Eisenhower Southwest Consortium for the Improvement of Mathematics and Science Teaching

Classroom Compass

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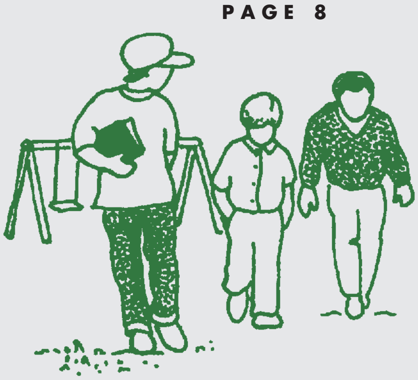

Using Community Resources to Enhance Mathematics and Science Education

Jonathan is very excited. His fifth-grade class is visiting the Martinez Decorative Tile Company where his mother works. Near the end of the tour, Mr. Martinez challenges the students to create a design for a tiled wall the company has been asked to complete. If he can use the design, he will treat the class to a pizza party. Now it's Jonathan's teacher who is excited. What a perfect opportunity to introduce tessellations to the class.

Taking students on field trips or using other community resources in their classes is not a new idea for teachers. Often, however, these experiences are thought to be frills or rewards that compete with instructional time in the classroom. Curriculum reform in science and mathematics calls for a new look at using community resources. The national standards in science and mathematics suggest that good programs require access to the world beyond the classroom so that students will see the relevance and usefulness of science and mathematics both in and out of school. Changing the educational experiences of children by moving beyond the classroom walls can diversify the array of learning opportunities and connect school lessons with daily life and real problems.

Away from the structure of the classroom, many characteristics of constructivism, a key idea in the current reforms, clearly emerge. For example, imagine the interactions that occur as a small group of students experiments with an interactive museum exhibit. They talk about what they see and what they know, relating

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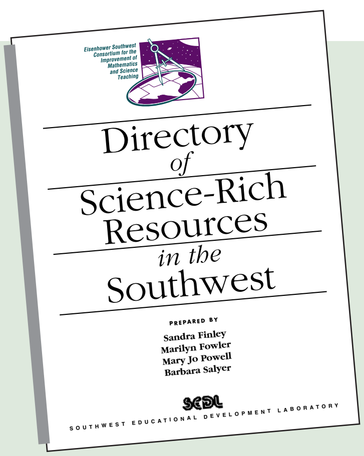
what they are doing in the museum to what they have learned in and out of class. They experience, create, and solve problems together. Social discourse and direct experience help them construct an understanding of the phenomenon. The exhibit puts constructivism in action.

Teachers always face the task of pulling together the diverse understandings their students bring to the classroom. The use of community resources provides a shared memory for the class. For example, going on a field trip is only part of the total experience. As students and teachers talk about the trip and think about it after it is over, they are building shared understanding. The event becomes part of the common knowledge of the class and can be referred to in subsequent lessons. What was learned is, thus, reinforced and extended in later discussions as the teacher refers to field observations.



*The *Directory of Science-Rich Resources,* a listing of museums, zoos, science centers, and other science-oriented resource locations in the Southwest can be ordered from the SCIMAST project as long as copies remain available. Call 1-800-201-7435 for information. The Directory is available on SEDL's World Wide Web site: <**http://www.sedl.org/**>.

Teachers can effectively develop interdisciplinary units with their students outside of the classroom. The world is not made up of discrete disciplines. Students working on a city street, for example, could be doing social studies (e.g., making a survey of how a building is used today and how it has been used over the years), language arts (e.g., writing a short story about the building), mathematics (e.g., devising ways to measure the height of the building), and science (e.g., observing the materials used in the building for signs of weathering). Subject matter barriers dissolve as children learn from their environment.

Community resources that can enhance mathematics and science learning include science centers to visit (museums, nature centers, interactive science centers, aquaria, gardens and zoos), places to explore that are unique to the local school (a nearby creek, pond, city street or business), people in the community, or materials that can be borrowed or purchased. SCIMAST's *Directory of Science-Rich Resources** (called the Directory in the remainder of this article) can be used by teachers as a guide to science centers, sources of curriculum materials, and other kinds of science-rich resources in the region.

