Building Math Capacity

BEAUTIFUL AND USEFUL:
- Emphasizing Mathematics in Science Centers

GEARING UP FOR MATH:
- Professional Development Builds Capacity

FINDING THE MATH:
- A Math Momentum Sampler

MEET MATH:
- A Tool for Cooperation between Palestine and Israel

HANDLING CALCULUS:
- Graphing Motion to Understand Math

BASKETS AND PINEAPPLES
- Indigenous Math Discovery in Brazil
In March 2001, the last time this journal focused on informal mathematics education, ASTC was about to publish Mathematics in Science Centers, the report of a National Science Foundation–funded survey of six institutions. That report closed by recommending that ASTC undertake a capacity-building initiative aimed at enabling more museums to offer mathematics exhibits and programming. Five years later, we mark the conclusion of our three-year participation in another NSF-funded project, Building Math Momentum in Science Centers (MMSC), led this time by the education research and development organization TERC. In this issue, we discuss some of the outcomes of MMSC (see pages 4–9) and also look beyond it to assess other challenges and rewards of the field’s commitment to hands-on math.

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Cover: Around the world, science centers are developing new programs and activities to encourage individual exploration and discovery in mathematics. Photos courtesy (clockwise from upper right) OMSI/Discovery Drawers; Francesco Esposito Met/Meet Math; Museum of Life and Science/Flip It! Fold It! Figure It Out!; St. Louis Science Center/Youth Exploring Science

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To submit news items and ideas for articles, contact Carolyn Sutterfield, editor, 202/783-7200 x130; e-mail csutterfield@astc.org. For editorial guidelines, visit www.astc.org.
My granddaughter, Hanna, is 2 years old, and I have many hopes for her life ahead. One of them is that she will love and enjoy mathematics as much as I do, finding it beautiful and fascinating as well as useful. But as I talk with my students, I get discouraged by how many of them—particularly, but not exclusively, females—say that they are totally turned off to mathematics. They find it intimidating.

I don’t want the same thing to happen to Hanna. That is where science centers come in, for I believe your institutions have a powerful potential to change attitudes about mathematics and to open this ancient field to a much wider audience.

As a teacher of mathematics and a former administrator at two research universities and a liberal arts college, I don’t have any direct experience with science centers. But several years ago, I had the privilege of serving on the National Science Foundation’s Education and Human Resources Advisory Committee. It was then I first began to understand the role that science centers play in the nation’s educational system, especially in attracting a more diverse group of young people to science.

More recently, I served on the national advisory committee for an NSF-funded project at the Museum of Life and Science in Durham, North Carolina: The museum was developing a mathematics exhibition that would travel regionally and nationally. That experience, plus the arrival of Hanna’s second birthday, triggered thoughts about my college students and whether science centers could have helped to shape their early ideas about mathematics in a more positive way.

It is critical to all nations in this new century that their citizens learn to see mathematics not as an enemy, but as a friend—a friend that is engaging and beautiful and of great significance to their lives and futures. For museums wishing to take up that challenge, here, from an amateur who believes in the power of your institutions, are seven ideas for an expanded emphasis on mathematics.

1. Focus on math as a human activity. If possible, ensure that people who love and do mathematics for work or for pleasure are involved in engaging visitors with your math exhibits. If that is not feasible, include photos or videos of different people (including young folks, women, and minorities) engaged in doing math.

2. Include examples of recently solved or still unsolved problems. Choose examples that are easy to state (e.g., the Goldbach Conjecture or the 4-Color Theorem) to illustrate that math is a living field, with many questions remaining.

3. Lead visitors from trivial problems to more conceptual challenges. Examples might include moving from finding the area of a rectangle with given sides to finding the area of a rectangle given one side and the perimeter.

4. Include lots of non-numerical mathematics. Explore, for instance, the development from Euclidean to non-Euclidean geometry (e.g., “When are two ‘lines’ parallel?”).

5. Illustrate applications of mathematics in everyday life. Ratio and proportion are difficult concepts for many children (and adults), but they can easily be illustrated in terms of changing amounts in recipes, making scale drawings, and so forth.

6. Communicate that mathematics abstracts common properties of different systems. Stress that math makes possible insights about different systems simultaneously. Show, for example, how the concept of a “group” is useful in different situations.

7. Target your exhibition to adults as well as students. Parents’ attitudes are likely a powerful influence on how their children will view mathematics. Develop or provide ancillary materials or kits (these could be sold in the museum shop for families to use at home) that reinforce some of the mathematical ideas illustrated in the exhibition.

In the next few years, I hope to see many more science centers actively engaging their visitors in the beauty, wonder, and astonishing utility of mathematics, a critical part of life in the 21st century. If you build exhibitions that do this, it will be a pleasure for me to bring Hanna to as many of them as I can manage!

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Melvin D. George, president emeritus of the University of Missouri, serves as an advisor to the National Research Center and the National Science Foundation.
“Lack of mathematical literacy...raises serious issues for our nation’s production of scientifically literate citizens and workers at every level...[and] is attracting the attention of the scientific and business community to an extent not seen since A Nation at Risk.”—Elizabeth Stage, Director, Lawrence Hall of Science

“The CEO needs to be up front that math is an essential literacy for the future, for public participation, for the economic future of our youth and our workforce.”—Eric Jolly, President, Science Museum of Minnesota

As panelists in the 2005 ASTC Annual Conference session “Gearing Up for Mathematics in Science Centers: A View from the Top,” Elizabeth Stage and Eric Jolly highlighted the “mathematics achievement gap” and offered a compelling case for why U.S. science centers should be working with their communities toward a national goal of giving all children, particularly those from underserved populations, increased levels of proficiency in mathematics.

