

Looking Outside for Learning

In many science classes, students are expected to listen, memorize terms, and regurgitate definitions. They often perform these tasks flawlessly—but without making much sense of the content.

The reasons for such inquiry-based learning are clear: passive learning doesn't stick. When children take control of their own learning, they become invested in it. Through the process of discovery, children understand more clearly, they retain knowledge longer, and they are able to apply it more meaningfully and widely in other situations.

To engage students in inquiry, teachers around the country are using a broad range of commercially available, inquiry-based, hands-on science modules. These kits—with titles like “Balancing and Weighing” and “The Life Cycle of Butterflies”—were developed with clearly articulated learning goals. They go a great distance in promoting the kind of science learning that builds upon children's natural curiosity and eagerness to understand how things work. And although they can form the basis for a rigorous school science program, they have their limitations.

We understand that often there is no more powerful learning experience than one grounded in the natural world. A young child at the seashore—picking up a smooth shell from the sand, running a net through the water as waves come in,

continued on page 2



New Jersey Marine Sciences Consortium

Using a seine net helps students discover the surprising variety of aquatic life at Horseshoe Cove in Sandy Hook, N.J.

In other classes, where science is taken more seriously, teachers try to model the process of scientific inquiry that scientists use. Students are encouraged to ask questions, make predictions, conduct experiments, draw conclusions, and share their findings.

Highlights

Outside Resources Issue

Overview	P/1
Perspectives	P/3
Raritan River	P/4
Field Trip Tips	P/6

Looking Outside

continued from page 1

watching and listening to the gulls—experiences a world that a science kit cannot possibly replicate.

This issue of *Explorer* is intended to provoke teachers into looking beyond the module. The opportunities for supplementing classroom learning with outside resources are great.

Outside resources come in many forms. They may be parents with special science or technology skills who have an interest in working with teachers or students. They may be scientists from local industry interested in mentoring teachers or in making classroom visits. Outside resources also may be museums, planetariums, aquariums, factories, guided natural habitats, state parks, and any number of other locales.

Online Resources

The Eisenhower National Clearinghouse is a project of the U.S. Department of Education that provides K–12 teachers and others with a central source of information about math and science materials. ENC acquires and catalogs curriculum resources and supports teachers' professional development. To view their online catalog and other services, visit www.enc.org.

NSRC Guides

Having recognized the need for a well-researched guide to resources outside the classroom (and some within), the National Science Resources Center revised its directory of instructional materials and other resources for elementary teachers in 1996 and published a new directory for middle school teachers in 1997. These two books, *Resources for Teaching Elementary School Science* (ISBN 0-309-05293-9) and *Resources for Teaching Middle School Science* (ISBN 0-309-05781-7), continue to provide teachers with valuable information about ways to enrich their science programs.



New Jersey Marine Sciences Consortium

Students get acquainted with horseshoe crabs at a hands-on exhibit in Sandy Hook, N.J.

Inviting scientists or people with technology skills into the classroom can help bring alive the content by making it more relevant. As Donna Kwiatkowski, a science teacher at Readington Township's Holland Brook School, notes within these pages, outside visitors help children answer the question, "Why am I learning this?"

Alan Friedman, director of the New York Hall of Science, comments in this issue of *Explorer* that museums add value to the classroom experience because they help children make quick connections between what is personally known and something new; give children authentic learning experiences; and help them name, identify, observe, imagine, and fantasize.

Also in this issue, Jane Horwitz, coordinator of the Penn-Merck Collaborative for the Enhancement of Science Education in Philadelphia, discusses the benefits and potential pitfalls of visits to museums and other resources from her perspective as a former museum educator.

Many of the experiences described in these pages highlight what we consider to be a "best practice" of science teaching: that the learning goals of a science unit should drive the selection of, preparation for, and management of any outside resource that is used to complement that lesson.