The Community beyond the Classroom Walls

Hector, Angela, and Melissa are around a resonant pendulum at the science museum. At this exhibit, they can affect the swing of the heavy pendulum by attaching weak magnets and pulling on the attached cords. Angela tries it and they notice that the swing of the pendulum gets larger when she pulls on the cord. Melissa tries it but her magnet falls off as soon as she pulls the cord. Together, they try to figure out what happened.

Outreach. Many students do not live near a zoo, nature center, or museum for a field trip to be practical, but numerous sites listed in the Directory offer outreach programs. A visit to your classroom by Wildlife on Wheels (Ellen Trout Zoo, Lufkin, Texas) or Creature Comforts (Little Rock Zoological Gardens, Little Rock, Arkansas) can be an engaging learning event for students.

Their class at City School is making a vegetation map of the city block. Shawna, Antoine, and Jennifer are recording the trees and shrubs in front of the school building and measuring their diameters when Antoine notices that little plants are growing out of the sidewalk cracks. They wonder if their map should include small plants as well as large ones and go to check with the group working around the corner.

Science Centers. A learning activity must have a purpose or reason so field trips should be thought of as part of the curriculum. As such, they should provide something to think about as well as something to do or some place to go. If possible, the teacher will want to visit the science center before the field trip to help her balance the needs of the teaching unit with the resources of the site. She can then focus on those exhibits that demonstrate the concepts she is teaching and match the students' cognitive levels. Learning activities are prepared for use before, during, and after the field trip and include student orientation material, such as a map, a list of exhibits to be visited (although they could visit others), and the educational objectives of the trip. This focused approach will advance student learning more effectively than an unfocused scavenger hunt or a generic worksheet written without the benefit of the teacher's preparatory visit. The Directory offers numerous examples of informal places that link to curricula. The Louisiana Children's Museum (New Orleans, Louisiana), for example, has an air hockey table adapted for experimentation with angular geometry, and the Texas State Aquarium (Corpus Christi, Texas) has a laboratory facility that demonstrates the physics of buoyancy and fluids.

Children generally find interactive exhibits engaging. These exhibits can be appealing and effective tools for teaching science and mathematics and for generating a positive attitude toward learning these subjects. At the Harmon Science Center (Tulsa, Oklahoma), students walk, climb and slide through the Underground Tulsa exhibit. At the Santa Fe Children's Museum (New Mexico), children use homing pigeons to send messages from an outside site to the museum.

Near the School. The lack of a nearby science center need not be a limitation. Community resources include unconventional sites, such as the tile factory or a hardware store, fabric store, farm, or ranch. While extended field trips can be rewarding, short school yard trips can be equally valuable. These allow children to discover answers for themselves in a familiar context. Whether your school is urban, suburban, or rural, it reflects the habitat of its neighborhood—the hard-topped surfaces, the soils, grasses, and trees, the weather, and so on. The young inquirer can easily return to the school yard for further data gathering if a question is left unanswered or new questions arise. A class studying the sun and its shadows in a particular location, for example, can gather data at intervals throughout the day.

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Environments for Learning Science

National Science Education Standards, Teaching Standard D

Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science.

Time, space, and materials are critical components of an effective science learning environment that promotes sustained inquiry and understanding. Creating an adequate environment for science teaching is a shared responsibility. Teachers lead the way in the design and use of resources, but school administrators, students, parents, and community members must meet their responsibility to ensure that the resources are available to be used. Developing a schedule that allows time for science investigations needs the cooperation of all in the school; acquiring materials requires the appropriation of funds; maintaining scientific equipment is the shared responsibility of students and adults alike; and designing appropriate use of the scientific institutions and resources in the local community requires the participation of the school and those institutions and individuals.