Their charge to the field—delivered in a session devoted to strategies for introducing or enhancing mathematics experiences for staff—was a reminder of how much more remains to be done. Seven years ago, prompted by the absence of mathematics in ASTC’s science-rich YouthALIVE! programs and by the 1997 report detailing the poor showing of U.S. secondary students in the Third International Mathematics and Science Study (TIMSS), ASTC first invited conversations on the role of science centers in mathematics education.

Those conversations led to the 2001 publication of Andrea Anderson’s Mathematics in Science Centers; to the formation of the Math Special Interest Group that meets annually at ASTC’s conference; and, ultimately, to ASTC’s participation from 2002 to 2005 in Building Math Momentum in Science Centers (MMSC), a three-year, National Science Foundation–funded, mathematics professional development project led by the education research and development organization TERC.

Although summative evaluation of MMSC is forthcoming, several lessons have already emerged for ASTC staff from the observations, interviews, and reflections of participating museum professionals, as well as from the “Gearing Up for Mathematics” session noted above. This article, based on those lessons, is grounded in the “can-do spirit” manifested by the 13 MMSC science centers.

**Acknowledgment of Math Anxiety**

“One of the important things...is to make sure you take care of people who are afraid of math on your staff and, in particular, to help to expand their understanding of what math is.”—Anders Liljeholm, OMSI math team

Math anxiety cannot be ignored! (See “Let’s Replace Math Phobia...,” page 15.) This was the number-one institutional challenge identified by most staff and directors involved in the MMSC project. At their first MMSC workshops, professionals who felt quite comfortable developing engaging experiences in informal science did not necessarily exude confidence about their ability to address mathematics in similar ways.

**Encourage Interdepartmental Collaboration**

“When I laid out my ‘Ruling Reptiles’ idea to our team and explained that I wanted visitors to do what scientists do in the field, the team’s educators came up with strategies for better relating the math concepts to the visitors, particularly children who have no idea of how long a foot
or yard is."—Carlos Plaza, Miami Museum of Science & Planetarium math team

Each of the MMSC institutions appointed a three-person, interdepartmental mathematics team for the project. Composition of the teams and participants’ previous math experience varied (and attrition was a challenge for several teams), but the presence of an exhibits specialist and an educator on each team lent consistency over time. At least eight teams included a youth programs specialist as well.

Team members were charged with finding appropriate ways of applying their science centers what they were learning in the MMSC workshops. Specifically, they were to identify at least one science program or exhibit that could be “mathematized”—i.e., have its inherent mathematics made explicit. (See “Finding the Math,” this page.) All of the teams, even those without math expertise, were creative in recruiting others to help them with this task.

The Sciencenter team, for example, invited a group of dedicated, math-savvy volunteers to help them develop their “How Quick Are You?” reaction time tester. The team at Boston’s Museum of Science organized brown bag lunches to garner advice and support from other departments. The exhibits and education departments at OMSI already had a tradition of collaborating on exhibit ancillaries, but MMSC team members said coordinating math efforts would have been more difficult without the joint professional development. “It made a difference to have advocacy on both exhibits and education simultaneously, rather than having to build on one and then bring in the other,” they concluded.

Utilize external resources

“Rice University School Mathematics Project saw [our museum] as a partner that could…engage families in hands-on exploration of math’s real-world connections as they (Continued on page 9)

Finding the Math:
A Math Momentum Sampler

By Carolyn Sutterfield and the MMSC Teams

Participation in Math Momentum in Science Centers (MMSC), the project led by TERC in collaboration with ASTC, required a major commitment from the 13 participating institutions. In the course of three years, each chose an in-house math team, took part in professional development activities, worked to “find the math” in its existing programs and exhibits, hosted a math-related workshop open to other museums, and developed a project that reflected the institution’s new understanding of, and commitment to, the mathematical content of science. The following accounts are based on the experiences of four MMSC teams. They represent just a sampling of the kinds of challenges and rewards experienced by all of the project partners.

Math in a Box: Oregon Museum of Science and Industry (OMSI)

The Oregon Museum of Science and Industry (OMSI), in Portland, built its Math Momentum project around an existing resource, the thematic Discovery Boxes and Discovery Drawers housed in the museum’s early childhood Discovery Lab.

Each of the 10 large Discovery Boxes contains an integrated curriculum on a particular science topic, with materials ranging from storybooks, puppets, and puzzles to science books, artifacts, activity supplies, and educational toys. The boxes are used by museum educators for story time and reserved lab classes, and they are also available to staff and volunteers in other areas of the museum to use with OMSI’s youngest visitors.

The smaller Discovery Drawers, also thematic, are designed to be used by adults and children together. The 24 drawers are divided into two sets of 12, which allows them to rotate out twice a year for maintenance. Like the larger boxes, the drawers include storybooks, science books, puzzles, artifacts, and toys, along with a simple instruction card that outlines some activities and open-ended questions to encourage children’s learning. Parents frequently spend long sessions exploring these materials with their kids in the lab.

Funding and professional development from MMSC enabled the OMSI team to integrate mathematics into the Discovery Boxes and Drawers. Initially, the idea was to develop a math component for each of the resources (that plan is still in the works). For the immediate task, the decision was made to create several new resources focused specifically on math. The result was a new Weights and Measures
Discovery Box, and four new Discovery Drawers: *Numbers and Counting, Shapes and Patterns, Weights and Measurements,* and *Telling Time.* Each contains instructions for educators and parents and tools for exploration and experimentation, such as measuring tapes, a balance scale, and volume measures.