Explorer Staff

MISE Editor: Joan Leonhardt

Writers: Gerald S. Cohen

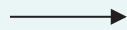
Kathleen Larson Florio

Philip Franchine

Editorial Direction: GSC Communications

Design: Janin/Cliff Design

Any portions of *Explorer* not reprinted from other publications may be freely reproduced and circulated without prior permission provided the source is cited.



They're Having Fun ... but Are They Learning?

By Alan J. Friedman, Ph.D., Director, New York Hall of Science, and MISE Advisory Board Member

One hundred million people visit science centers each year, and equally huge numbers visit zoos, botanic gardens, natural history museums, and planetariums. For the students taking classroom excursions, these visits



are all billed as learning experiences. But as you watch the chaos and motion and listen to the noise, you have to wonder: How much are they really learning? If the facility is a quality institution, and if the students have received adequate preparation, they're probably learning quite a bit.

Learning is rarely something you can observe by just watching, either in a museum or in a classroom. Everyone knows the traditional look of learning—children sitting quietly at desks and reading texts, listening attentively to teachers, or concentrating hard on calculations.

The last 20 years of research, however, have suggested that it is not so easy to determine whether learning is taking place. Just as classroom pedagogies must be studied carefully to determine whether they are really working in the long term, recognizing learning in informal settings is not a simple matter of noting the level of noise or motion. Nevertheless, researchers are learning things about informal science education that can help parents and teachers take the best advantage of the remarkably rich resources that happen to be outside the school building.

Although not every exhibit works as an effective educational tool for every visitor at every moment, researchers have hard evidence that measurable learning does indeed take place in typical museum and science center settings. And now hundreds of studies are available to help us define and improve that learning. For example—

- ▶ In a major study at the Franklin Institute Science Museum in Philadelphia, children in grades 7 through 9 were given both previsit and postvisit tests of science content. The results showed significant increases in scores as a result of the visit.
- ▶ A traveling exhibition on viruses developed by the New York Hall of Science was tested in New York and in other museums around the country. Teenagers who used the exhibition doubled their scores on several important questions about how a virus is transmitted from person to person.

Beyond these cognitive gains related to the content of exhibitions, two other kinds of learning are happening when children burst into a museum. First, museums help children construct mental maps of their surroundings. When they first enter a museum, youngsters build a mental catalog of what experiences are available. Toward the end of their visit, they often come back to a few exhibits that especially aroused their interest, even if they only pushed the button and ran the first time around. Youngsters need to acquire a mental map of the environment to make it theirs. Although they are too young to understand the schematic maps on the walls, physically being in every space and locating its landmarks—the big objects—are effective ways for them to construct mental maps.

Second, significant and measurable learning in museums also occurs in what researchers call “the affective domain,” creating the deep interests that motivate later learning both inside and outside the classroom. As Stephen Bitgood and colleagues write in *Informal Science Learning: What the Research Says About Television, Science Museums, and Community-Based Projects*, key elements of this kind of learning at museums include the following:

- ▶ Making quick connections between what is personally known and something new,

continued on page 8



Knee-Deep in Learning

Learning about water quality and erosion in a classroom setting is one thing, but getting a chance to test water quality and view erosion is quite another.

In Readington Township Public Schools, one of four MISE partner districts in New Jersey and Pennsylvania, 4th grade students are diving feet first into the study of erosion and river habitat as they wade through a series of scientific experiments in the Raritan River.

During their annual springtime trip, the 4th graders pull on their boots, step into a shallow spot in the river, and begin their experiments with eyes wide open. It's all part of a daylong investigation of the river's water quality, the changing riverbank, and the effects of weather upon the river.

"It's a culminating activity that pulls together what we talked about in September, October, and November," says Donna Kwiatkowski, a teacher in Readington Township's Holland Brook School. "They make all kinds of connections between in-class activities and what they see. You can learn something in the classroom, but coming outside and seeing it as part of the environment is much more powerful."

