sedimentation is understandable and observable, students may find it difficult to imagine the span of geologic time.

In the study of processes that shape the earth, students by the end of the **8th grade** should know that the interior of the earth is hot and that heat flow and movement of material within the earth cause earthquakes to occur and volcanoes to erupt. Changes on the earth's surface can be abrupt (earthquakes) or slow (glacial cutting) and the earth's surface is shaped in part by the motion of water and wind over very long periods of time.

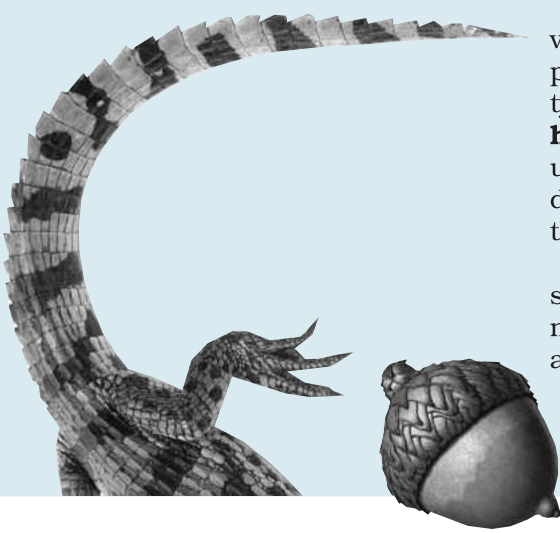
From the **9th through 12th grades** study should turn to modern explanations for the phenomena the students have learned descriptively and to consideration of the effects that human activities have on the earth's surface. Reduction of the forest cover, increases in the amount and variety of chemicals released into the atmosphere, and intensive farming have changed the earth's land, oceans, and air. Some of these changes have decreased the capacity of the environment to support some life forms.

Questions of environmental policy should be pursued when students become interested in them, usually in the **middle grades**, or later. Care should be taken not to bypass science for advocacy. Critical thinking based on scientific concepts and understanding is the primary goal for science education.

Students should see as many varieties of landforms and soils as possible. Knowledge of radioactivity, which should occur in the **high school years**, helps students understand how rocks can be dated and helps them appreciate the scale of geologic time.

By the end of the **12th grade** students should know that the formation, weathering, sedimentation, and reformation of rocks constitute a continuing "rock cycle" in which the total amount of material stays the same as its forms change. The concept of plate tectonics is formally introduced at the high school level and by the end of **high school** students should know that the solid crust of the earth consists of separate plates that ride on a hot, denser layer. The crust sections move very slowly, pressing against one another in some places, pulling apart in others. The surface layers of the plates may fold, forming mountain ranges.

This synthesis is based on several portions of "Processes that Shape the Earth," a chapter in *Benchmarks for Science Literacy* by the American Association for the Advancement of Science (AAAS).



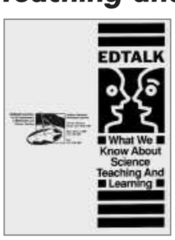
Other Voices: Resources for Mathematics and Science Instruction

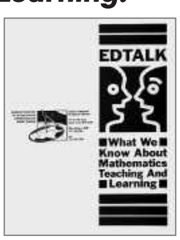
Connect: K-8 Hands-On Science and Math.

Published by Teachers' Laboratory, Inc., PO Box 6480, Brattleboro, VT 05302. ($18 for 5 issues a year)

This practical teacher magazine packs activities, illustrations, teaching tips, thoughtful essays, and literature suggestions into its 20-page issues. Many of *Connect*'s articles are by practicing teachers who convey their enthusiasm for experiential approaches to science and math instruction. Previous issue themes include Life Cycles; Running Water; Investigating Your Environment; and Models, Scales and Metaphor (visualizing difficult concepts through models and metaphors).

EdTalk: What We Know about Mathematics Teaching and Learning and EdTalk: What We Know about Science Teaching and Learning.





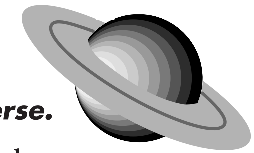
both by Nancy Kober. Available from: Council for Educational Development and Research, 2000 L Street, NW, Suite 601; Washington DC 20036. ($5 each, payable by check or purchase order)

For anyone interested in current thinking about effective science and mathematics instruction, these two guides to recent research are a handy place to start. Presented in topical segments, the *EdTalk* books address such questions as: How do students' attitudes affect science learning? What amount and what level of mathematics content should be included in the curriculum? What role do manipulatives play in mathematics instruction? What are effective ways to integrate science with other curriculum areas? A special segment in each book examines the role of parents and the home environment in student success.