The response, particularly from parents, has been overwhelming. “What amazes us,” said a team member, “is hearing from parents that (1) they can’t believe their 2-year-olds would be interested in what a balance is or how to use it, and (2) how thankful they are that we provided this opportunity for them to put tools in their kids’ hands and let them explore.”

The MMSC team is especially mindful of the need to increase access to such experiences for children from low-income communities. For the Head Start groups that come to OMSI, or for the families that have recently begun visiting with support from the Latinos en Ciencia Project, a session with the Discovery Boxes or Drawers may be the first time the children have had the chance to see or handle the tools of science and math. “Just having looked through a microscope, having used a balance scale, makes them feel more comfortable,” says a team member, “and raises their confidence level for school.”

**From Mastodons to Master Planning: Buffalo Museum of Science**

For more than 20 years, staff and volunteers of the Buffalo Museum of Science have been working under the direction of Dr. Richard Laub to excavate and analyze the Hiscock site, a paleontological Ice Age dig site in western New York State. Exciting finds have included mastodon jaws and tusks, an Ice Age beaver tooth, and Paleo-Indian artifacts like projectile points. As their MMSC project, Buffalo’s math team decided to combine two museum goals: increasing public awareness of the Ice Age research and incorporating more inquiry-based math activities in exhibits and programs. The result was *Mathtodons & Co.,* a multigenerational experience in the museum’s Byron Dig Experience Lab that focuses on data, measurement, graphing, and ratios.

Ideas came from various sources. In Buffalo’s regional MMSC workshop, held June 28, 2005, participants practiced uncovering math concepts in the museum’s new Connections gallery.
A “Meet the Scientist” session with
the staff paleontologist offered insight
into the ways he uses data and meas-
urement in the field and the labora-
tory. Inspiration also came from
sources like the Family Math books
published by the Lawrence Hall of
Science. “The greatest challenge,”
says one team member, “was trying
to formulate open-ended questions.”

Because Buffalo’s staff works in
cross-departmental “experience
team s” that blend program m ing and
exhibits, it was natural that a math
focus would filter into other areas of
programming, say team members. In
particular, workshop discussions
about equity in mathematics raised
awareness of the need to help en-
hance children’s experiences outside
the museum walls. Buffalo was al-
ready involved, under a different
grant, in providing outreach pro-
gram m ing to 12 underserved com-
munities in northwestern New York
State. Math team members put to-
gether mathematics activities in kits
for 6- to 12-year-olds and distributed
them to community partners.

Recently, the museum completed
a staff restructuring and a new strate-
gic master plan. Though the process
has limited the amount of time and
energy available for projects like
Math Momentum, it also promises
new opportunities in areas like
biomechanics, one aspect of the
museum’s new theme of Biology
and Life.

“This has been the ideal time for
us to do Math Momentum,” says a
team member. “As we plan, it will
be easier to keep math in the back
of our minds.”

Taking Math Home:
Fort Worth Museum of
Science and History

One of the main content
areas at the Fort Worth
Museum of Science and
History (FWMSH), in Ft. Worth,
Texas, is dinosaurs. The museum’s
8,000-square-foot Lone Star
Dinosaurs exhibition, opened in May
2005, introduced five new species
found in Texas within the past 18
years, two of them discovered by
children.

So it was logical that FWMSH
staff would choose to build their
MMSC project around the exhibi-
tion. Five outreach projects were
called for in the original proposal,
which was funded in part by the
National Science Foundation. One
of the collaterals, the Lone Star
Dinosaur Family Activity Guide, was to
be a four-page, take-home publica-
tion, in English and Spanish, that
would support and facilitate post-visit
conversations about dinosaurs. The
target audience was children aged 5 to
11 and their caregivers.

At first, planners saw the guide as
focused on science process skills. But
after staff participated in the MMSC

Contact: Loren Stolow, lstolow@mos.org

New England Aquarium (not an ASTC member)
Boston, Massachusetts
Penguins: An on-site and outreach program for 2nd–4th
grades, focusing on data collection and analysis.
Contact: Billy Spitzer, bspitzer@neaq.org

New Jersey Academy for Aquatic Sciences
Camden, New Jersey
“How Much Food Would You Eat If...?“: A facilitated floor
program that centers on comparing the food consumption
rates of sand tiger sharks and African penguins.
Contact: Cheronda Frazier, cfrazier@njaas.org

Oregon Museum of Science and Industry (OMSI)
Portland, Oregon
Discovery Lab Discovery Box & Drawers (see page 5)
Contact: Marilyn Johnson, mjohnson@omsi.edu

Science Museum of Minnesota, St. Paul, Minnesota
Math Packs: A non-staff-facilitated, standards-aligned school
program that includes tool-filled backpacks for use in muse-
um galleries, on-line background information, and pre- and
post-trip class activities.
Contact: Maija Sedzielarz, maija@smm.org

Sciencenter, Ithaca, New York
“How Quick Are You?” An interactive exhibit where up to
three visitors can test their reaction time by releasing a
pushbutton when a light flashes at random wait times.
Contact: Charlie Trautmann, cht2@cornell.edu

St. Louis Science Center, St. Louis, Missouri
Science Corner (see page 8)
Contact: Lance Cutter, lcutter@slsc.org
Taking a closer look: Science Corner staffer Nao Ueda, right, observes as a YES participant practices making precise measurements. Photo courtesy St. Louis Science Center

professional development experiences, the vision shifted to include math.

In the on-site exhibition, certain areas lend themselves well to basic measurement and data collection. Among them is the Lab, where visitors can use a measuring tape to explore the dimensions of a fossilized dinosaur femur or estimate the weight of a live dinosaur. “People have a tendency to dig into this and try to make sense of it in a mathematical way,” says an MMSC team member. “The participation with MMSC enabled us to ‘extrovert’ the mathematics that was naturally embedded within our new exhibition.”