In addition to hunting for the presence of various types of marine life, the students check for evidence of erosion. "They saw that Hurricane Floyd had done tremendous damage," Kwiatkowski says. "The children could see how high the water level had risen, that there was river-borne debris in the trees. They could see how the banks had changed. With some of the tree roots exposed out of the dirt, they were drawing conclusions about what would happen to the trees—that some would not survive."

Going to the Raritan is not something that occurs through serendipity. Months before the river trip, a districtwide team of 4th grade teachers plans the year's curriculum, working from state and district standards. The curriculum is broken down to monthly increments, and "then



Merck Visual Communications

MISE volunteer Philip Kuhl watches as students measure a crayfish.

it's up to the individual teacher. Everyone has a different style," Kwiatkowski says.

When the students go to the Raritan, they learn firsthand the process of scientific inquiry. They make and test predictions of water quality, combining classroom lessons on the categorizing of macroinvertebrates and field research involving those river creatures, including leeches, crayfish, and various larvae. The presence of too many leeches and other pollution-tolerant macroinvertebrates means the water is unhealthy, but a strong population of, for example, crayfish and mayfly nymphs indicates a healthy balance.

Kwiatkowski begins the related classroom lessons months before the trip, using two science modules: "Weather," which covers the water cycle, and "Land and Water," which covers erosion.¹ She teaches students to recognize and categorize the river macroinvertebrates so that they

continued on page 7

¹Both modules are from the Science and Technology for Children™ (STC) curriculum developed by the National Science Resources Center and published and distributed by Carolina Biological Supply Company, Burlington, NC.

Sterling Hill Mining Museum

Students' eyes light up when they see rocks glow green and red in the Sterling Hill Mining Museum, and teachers appreciate the experiential learning that supports the concepts and learning goals of classroom science modules.

The rocks—chunks of zinc ores from the former mine—glow under the tour guides' ultraviolet lights. Calcite glows red and willemite glows green. They are marbled throughout the rocks, providing a radiant illustration of the concept that rocks are made up of pure minerals.

Fifth grade teacher Lois Eckelman of Rahway's Madison School says the trip, which follows her students' classroom study of the "Earth Materials" module, is important because "it connects things to real life. [That's] important to motivate the kids."

In the classroom, Eckelman's students learn how to distinguish rocks from minerals and how to categorize rocks. They use vinegar, an acid, to remove calcite crystals that are marbled throughout the rocks. At the mine they learn these same concepts somewhat different-

ly by observing the glowing colors. They also examine piles of rocks and identify samples of six different types, which they can take home.

"The trip is a way of seeing science lessons as part of a bigger picture," Eckelman says. "We start with the concept that minerals are part of rocks, then see at the mine where they come out of the earth itself, and the larger picture is that the earth is shaped in different ways—flat, hilly, mountainous, with rocks inside the earth."

During the two-hour tour, students travel underground to an old mining shaft, learning about mines as workplaces, and they inspect samples of many of the 340 minerals found locally. They also learn about zinc's history and many uses: in the colonial era it was used in the production of cannon and shot, and today it is an ingredient in toothpaste and sunscreen.

The Sterling Hill Mining Museum is at 30 Plant St., Ogdensburg, NJ 07439-1126. Telephone: 973-209-7212. Web site: www.sterlinghill.org. ◀

Making the Most of Guest Speakers

All outside resources require careful management, and that includes the visiting "experts" who are recruited to speak before students.

Before experts make presentations in Donna Kwiatkowski's class at Readington Township's Holland Brook School, she meets with them briefly to familiarize them with the curriculum and to discuss what they plan to say and how.

She encourages them to replace the lecture format with a more experiential approach that is better suited to the shorter attention spans of children. Often she will ask guest speakers to practice on children before coming to class.

Frank Cuccio, a parent and electrical engineer, recently volunteered to make a presentation in Kwiatkowski's class as part of a science unit on electricity. She advised him to practice

on his son, and, as a result, he discovered that he could enhance his lesson by using a voltmeter as a learning prop.