Hands On!

Published by TERC, 2067 Massachusetts Ave., Cambridge, MA 02140. (Free)

This newsletter from TERC (Technical Education Research Center), a nonprofit educational research and development organization, does an engaging job of including interesting essays and practical examples for science and mathematics educators. Recent issues have explored curriculum design, calculus at elementary levels, and the development of number concepts. Several issues have explored the effective use of educational technology and interactive networks.



A Private Universe.

by Matthew H. Schneps. Available from Pyramid Films, PO Box 1048, Santa Monica, CA 90406. ($95 plus $5 shipping and handling fee)

What are students really learning in class? Sometimes it isn't easy to tell. Take the case of the middle school science class caught on camera in this 18-minute video production. In a series of interviews it becomes apparent that while the students in class seemed to grasp the teacher's astronomy lesson, their "private" view of the universe remained unchanged. This thoughtful film provides a window on the ways students incorporate ideas from many sources; it may give many of us an uncomfortable glimpse of our own misconceptions. The film can be an effective starter for teacher discussion, and is a particularly strong persuader for the power of manipulating physical models to enlighten understanding.

Science Education News.

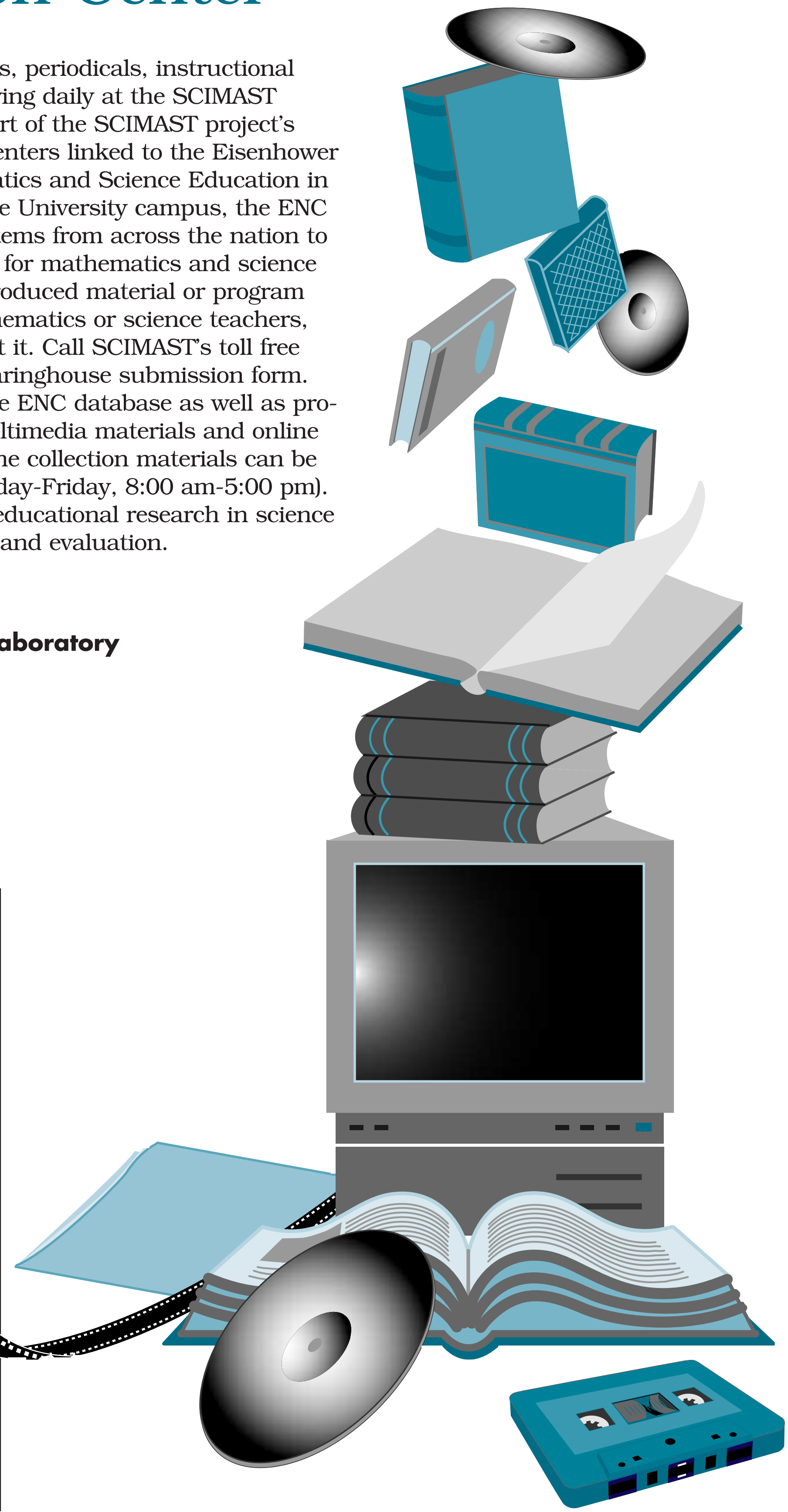
Published by American Association for the Advancement of Science (AAAS), 1333 H Street NW, Washington, DC 20005-4792. (Free)