In compiling the guide, FWMSH staff drew on the prototyping done for the exhibition. For example, after seeing how the measuring tape tool got people actively engaged with the math at the femur station, they came up with simple measuring activities that people could do in their homes and backyards. One thing that parents like to do at frequent intervals is to measure their children: “How tall are you now? How much do you weigh?” Plotting this information allows them to compare family members and see change over time.

The museum’s staff believe strongly in providing phenomena-based experiences with science as a complement to what children get in school. “Having that personal experience makes the science real and acts as a bridge between these two worlds,” says a team member, adding that the same applies to math. Now, when museum planners think about new exhibits, he says, they ask themselves, “How can we help our visitors to ‘see’ quantity? What tool can we provide to help people start quantifying these qualitative things they’re experiencing?”

Staff realize that they don’t have to build math into their exhibits, the team member explains. “The math is there, and it is inside the heads of our visitors, inside their bodies, inside the way they think about the world.... The tendency is to say, ‘Oh, they don’t want to know the math.’ But when there is an interesting exhibit, they do want to see the nuts and bolts. And a lot of times those nuts and bolts are math.”

Doing Math with Teenagers: St. Louis Science Center

The St. Louis Science Center (SLSC), in St. Louis, Missouri, implemented its MMSC project within an existing program for teenaged audiences. The institution had been a participant in ASTC’s 1990s YouthALIVE! initiative for underserved populations, and its current youth programs carry on that work.

The project SLSC chose was a genetics experiment in which the teens attempted to clone carrots in the laboratory. This work took place during summer sessions, under the auspices of the museum’s Youth Exploring Science (YES) program, a four-year, work-based training program that serves children aged 14 to 18 from low-income areas of the city. Many of the students also participated in a math-related outdoor project that compared the rates of growth of two different corn plots over the summer.

The SLSC math team included two programs staffers and the director of community science projects. One challenge they faced was creating an environment where teens could feel successful even if they didn’t have a strong math background. Another was managing the dynamics of small groups, so that a teen who was more competent in math did not wind up doing most of the work. In both projects, the teens learned to use math concepts, such as formulas and ratios, as well as tools like electric scales, to assess their results. Math thus became a means to complete their research, rather than just an abstract activity.

YES is unique among science center programs in that it has its own separate building (the Taylor Center) and its own audience. Participants are recommended by community organizations; there are no academic requirements for acceptance. For half of the day, the students learn about math and science content, and for the other half, they work on life skills.

The math projects were based in the program’s Science Corner, which comprises both a laboratory and an outdoor work site for life science projects. The science center’s commitment to including math in community science programs is ongoing, says the project director. “With every program we do, we now ask ‘What is the math link?’”

Future Science Corner activities will include topics from geometry, such as volumes and solids—“things they will need for their future education,” says a staff member. “Maybe we can push the math a little more,” he adds, “and use the resources we have within the institution. It’s powerful for a teen to be able to say, ‘Yes, I did some calculus.’”

Carolyn Sutterfield is ASTC’s editor. This article was compiled from interviews conducted by Jacquelyn Lowery, assistant director of ASTC’s Partnerships for Learning, in spring 2005. Our thanks to all of the MMSC teams who participated.
(Continued from page 5) pertain to each of the strands of math learning identified by the National Council of Teachers of Mathematics.”—Tammie Kahn, Director, Children’s Museum of Houston

Some MMSC institutions drew on the mathematics resources of local engineers, volunteers, or universities—balancing that expertise by recruiting math educators from local school districts to brainstorm, review plans, clarify mathematics concepts, or determine the age-appropriateness of proposed exhibits or programs.

The Principles and Standards for School Mathematics developed by the (U.S.) National Council of Teachers of Mathematics (www.nctm.org) provided a common language for dialogue between formal and informal educators. A few math team members attended NCTM conferences or workshops, and some began to align their work with the NCTM standards or those developed by their states.

At the 2005 “Gearing Up for Mathematics” session, panelist Linda Gojak, president of the National Council of Supervisors of Mathematics, assured her listeners that formal math educators would be “thrilled” to assist local science centers. Science provides a context for presenting mathematics in a way that is meaningful to kids, Gojak said, adding that the NCTM “Process Standards” (problem solving, reasoning and proof, communication, connections, and representations) are tangible areas in which science centers can help students and classroom teachers.

Support ‘mathematics awareness’ from the top

“[As CEO] you have to provide the leadership, you have to provide the resources, you have to support people putting math in their professional-development planning, and you have to create the partnerships.”—Eric Jolly, President, Science Museum of Minnesota

Mathematics cannot become a strategic priority in any science center or museum without the support of upper-level management. Only advocacy by a CEO and/or senior staff can ensure the creation of a “math culture.” Such a culture evolves through professional development that helps staff focus on math concepts and their applications for science centers and also fosters awareness of the larger context for this work. Mathematics standards, local mathematics curricula, and equity issues associated with local achievement gaps in mathematics are contextual issues that require attention as staff capacity grows.

From the start, senior staff at the MMSC science centers were committed to the concept of math inclusion. Vice presidents from eight institutions participated in project workshops at some point during the three years. CEOs received regular updates from their math teams and met annually during the ASTC conference to review progress and offer suggestions for field-wide capacity building.

One recommendation was to develop an exhibit and program design protocol that includes mathematics. If we are to broaden the pool of museum professionals who have the comfort and competence in mathematics to create and apply such tools effectively, top-level support for ongoing professional development is essential.