Cuccio hooked up the meter to several light bulbs, which allowed his son to see the needle move about as it indicated different voltages. Cuccio eventually brought the voltmeter to class, where it held the attention of students so well that he wound up using it to illustrate most of his talk and skipped the slide show he had prepared.

Kwiatkowski says inviting outside experts into the classroom helps make lessons relevant. "The kids often don't see the purpose behind what they are learning," she says. "An outside person can say, 'What you are learning is something I need to know for my job.' It brings motivation to the children." ◀

Tips for Field Trips

A field trip to the Grand Canyon is the stuff of fantasy for middle school teachers in Philadelphia who teach earth science. But Jane Horwitz, coordinator of the Penn-Merck Collaborative for the Enhancement of Science Education, can direct them to an interesting alternative.

At the Wissahickon Valley in Philadelphia's Fairmount Park, students can see geological formations sculpted by wind and water—the same forces that shaped the natural wonder in Arizona. The Wissahickon is not the Grand Canyon, Horwitz is quick to admit; but on the other hand, the school bus never has to venture outside the city limits.

“The Philadelphia area is incredibly rich in informal science resources,” says Horwitz, who was a museum educator for 20 years before she became coordinator of the collaborative.

Helping teachers integrate such resources into the science curriculum is an important part of the collaborative's work. Funded through a grant from the National Science Foundation, the collaborative links the School District of Philadelphia, MISE, and the University of Pennsylvania's Graduate School of Education, School of Engineering and Applied Science, and School of Veterinary Medicine. Teachers of grades 5 through 8 participate in the collaborative's 13-month cycle of programming, which includes two three-week summer institutes and a series of seminars and other activities during the school year.

The summer program uses the university as its base but incorporates frequent field trips to familiarize teachers with the learning opportunities available at nearby locales. After visiting these sites and using the resources they provide, teachers can return with their students for enriched learning experiences. Destinations in recent years have included the Academy of Natural Sciences, the Schuylkill Center for Environmental Education, the Morris Arboretum of the University of Pennsylvania, the Cobbs Creek Community Environmental Education Center,

the John Heinz National Wildlife Refuge at Tinicum, the Philadelphia Zoo, and the New Jersey State Aquarium in Camden.

For other out-of-classroom experiences, Horwitz suggests that teachers look to such community resources as local parks, utility companies, manufacturing plants, and chambers of commerce. No matter what the destination, however, the following tips can help ensure a worthwhile experience for students:

Plan the itinerary carefully so that the field trip has a clearly defined educational focus. Horwitz suggests, for example, that the trip can serve as the means by which students find answers to questions developed earlier in the classroom; or it can be the context in which they develop questions to pursue later. In any case, give students a specific assignment and provide worksheets to keep them on task. On a trip to the Academy of Natural Sciences, NancyLee Bergey, science coordinator for the Perelman Jewish Day Schools of Philadelphia and a master teacher in the Penn-Merck Collaborative, had 2nd graders fill in worksheets on classification as they went through the dinosaur exhibit. Among other things, they looked at the skeletons to determine which were plant-eaters and which were meat-eaters. Bergey says the young paleontologists, armed with clipboards, were “doing science” and felt justifiably proud of themselves in the process.

Always visit on your own first to get a sense of all the facility has to offer. This will help you develop your itinerary and focus. In addition, Bergey notes that knowing as much as possible about a facility will prepare you for dealing with possible snafus. She recalls her experience on the first day of a Merck summer institute for middle school teachers, when she had planned to use a particular pond for an environmental science lesson. She arrived that morning to find the site surrounded by a fence and construction equipment, and a work crew set to drain the pond. Quick action—and a friendly plea to the workers—allowed her to salvage some

of the pond-related activities she had planned, but her knowledge of what the surrounding park offered enabled her to restructure some of the other tasks and maintain her teaching objective.

Make your needs known to the facility you plan to visit. If the facility offers a prepackaged program, review descriptive materials and talk with the education staff of the institution beforehand to make sure the program will be suitable for your students.