Teachers must be given the resources and authority to select the most appropriate materials and to make decisions about when, where, and how to make them accessible. Such decisions balance safety, proper use, and availability with the need for students to participate actively in designing experiments, selecting tools, and constructing apparatus, all of which are critical to the development of an understanding of inquiry.

The classroom is a limited environment. The school science program must extend beyond the walls of the school to the resources of the community. Our nation's communities have many specialists, including those in transportation, health-care delivery, communications, computer technologies, music, art, cooking, mechanics, and many other fields that have scientific aspects. Specialists often are available as resources for classes and for individual students. Many communities have access to science centers and museums, as well as to the science communities in higher education, national laboratories, and industry; these can contribute greatly to the understanding of science and encourage students to further their interests outside of school. In addition, the physical environment in and around the school can be used as a living laboratory for the study of natural phenomena. Whether the school is located in a densely populated urban area, a sprawling suburb, a small town, or a rural area, the environment can and should be used as a resource for science study. Working with others in their school and with the community, teachers build these resources into their work with students.

ACTIVITIES FOR ELEMENTARY STUDENTS

Learning From the World Outside the Classroom

Your school yard and its surrounding neighborhood is a laboratory where teachers and elementary students can actively investigate mathematics and science.

Teachers whose classes are not near such rich centers as museums or botanical gardens must use the local community as a source for science and mathematics learning. Short trips to the school yard that become an integral part of the class schedule can help students build an understanding of the natural world and increase their sophistication in observing and interpreting their surroundings. In fact, 10- and 15-minute field trips may be ideal for many topics. Students who develop skills working in groups, forming questions, collecting data, and observing their school yard laboratory will find that these experiences enhance their visits to other places as opportunities arise.

School yard explorations can focus on such topics as plants, trees, animals, the interdependence of living things, physical and chemical changes, sound, weather and climate, and geology. For example, shadow activities can enhance the study of the solar system and provide concrete experiences of the sun's influence on our planet.

- Let younger children explore shadows in the school yard. What is the largest shadow? What is the smallest? Put the children in a circle and have them count the number of shadows. Which way do all the shadows point?
- Use a thermometer with older students to compare the temperature difference in full sun and shadow. What conclusions can they draw from these measurements? What temperature differences might be plotted on the same location throughout the day? Throughout the week or month?

The outdoors can reflect mathematics principles as well. Data gathered by student teams may present more solid examples than textbook representations.

- The size of a shadow is directly proportional to the size of an object. Therefore, if a 1-meter ruler held perpendicular to the ground throws a 66-centimeter shadow and a tree shadow is 5.5 meters long, the tree's height can be calculated to be 8.33 meters (66:100=5.5:x). Try these calculations at different times of the day and at different times of the year.
- Let the students discover the constant π. Send teams of students outside to measure circular objects: trees, flagpoles, trash cans, utility poles. They may want to use yarn or string or a tape measure to wrap around the object for measurement of the circumference. To determine the diameter, use three yardsticks or meter sticks. Place a stick on each side of the object, making sure the two sticks are parallel and at the same height from the ground. Then use the third stick to measure the distance between the extended portions of the two parallel sticks—that is the diameter. The teams can post the measurements for their various objects on a statistical table. They may also want to note the radius for each of the objects. Ask the students to look at the data and see if they notice any special relationships among the various measurements. Ask each team to divide the value for the circumference by the value of the diameter and post the results. The constant π, 3.14 or 3 1/7, will emerge from these results.

For more ideas on using resources outside the classroom, see **Ten-Minute Field Trips** by Helen Ross Russell (1990). These have been used with permission of the National Science Teachers Association, 1840 Wilson Blvd., Arlington, VA 22201. Cost: $16.95 + $4.95 s/h (1-800-722-6782).

AN ACTIVITY FOR UPPER LEVEL STUDENTS

Using Mathematics in Fossil Reconstruction

This activity from a SCIMAST professional development event sent the participants on a mathematical exploration in a local natural science museum.