DeAnna Beane is director of Partnerships for Learning at ASTC, Washington, D.C. For more information on ASTC’s math initiatives, or to read the text of Mathematics in Science Centers, visit www.astc.org/resource/education/math.htm.

Math Momentum Book Coming Soon

Written by TERC staff and scheduled for publication in 2006, Math Momentum in Science Centers is based on the work of the 13 participating U.S. science centers. The book will be distributed by ASTC.

Throughout Math Momentum in Science Centers, math is seen as a tool for quantifying and communicating experiences in science. The book’s intended audience is practitioners and decision makers in science centers, aquariums, zoos, and children’s museums. Its goal is to inspire institutions to increase access to math for everyone, especially those who have been sidelined by discouraging experiences in school. Nine chapters address the following topics:

- Why Math in Science Centers? A rationale for incorporating more math, as well as a vision of how math can complement and enhance existing scientific and educational missions.
- Getting Started. Creating staff buy-in and comfort through learning math, doing math with colleagues, examining how visitors learn math, and finding out how scientists and other content experts use math.
- Mathematical Challenges. Ingredients and instructions for reaction-time exhibits, catapulting activities, gear activities, and other experiences based on the content areas of data, measurement, and algebra.

- Building Math into Exhibits. What does it mean to “mathematize” exhibits? How can math be made interactive in both mediated and unmediated exhibits?
- Math and Programs for Families. Programs and activities to get families involved in mathematical reasoning, with special attention to cultural and linguistic appropriateness.
- Math in Outreach Programs. A variety of models for integrating math into community, after-school, and youth programs, especially in underserved areas.
- Connecting Schools and Science Centers Through Math. Addressing accountability questions asked by teachers and linking content to school learning.
- Making Math Open to All Visitors. Tapping into visitors’ backgrounds and funds of knowledge.
- Resources for Math in Science Centers. Effective resources for staff development, exhibits, and programs, plus background information on school math reform.

For more details, visit http://mathmomentum.terc.edu.
Meet Math:
A Tool for Cooperation Between Palestine and Israel

By Peter Hillman

When the idea first arose to create a major exhibition as the core of the new Interactive Science Center at East Jerusalem’s Al Quds University (AQU), the small consortium in charge of the project considered a number of themes.

Mathematics might not seem a natural choice, since math is often perceived as inaccessible, abstract, and difficult to make interactive and attractive. Nevertheless, we chose mathematics, and for several reasons. First, we wanted to highlight the major contributions that the Islamic world, along with other cultures, has made to the development of mathematics. Second, we recognized the urgent need of Palestinian (as well as Israeli and Italian) school populations for a program that would enrich the teaching of mathematics. And finally, we welcomed the challenge of doing something new and different.

The “we” in this case was AQU, La Città della Scienza in Naples, Italy (Città), and the Bloomfield Science Museum Jerusalem (BSMJ). All of the partners had had experience in bringing the “joy of science” to the public, and we felt we could do the same for mathematics. The project was developed under the aegis of Ecsite (see sidebar, opposite page), and much of the groundwork, as well as presentation and discussion of preliminary stages, was done at the annual Ecsite conferences.

The process

Development of the exhibition began with the formulation of a rationale and aims, continued with the characterization of content, and finally resulted in a list of specific exhibits and activities. The whole process was supported by front-end evaluation at BSMJ, where Jewish and Arab teachers and potential exhibition visitors were surveyed in an attempt to establish existing attitudes, knowledge, needs, and expectations.

We started by identifying some fundamental questions about mathematics that the exhibition would try to raise (and, in some cases, answer):

- What is mathematics?
- Is it a language of all sciences, or a science for its own sake?
- Is mathematical thinking deductive or inductive?
- Does the mathematician discover or invent the mathematical world?
- What does one mean by saying that mathematics is the pursuit of structure?
- What is the relation between mathematics and the experimental sciences?
- Is there experimentation in math?
- What is a proof, and why does it stand forever?
- What is a mathematical prediction?

- What is the relation between mathematics and aesthetics?
- What do mathematicians look like?

After much discussion, we decided to build the exhibition, which we named Meet Math, around four themes, or “islands”:

1. Number: Most people connect mathematics with numbers, but the concept of “number” has undergone dramatic changes.
2. Shape: Application of mathematical tools to the study and classification of geometric shapes leads to a broadening of our concept of space and to many surprises.
3. Pattern: The search for order and structure is part of our nature, but is also an important mathematical tool.
4. Computing: Although a relatively young field of mathematical research, computing is now central because of its connection to computer science.

Creation of components and activities was divided among individuals and institutions according to expertise. Mathematical content was largely determined (and much of the accompanying material written) by professor Udi de Shalit of the Hebrew University of Jerusalem, in consultation with Italian and Palestinian mathematicians. Overall design of the exhibition—scenery, layout, and exhibits—was the responsibility of the staff at Città; they developed the graphics, managed and administered the project, and were responsible for production of many of the exhibits.

Additional interactive exhibits, most of the exhibition software, and educational activities related to the exhibition were developed by BSMJ, which was also responsible for front-end,
formative, and summative evaluation. AQU designed and built several exhibits (including the featured Entrance Sculpture) and is developing the web site for the exhibition, as well as guiding the process toward its ultimate Palestinian goal.

The exhibition

Meet Math is colorful and light, with a careful mix of intriguing, didactic, and humorous elements. Each of the “islands” is introduced by a thought-provoking quote from a mathematician. Leopold Kronecker’s observation that “God made the integers; all else is the work of Man,” marks the entry to the Number island, for example, while visitors entering Pattern read that “There is no place in the world for ugly mathematics” (G.H. Hardy).