Familiarize students with the setting before they arrive. This allows for more efficient use of time and also helps reduce the anxiety that many students—especially young children—may feel in anticipation of the trip. Bergey notes that if students are preoccupied with worries about getting lost or finding a bathroom, they'll be unable to concentrate on the learning that the trip is intended to provide. She suggests taking pictures of the facility—including bathrooms and dining areas—and presenting an orientation slide show for students before the actual visit. Another strategy she's used successfully is having students study maps of the facility. It's a great way to teach map skills, she says,

because the students are highly motivated. If the facility has a Web site, students can use the Internet for a "previsit."

Plan your class trip when the facility is likely to be less crowded—in the afternoon rather than the morning, and early in the week rather than later. Horwitz offers additional words of cautionary advice on this point: Don't wait until June to take a field trip, when the peak visiting season is underway and students are likely to be drifting into a summer vacation frame of mind. "The worst possible field trip experience would take place on a Friday morning at the end of the school year," she says with a knowing laugh.

When she was a museum educator, Horwitz held the view—common among her peers, she says—that museum trips and other out-of-classroom experiences generally were more valuable than what teachers could provide for students inside the school. Now, however, she appreciates the importance of both elements. By bringing together out-of-classroom resources and good classroom instruction, she says, teachers can create the best possible science learning for their students. ◀

Knee-Deep in Learning

continued from page 4

can make the judgments and predictions about the river's water quality.

Using the "Weather" module, students make barometers, thermometers, and other measuring devices. They also investigate the water cycle as they heat water and observe evaporation, capture the rising water vapors in a cold inverted jar, and observe the vapor as it condenses back into water and drips into the original container. Kwiatkowski says that some students inevitably make the connection that the experiment captures the essence of the water cycle.

The "Land and Water" module contains various kinds of soil—from sand and gravel to clay and humus—plus rocks, sticks, grass seeds, and Lego houses in plastic terrariums. Students place the houses on various combinations of



Merck Visual Communications

Observation is fundamental to learning in science.

materials and test which combinations resist water erosion, discovering that rocks, sticks, and vegetation help anchor the soil.

"It's a great motivator," Kathy Edmonds, science resource teacher for the Readington Township school district, says of the trip. "It is an excellent example of an outside resource that ties science lessons into the real world." ◀

... But Are They Learning?

continued from page 3

- ▶ Having an authentic experience, i.e., seeing the real stuff, experiencing actual phenomena, or having access to the accurate, simulated device;
- ▶ Having experiences that involve naming, identifying, observing, imagining, fantasizing, imitating, role playing, cooperating, demonstrating, and discovering; and
- ▶ Being able to covet objects (guiltlessly).

Some of these experiences can be accomplished in the classroom, especially with well-trained teachers and good curricula. Video, the Internet, and visiting experts can help. But museums, zoos, and other informal learning institutions are uniquely equipped to provide a great variety of appropri-

ate settings for affective domain learning. What children learn on their own and can think of as their own personal discovery often has the most lasting effect.

My favorite early indicator of the success of an exhibit is observing a child suddenly step back from the exhibit, look around, and call out, “Hey — come look what I found!” Whether that youngster understood the full science content of the exhibit, or whether the child learned the correct scientific terms to describe the exhibit, it is clear that the child has just claimed ownership over something scientific. If that ownership can be nurtured, reinforced, and connected to later experiences, the basis for a lifelong hunger to learn may soon be in place. ◀

Adapted and reprinted with permission of the Parents League of New York, Inc. The original version of this article appeared in the 1998 issue of the *Review* (Vol. 32, pp. 164–170).

the executive director.

Foundation. Dr. Carlo Parravano is grant from the National Science supported also by a five-year with its partner school districts is the public schools. MISE's work science teaching and learning in Merck & Co., Inc., to improve with a long-term commitment by MISE was established in 1993

About the Merck Institute for Science Education



**P.O. Box 2000
126 E. Lincoln Ave.
Rahway, NJ 07065
732-594-3443
732-594-3977 fax
E-mail mise@merck.com**