A display at the Texas Memorial Museum on the University of Texas at Austin campus presents several wing bones of a pterosaur believed to be the largest flying animal that ever existed—*Quetzalcoatlus northropi* (Qn). The museum's reconstruction of the animal's wing incorporates fragments, an intact humerus and several bone pieces that were found in the Big Bend National Park in Texas in 1971. How would scientists predict the pterosaur's probable wingspan from these pieces?

Data from similar pterosaurs found throughout the world were available from museum sources. These provided a glimpse of the creatures' proportionality and helped the students construct a table that compares wingspan and humerus lengths.

Taking the two variables provided, length of humerus and total wingspan, students were able to estimate the total wingspread of *Quetzalcoatlus northropi.* The data plotted on graph paper provided a scatter plot used by the students to determine the line of best fit. This linear regression provided a best estimate from the Qn humerus length. (To determine the entire wingspan, students had to factor in the pectoral girdle—estimated at .5 meter across—that separated the animal's wings.) Other students worked with the data to determine a best ratio, and a few used graphing calculators instead of (or in addition to) the manual plotting.

After determining their predictions, the students went to the Texas Memorial Museum for an up-close view of the wing fragments and the opportunity to measure the reconstructed left wing. While the students' predictions did not exactly match the reconstructed animal (because the line of regression only provides a "best possible fit"), the museum's reconstruction was within the graphed possibilities.

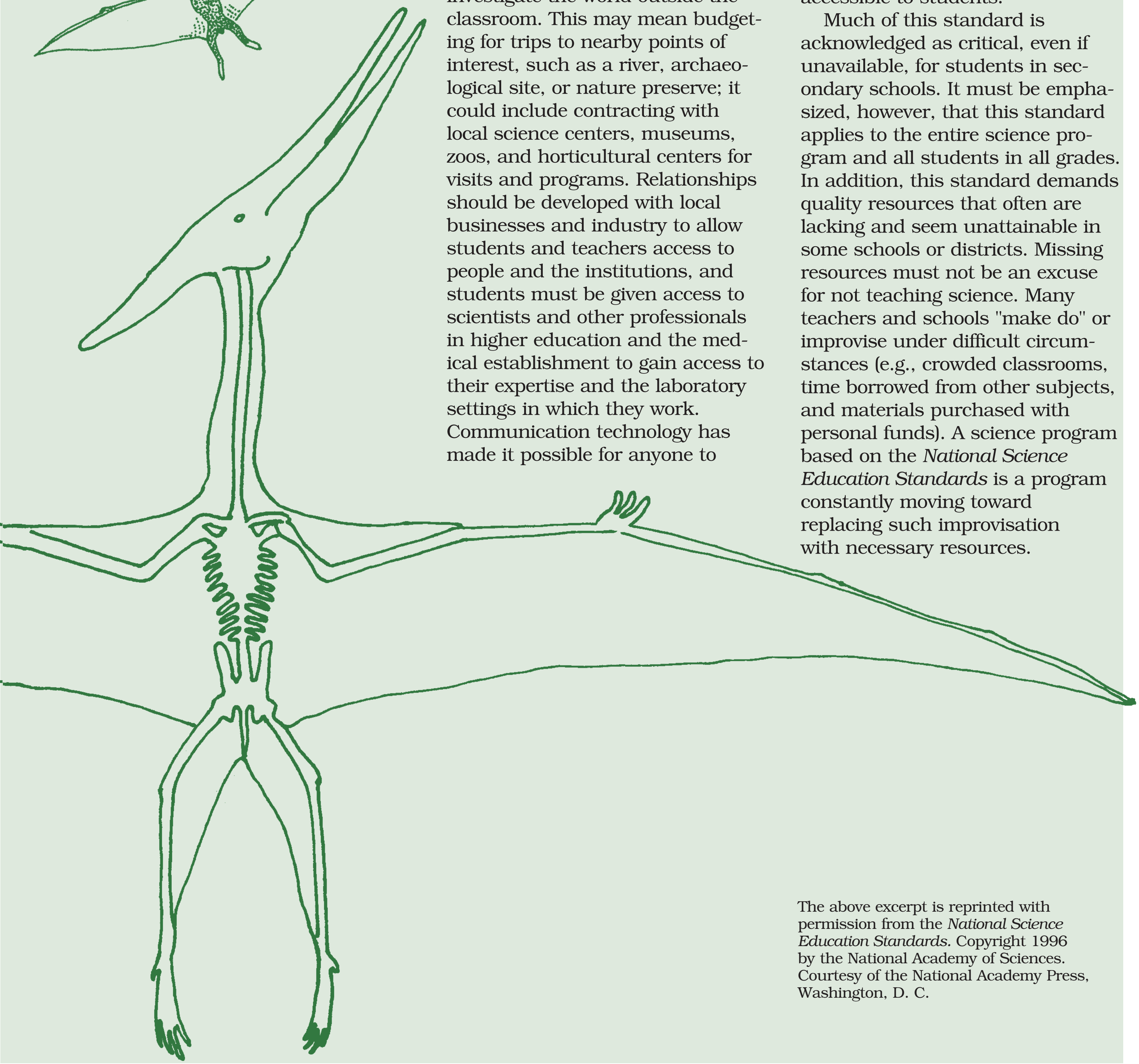
Lingering questions: Why was the estimate not exactly the same as the museum's reconstruction? What does the "best possible fit" mean? Would it be reasonable to use the pterosaur data to estimate the wingspan of a bird or a bat? If we measure our own humerus, and use the pterosaur correlation table, how wide would a human's wingspan be? Is this a realistic estimate? Why or why not?