Individual islands include five to nine interactive exhibits. Some are related to the school curriculum, while others are surprisingly remote from what most people consider to be math. All exemplify central questions in mathematics, and many note the distinction between illustrating a mathematical principle and proving it.

Here is a sampling:

• Proportions (Number): By getting people to compare the ratio of their own arm-spreads and heights to those of other visitors (and to Leonardo da Vinci’s “man in the circle”), we show that proportions are pure numbers, independent of absolute size and units of measurement.

• Win $1,000 (Number): Pick a number. If it is even, divide it by 2; if odd, multiply by 3 and add 1. Continue, and you will always end up with 1. Besides illustrating the idea of repeated trials, this exhibit based on a simple game demonstrates how easily stated and apparently true results may be exceedingly difficult to prove. (The $1,000 is a cash prize offered for proving the result or finding a counter-example.)

• The Pythagoras Theorem (Shape): The theorem is illustrated by a colored liquid that flows from a square box on the hypotenuse of a triangle to square boxes on the other two sides. It is proved by manipulation of a tangram—success being clearly independent of the specific angles chosen.

• Geodesics (Shape): Airplanes that fly from Jerusalem or Rome to Los Angeles take a surprising route over Greenland. A globe with elastic strings shows why, illustrating the difference between flat and spherical geometry.

• Sphere packing (Pattern): Not solved for three dimensions until 1998, Johann Kepler’s 400-year-old problem of how to pack the maximum number of spheres into a box is illustrated in two dimensions with a variable-angle rhombus and table-tennis balls. In 2-D, visitors find that hexagonal packing is best (but not easy to prove!).

• The Königsberg Bridges (Computing): The practical problem of how to cross all seven bridges of a German town without recrossing any of them led Leonard Euler to found the important mathematical discipline of Graph Theory. Using a rope, the visitor tries to show how to cross the bridges—and fails, until an eighth bridge is built.

• Design a Person (Computing): A large totem allows visitors to connect one of 5 faces to one of 4 bodies and 3 pairs of legs, illustrating combinatorics, a branch of mathematics that deals with counting, specifically combinations of discrete objects.

In addition to the exhibit islands, Meet Math features a History Piazza, emphasizing intercultural contributions to mathematics; a Discovery Area, where children aged 5–9 can

The Meet Math Partners

BSMJ is a natural partner of the Interactive Science Center (ISC) at AQU. Located only a few miles apart, both institutions are university-affiliated, and both have substantial academic input. BSMJ has also had relatively recent experience both in the creation of a new science center and in hosting Arab teachers and schoolchildren.

In fact, as part of a broader Israeli-Palestinian cooperation in science education, BSMJ and AQU have been working for several years on a pilot project toward establishment of the ISC. AQU had had no prior experience in creating exhibitions, and the partnership has enabled the university to follow an exceptional path toward what will eventually become an independent national science museum.

Nevertheless, political realities mean that mutual access is often interrupted. Difficulties arise from both sides: Israel frequently closes key border crossings, and many Palestinians are hostile to any kind of cooperation with Israel. The result is that it is sometimes easier to meet and work together in Naples than in Jerusalem.

The partnership with Città della Scienza came about through personal contacts between professor Sari Nusseibeh, president of AQU, and Antonio Bassolino, president of the Campania region of Italy. President Bassolino has long expressed a desire to help the Palestinian people; he encouraged Città, AQU, and BSMJ to submit a joint project to the European Union. This project, which became the mathematics exhibition, was accepted and funded by the EU, and received additional support from Campania and UNESCO.

By constructing its own math exhibits, rather than purchasing them, AQU is encouraging development of the necessary human resources for independent operation. And thanks to the success of the Meet Math project and the level of financial support it has attracted, a number of Palestinian companies have come forward, offering their support in building new exhibits for the sake of generations to come.—P.H.
Math as an Equity Issue: Launching After-School Math PLUS

By Preeti Gupta

A basic understanding of math would seem to be essential if individuals are to be productive members of society and function in an increasingly technological world. Yet research demonstrates that many students do not make the connection between their study of mathematics and their future job and career opportunities. Dana Markow and Kathleen Moore report that nearly half of students who decided not to take mathematics and science classes in high school said they did not think they needed these classes, and enrichment activities for members of society and function in an increasingly technological world. Yet research demonstrates that many students do not make the connection between their study of mathematics and their future job and career opportunities. Dana Markow and Kathleen Moore report that nearly half of students who decided not to take mathematics and science classes in high school said they did not think they needed these classes, and enrichment activities for members of society and function in an increasingly technological world. Yet research demonstrates that many students do not make the connection between their study of mathematics and their future job and career opportunities.

After-school programs that specifically address mathematics have been shown to be effective in improving students’ attitudes and understanding, as well as math outcomes. The Family Math program at the Lawrence Hall of Science, Berkeley, California, for example, and the National Action Council for Minorities in Engineering’s SAY YES to Family Math/Science program in New York City have both shown positive effects on parents’ and students’ attitudes about mathematics. Students in California’s Mathematics, Engineering, Science Achievement (MESA) program, which offers counseling, student-centered classes, and enrichment activities for middle and high school students, were much more likely to complete advanced mathematics, chemistry, and physics courses than other high school students in the state were to even enroll in those courses.

In 2004, the Educational Equity Center (EEC) at New York’s Academy for Educational Development (AED) received a three-year National Science Foundation grant for After-School Math PLUS (ASM+). Designed to find the math in everyday experiences and to create awareness among young people in grades 3–8 about the importance of math skills for future career options, ASM+ is being developed in collaboration with the New York Hall of Science and St. Louis Science Center and their local after-school centers.