Published 8 times a year, this small newsletter reports on AAAS and its affiliates. It also provides information on grants, internships, publications, conferences, resource materials, and any other ideas it can pack into its 4 pages. It serves as an "idea bank" for organizations expanding their school science, mathematics, and technology education activities.

The SCIMAST Demonstration Center

Science and mathematics materials—books, periodicals, instructional packages, films, and other items—are arriving daily at the SCIMAST Demonstration Center. The collection is part of the SCIMAST project's role as one of 12 regional demonstration centers linked to the Eisenhower National Clearinghouse (ENC) for Mathematics and Science Education in Columbus, Ohio. Located on the Ohio State University campus, the ENC is charged with identifying and collecting items from across the nation to build a database of instructional materials for mathematics and science education. Should you know of a locally produced material or program that seems particularly promising for mathematics or science teachers, the Clearinghouse would like to hear about it. Call SCIMAST's toll free number (1-800-201-7435) to obtain a Clearinghouse submission form.

The SCIMAST center will be linked to the ENC database as well as providing access to instructional software, multimedia materials and online information at its Austin location. Any of the collection materials can be viewed during resource center hours (Monday-Friday, 8:00 am-5:00 pm). The collection also includes references on educational research in science and mathematics, alternative assessment, and evaluation.



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The National Diffusion Network (NDN)

To help educators share some of the good things going on around the country, the U.S. Department of Education supports the National Diffusion Network (NDN)—a collection of exemplary programs assisted by a cadre of **State Facilitators** who provide the link between interested practitioners and the NDN programs. The network has been sharing success stories for almost 20 years (it was begun in 1974) and its catalog, ***Educational Programs That Work***, now includes more than 450 programs from all states and several territories. The catalog is available from Sopris West Inc./1140 Boston Avenue/ Longmont, CO 80501 for $17.00. Contact your state's facilitator for more information about NDN and its programs.

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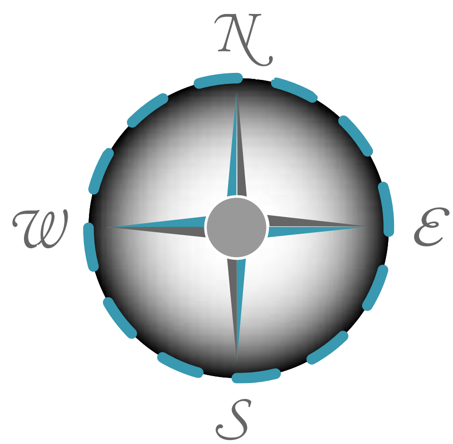

The Private Universe Project

Harvard-Smithsonian Center for Astrophysics is sponsoring a series of interactive videoconferences for K–12 science teachers. This effort, entitled The Private Universe Project, will result in a six-part public broadcast television series. If your school or district has a satellite downlink, it could serve as a conference host and present the series to area teachers. The broadcasts will begin in October, 1994. For further information, contact:

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Phone: 617-496-7676/Fax: 617-496-7670/e-mail: PUP@cfa.harvard.edu