Pterosaur	Humerus Length	Total Wingspan
Quetzalcoatlus northropi	54 cm.	???
Quetzalcoatlus sp (small)	24 cm.	600 cm.
Ornithodesmus	20 cm.	500 cm.
Pteranodon	32 cm.	750 cm.
	27 cm.	570 cm.
	22 cm.	430 cm.
	15 cm.	300 cm.
Santanadactylus	17 cm.	370 cm.
Nyctosaurus	15 cm.	310 cm.
	13 cm.	270 cm.
	9 cm.	240 cm.
Pterodactylus antiquus	4.4 cm.	68 cm.
	3.6 cm.	55 cm.
	3.2 cm.	53 cm.
	2.9 cm.	50 cm.
	1.5 cm.	24 cm.

The World Beyond the Classroom

National Science Education Standards, Program Standard D

Good science programs require access to the world beyond the classroom.



District and school leaders must allocate financial support to provide opportunities for students to investigate the world outside the classroom. This may mean budgeting for trips to nearby points of interest, such as a river, archaeological site, or nature preserve; it could include contracting with local science centers, museums, zoos, and horticultural centers for visits and programs. Relationships should be developed with local businesses and industry to allow students and teachers access to people and the institutions, and students must be given access to scientists and other professionals in higher education and the medical establishment to gain access to their expertise and the laboratory settings in which they work. Communication technology has made it possible for anyone to access readily people throughout the world. This communication technology should be easily accessible to students.

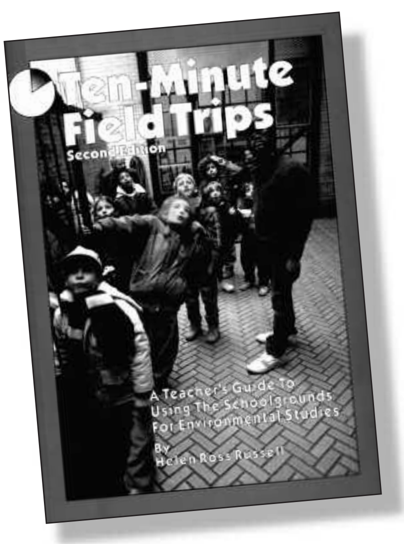
Much of this standard is acknowledged as critical, even if unavailable, for students in secondary schools. It must be emphasized, however, that this standard applies to the entire science program and all students in all grades. In addition, this standard demands quality resources that often are lacking and seem unattainable in some schools or districts. Missing resources must not be an excuse for not teaching science. Many teachers and schools "make do" or improvise under difficult circumstances (e.g., crowded classrooms, time borrowed from other subjects, and materials purchased with personal funds). A science program based on the *National Science Education Standards* is a program constantly moving toward replacing such improvisation with necessary resources.