Now in its second year of development, ASM+ is incorporating best practices from EEC’s existing After-School Science PLUS program, while adding new elements. Besides the museum collaborations, these include using museum explainers from diverse cultural backgrounds; displaying student-created math exhibits in community public spaces; integrating literacy, science, and career role-model components; and offering practical strategies for family involvement with math.

EEC, museum staff, and math experts are developing an age-appropriate curriculum in four theme areas: Jump Rope Math, the Built Environment, Artmath, and the Sound of Math. Activities focus on math concepts, themes, process, skills, and inquiry, and are intended to complement but not duplicate classroom math experiences. In New York, the program is led by after-school group leaders at the after-school site and by instructors and explainer staff at the museum site.

The ultimate goal of ASM+ is to create a standards-based national model with educational materials that can be used by other after-school program/museum partners around the nation. In late 2005, the Louisville Science Center, Louisville, Kentucky, was selected as the first outside field-test site. Based on feedback and evaluation from that project, curriculum will be modified for future science centers.

EEC will be signing up new dissemination sites at the 2006 ASTC Annual Conference in Louisville. To learn more about the ASM+ project, contact AED science program coordinator Maryann Stimmer, 212/367-4574 or mstimmer@aed.org.

Preeti Gupta is vice president for education at the New York Hall of Science, Queens. She recently won AED’s 2005 Roy L. Shafer Leading Edge Award for Experienced Leadership.

Peter Hillman is professor of neurobiology at the Life Science Institute of Israel’s Hebrew University of Jerusalem and founder/science director of the Bloomsfield Science Museum Jerusalem: www.mada.org.il.

Meet Math opened in Naples on October 6, 2005; in February, it will travel to BSMJ for nine months, after which it will move to its permanent home at AQU. There it will form the core of the future Palestine National Museum of Science and Natural History. In all three places it is to be accompanied by a range of educational activities.

A story told by Palestinian team spokesman Awwad Sharaf about the exhibition’s Discovery Area—where drawings and handprints of Palestinian, Israeli, and Italian children make up the scenery—illustrates the challenges and the potential of this cross-cultural work. “You can imagine the joy and pride of the little Palestinian children when we showed them photographs of their paintings with their names...and told them that all this is now on display in Italy,” Sharaf recalls. The children then noticed the paintings with non-Arabic names. Told that these were made by Israeli and Italian children, they initially recoiled. “However, a short discussion among themselves, and with their teachers and the exhibition team,” Sharaf says, “showed them that all children had similar ideas and that it should be possible to work together for a better future.”

Children are not the only skeptics. “We had difficulty convincing others at AQU that our meetings with our partners at BSMJ would lead to something of value,” says Sharaf. “They do not see results on the ground from other agreements. But when the exhibition comes to AQU next year, we hope and expect that attitudes will change, not only about the fruits of scientific cooperation but also about other kinds of cooperation between the two neighbors.”
For their 2001–2005 National Science Foundation–funded project Handling Calculus: Math in Motion, the Science Museum of Minnesota and TERC created a series of interactive exhibits on basic concepts of calculus. In the following article, the co-principal investigator from TERC and the exhibition’s evaluator describe how research into the kinesthetics of mathematical understanding informed development of the exhibition and affected the experience visitors had on the floor.

**Mathematics in the Body**
By Ricardo Nemirovsky

The notion that thinking is an “embodied” activity—that the active human body as a whole, not just the brain, is involved in how we conceptualize situations—has been developed in the writing of philosophers like Maurice Merleau-Ponty and cognitive scientists like George Lakoff.

This bodily basis of understanding was central to the research on motion and mathematics that would eventually inform the Handling Calculus exhibition. But in contrast with other researchers, our intent was not to identify cognitive structures, but to gain insight into how situations involving body motion and symbols look to—and are experienced by—students across levels from elementary school to college.

Many approaches have been developed to account for how people construct and interpret symbolic expressions. Take the situation of the speaker’s utterances and gestures.

How then to capture the dynamics of pointing to something that is partly visible and partly imagined? For our studies, we used different types of motion detectors (i.e., computer devices that generate graphs in real time as one moves one’s body or an object), as well as other tools that can help people to examine phenomena, such as flow or turning wheels, and symbols, like graphs or number tables, by engaging in bodily activity.

We also studied how people move their hands and eyes as they try to make mathematical sense of situations of change. In our research work, we identified different aspects of what symbol-users experience as they construct and interpret symbolic expressions based on the use of a tool like the motion detector.

We participated in these conversations to gain insights not only into how mathematical situations appeared to the students, but also into our own mathematical understandings.

One of the aspects we described was the experience of fusion: the blending of action and symbol. Fusion entails merging the qualities of symbols with qualities of the signified events or situations—i.e., talking, gesturing, and envisioning in ways that do not distinguish between symbols and referents.

The child who plays “horse” with a stick, for example, is aware that the stick is not a real horse. Yet acting, talking, and gesturing as if the stick were truly a horse is at the essence of his or her ability to play, to be part of a make-believe situation.

Fusion is not exceptional or anomalous. On the contrary, it is ordinary and pervasive. It takes place when we use a map to explain to a friend how to get somewhere, or when we read a poem in which the sound of the words is a crucial aspect to what they come to mean. When fusion occurs, the protagonist enters a bodily space in which the symbols and what they refer to become one.

In our study, the students exhibited fusion when they began to speak of the graphs generated by their manipulation of the motion detector in terms of a journey along a particular trajectory.