Resources and Opportunities

Ten-Minute Field Trips

by Helen Ross Russell
National Science Teachers Association
$16.95 + $4.25 s/h
1-800-722-6782

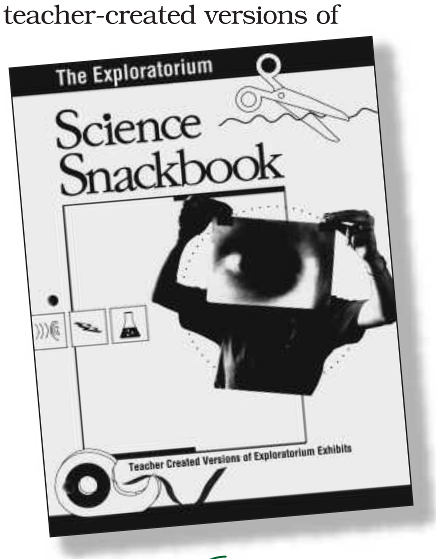
This collection of activities, ideas, and examples urges teachers to explore the environments around their schools, whether urban, suburban, or rural. In addition to more than 200 short, close-to-home field trips, the author provides introductions that support an understanding of what might be seen during the students' explorations. The book is divided into topic sections—Plants, Animals, Interdependence of Living Things, Physical Science, Earth Science, and Ecology—and includes a special cross-referenced list of field trips for hard-topped school grounds. The preface, "Saying 'I Don't Know,'" sets the tone for teachers who will join their students in discovering the world outside their classrooms.

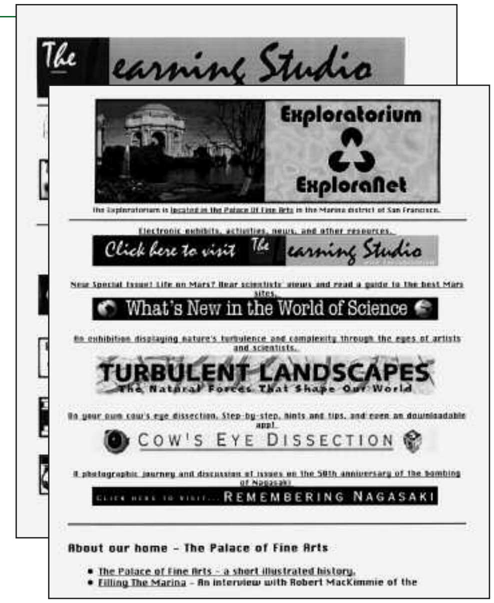


Exploratorium Teacher Institutes

The Exploratorium is an interactive science museum founded in 1969 by Frank Oppenheimer, noted physicist and educator. The center, located in the heart of San Francisco, presents hundreds of interactive exhibits and a variety of programs for children and adults. Every summer the Exploratorium offers 300 science teachers, grades 6–12, the opportunity to take part in a summer experience called the Teacher Institute. These intensive, two-, three-, and four-week programs provide a mix of content-based discussions, classroom experiments, and teaching strategies based on the Exploratorium's exhibits. Applications for admission to the summer 1997 Institutes are being accepted until April 1997. For those teachers accepted, tuition will be borne by the Exploratorium. For more information, take a look at the Exploratorium Web page **<www.exploratorium.edu>** or contact Exploratorium Teacher Institute, 3601 Lyon St., San Francisco, CA 94123. Phone: 415-561-0313

You can use materials created by these institutes if you get copies of the four-volume Exploratorium ***Science Snackbook*** Series, a collection of more than 100 teacher-created versions of



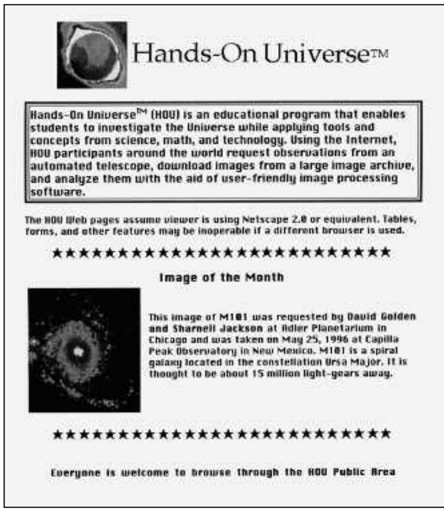


Exploratorium exhibits. The books provide instructions for classroom-based constructions (balancing a ball on a stream of air, building a light-scatter box) that illustrate such concepts as magnetism, polarization, and refraction.

- *The Cheshire Cat and Other Eye-Popping Experiments on How We See the World*
- *The Cool Hot Rod and Other Electrifying Experiments on Energy and Matter*
- *The Magic Wand and Other Bright Experiments on Light and Color*
- *The Spinning Blackboard and Other Dynamic Experiments on Force and Motion*

Published by John Wiley and Sons, the books are available for $10.95 each plus shipping from the Exploratorium Mail Order Dept., 3601 Lyon Street, San Francisco, CA 94123 (415-561-0393) or from the publisher.

Also of interest to classroom teachers is ***The Exploratorium Guide to Scale and Structure; Activities for the Elementary Classroom***. The activities are starting points for exploring the physics and mathematics of structure as well as the effects of scale on structure. The book sells for $29.50 and is available from Heinemann publishers, 361 Hanover Street, Portsmouth, NH 03801-3912 (1-800-541-2086).
It can also be ordered from the Exploratorium Mail Order Department.



Hands-On Universe™

Hands-On Universe™ (HOU) is an educational program that enables students to investigate the Universe while applying tools and concepts from science, math, and technology. Using the Internet, HOU participants around the world request observations from an automated telescope, download images from a large image archive, and analyze them with the aid of user-friendly image processing software.

The HOU Web pages assume viewer is using Netscape 2.0 or equivalent. Tables, forms, and other features may be inoperable if a different browser is used.

Image of the Month

This image of M101 was requested by David Golden and Sharnell Jackson at Adler Planetarium in Chicago and was taken on May 25, 1996 at Capilla Peak Observatory in New Mexico. M101 is a spiral galaxy located in the constellation Ursa Major. It is thought to be about 15 million light-years away.

Everyone is welcome to browse through the HOU Public Area

Hands-On Universe

For the past four and a half years this program, with the support of the National Science Foundation and the Department of Energy, has enabled high school students to request their own observations from professional observatories. The students download images to their classroom computers and use powerful HOU software to visualize and analyze their data. Until recently the project has forwarded all requests to the Leuschner Observatory at the University of California Berkeley astronomy department. New collaborations between observatories in Hawaii, Illinois, California, Washington, Sweden, and Australia will provide a network of automated telescopes that can respond based on such conditions as geography, weather conditions, scheduling, and equipment characteristics.

Exciting results can occur when students are given access to this powerful equipment, as witnessed when two high school students requested observations of the Whirlpool Galaxy as part of their lesson on spiral galaxies. Their observation captured the first light of SN1994I, a supernova. Their names will appear as co-authors on a photometry paper about SN1994I.

For more information about this project, write: Hands-On Universe, MS 50-232 Lawrence Berkeley Lab One Cyclotron Road, Berkeley, CA 94720 or email **houstaff@hou.lbl.gov**. The Web page address is: **<hou.lbl.gov/newpages/houtitle.html>**

S C I M A S T

Eisenhower Southwest Consortium for the Improvement of Mathematics and Science Teaching

Eisenhower Southwest Consortium for the Improvement of Mathematics and Science Teaching

The Eisenhower SCIMAST project supports science and mathematics education in five states with a combination of training, technical assistance, networking, and information resources. Eisenhower SCIMAST is funded by the U.S. Department of Education's National Eisenhower Program to serve educators in Arkansas, Louisiana, New Mexico, Oklahoma, and Texas. Eisenhower SCIMAST works in partnership with the Eisenhower National Clearinghouse, a national resource center dedicated to increasing the availability and the quality of information about instructional resources for science and mathematics educators. As part of that effort, Eisenhower SCIMAST has a resource/demonstration center open to visitors Monday through Friday, 8:00 A.M. to 5:00 P.M. The center houses a multimedia collection of science and mathematics instructional materials for grades K–12. It is located on the fourth floor of the Southwest Educational Development Laboratory, 211 East Seventh Street, Austin, Texas 78701. The center also has a toll-free number, **1-800-201-7435**, that provides callers in the five-state region information on multimedia and print instructional materials, assessment tools, and successful strategies for mathematics and science instruction.

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Using Community Resources to Enhance Mathematics and Science Education
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Bringing the Community into Your Classroom

Materials through the Mail. By necessity, most learning activities occur in the classroom. Organizations listed in the Directory can provide materials that enrich the curriculum and provide unique experiences for children. These inexpensive or free materials may be overlooked since they are not produced by educational publishing companies. Diaries in the Dirt, a program available from the Oklahoma Archaeological Survey, includes a set of artifacts for sand box explorations. Techniques, Technology, and Trade, a curriculum available from the Arkansas Ag in the Classroom State Leader, integrates science and economics. Numerous national organizations have also developed curriculum materials; guidance materials from professional organizations are useful ties to the workplace.

Electronic Connections. Many entries in the Directory have activities and programs that involve the Internet or e-mail communication and can be valuable additions for classes that have Internet access. Marsville, a project sponsored by Phillips Laboratory (Albuquerque, New Mexico), is a simulation for elementary classes. Students create prototypes of a colony on Mars and communicate by e-mail with other participating schools about colony operations. In the GLOBE Program, students take environmental measurements and post their data on the Internet. WeatherNet, listed under National Weather Service in the Directory, is an Internet resource that includes weather data and links to the home pages of more than 300 weather-related organizations.

Sharon likes mathematics, but she did not even know what a civil engineer did until Ms. Davies and Mr. Garcia came to her class. Now she thinks she would like to be one. The activity they did with the class about bridges intrigued her. After the class, she asks Ms. Davies about her bridge activity and then asks about colleges and jobs for girls in this field.

Guests. Guest speakers from the community can provide new information and experiences to students and link the school to the world outside. The teacher should spend time with the guest before the visit so they can discuss the age level of students and kinds of activities and information appropriate for this age group; the needs of the guest during the visit and his or her general comfort level with children; the topic of the presentation and the students' general knowledge about this topic; and what the teacher can do before to make the visit a success. Staff of state agencies can serve as classroom partners or as knowledgeable resource people. For example, staff from a conservation agency might be able to aid schools in setting up an outdoor classroom or civil engineers from the highway department may be able to show plans for a bridge project. Many potential speakers are overlooked, however, because they work in less technical fields. Valuable links to the community as well as connections between school subjects and the workplace may be created by inviting a cafeteria worker who could talk about using proportions in increasing the size of recipes. A mechanic or the owner of a feed store are other possibilities. Guests who can come back to the classroom numerous times may enhance the learning experience for the students.

Conclusion

The richness of the region's resources is apparent from the number and diversity of entries found in the *Directory of Science-Rich Resources.* Imagination and creativity in using community resources can help students connect school science and mathematics with applications in the community, as well as helping students better learn basic concepts. Children learn science and mathematics from many sources, in a range of different ways, and for a variety of purposes. Taking students to a science museum or out onto the school grounds, exposing them to innovative materials, or inviting guests who can give unique insights are a few ways to increase their learning experiences.

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