Another aspect of symbolic understanding is the idea of dwelling in symbolic spaces. Think of a room in your home. As you conduct your life in that room, you do not just “interact” with the room; you dwell in it. Dwelling is a bodily phenomenon through which one’s surroundings become an extension of the body, and in which the things and others present in those surroundings acquire the qualities of being close or far, to the right or to the left, heavy or light, accessible or hidden, and so forth.

Similarly, fluent symbol-users do not merely interact with symbols drawn on a surface; they dwell in spaces that include them. We call these spaces “symbolic places” or, when they involve mathematical activity, “mathematical places.” We see mathematics learning as a process of coming to dwell in mathematical places.

In one of our studies, a student used the motion detector to generate two line graphs simultaneously. She began to swing her arms forward and back in a regular movement, while the computer screen displayed two unfolding graphs of position vs. time, symbolizing the motion of her two arms. Afterward, she told the interviewer, “I thought of getting bigger, bigger, and then smaller, smaller... I just kind of thought of skiing.”

Equate this new experience with a
familiar bodily experience, she entered a mathematical place that included the graphs of position vs. time displayed before her on the monitor.

Observations like these were the background against which we began to design the exhibit experiences that visitors would encounter in Handling Calculus. We wanted to see whether experiences of fusion and graphical space might be possible in the context of a museum exhibition.

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**A Different Way to Do Math**

By Eric D. Gyllenhaal

The interactive exhibits in Handling Calculus linked visitors’ physical actions to symbolic expressions—i.e., graphs—on computer monitors. The project team termed this a “kinesthetic” approach to mathematics. Three exhibits explored the making and interpretation of motion graphs and the calculus concept of differentiation. Selinda Research Associates Inc. of Chicago conducted formative, remedial, and summative evaluations of these exhibits, using a naturalistic methodology and qualitative methods, especially conversations with visitors during and after their use of the exhibits.

Each exhibit provided a different opportunity for visitors to experience fusion between their actions and resulting graphs. At Motion Tracker, visitors took the perspective of the tool, making graphs that showed their own body’s motion over time. As visitors moved back and forth on a long rug, a sensor determined their position continuously, and these data were graphed on the monitor as either a position graph or a velocity graph (the derivative of the position graph). Visitors were challenged to create graphs matching the shapes of on-screen templates, which tested their understanding of their role in the exhibit’s graphical space. (Most were much more successful working in position-graph space; velocity-graph space seemed counterintuitive.)

The evaluators found that users of Motion Tracker had fun and playful experiences. They took away a physical knowledge of what it felt like to make—or, should we say, be—a graph, rather than abstract knowledge about graphs and derivatives.

At Math Tracks, visitors also assumed the tool’s perspective as they moved sliders along a track and watched the resulting position graphs on screen. Visitors could “fuse” in one of two ways, either assigning roles to the sliders and reenacting stories like “A Trip to the Post Office” or “Little Red Riding Hood,” or generating free-form graphs of the sliders’ motions. They could then replay and reflect on these graphs, watching the sliders reproduce their earlier actions as the corresponding graphs were redrawn on the monitor.

The evaluators found that Math Tracks, because of its strong kinesthetic approach, use of stories, and opportunities for reflection, successfully engaged visitors and helped them understand motion graphs in new and different ways. Elementary-aged students developed their understanding of what, for them, was a new kind of graph. Older children and adults often developed a gut-level understanding of motion graphs, comparing that favorably with earlier paper-and-pencil learning about graphs.

At Road Trip, visitors designed trips to cities across the United States, making sure to include food and gas stops and avoid speeding tickets. In this case, visitors used the computer as a tool to control a physical object—a car driving on a vertical track. Rather than moving physically to produce a symbol, visitors manipulated the shape of a symbol of the trip—a position graph on the monitor screen—to produce motion in physical space.

The evaluators judged this exhibit less successful at engaging visitors, in part because the more abstract remote control of the car provided a less kinesthetic experience. Perhaps it was harder to achieve fusion when symbols intervened between the visitor’s body and the physical motion.

Overall, the Handling Calculus team worked hard to achieve this level of success in the three exhibits. These were complex interactivities about difficult concepts, and not all issues of usability and understanding were resolved prior to summative evaluation. It was also a challenge to find the terminology to describe what visitors were doing in Handling Calculus and the concepts to explain what they were taking away from the experience.

A signal achievement of the exhibition was that many visitors understood that they were engaged in a different approach to math, an approach that was both “more fun” and “understandable in different ways” than traditional school math. For some who had struggled with earlier math experiences, this was both a relief and a revelation.

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Let’s Replace Math Phobia with Math Appreciation

By Jaine Kopp

As an advocate over the past 30 years for a mathematically literate society, I am disappointed that I still hear mathematics maligned by so many otherwise intelligent people. In my work with elementary school teachers, for example, too many report that they were “never any good at math” or that “math never made any sense.” Not only do they talk that way about their own math educations; they use their lack of understanding as an excuse to teach out of the textbook, with little thought about the lessons they present. Many find it easier to fall back on rules and procedures (“When dividing fractions by fractions, invert and multiply”) than to teach for conceptual understanding.

My experience is echoed in an early 1990s study by Julian Weissglass, in which math teachers were asked to speculate about the beliefs and values underlying their teaching. From a long list, these commonly expressed beliefs help paint the picture:
- It is all right not to be good in math.
- Math is difficult, and students need to be told what to do.
- People learn by listening and doing homework.
- Mathematics is developed linearly.
- Practice makes perfect.

These views and opinions are not limited to educators; they are echoed in society at large. The comic strip Calvin and Hobbes was famous for its amusing jabs at mathematics. Each time Calvin “freaked out” at realizing that math is part of real life, the humor reflected a universal experience.

When I am introduced as a math educator, I get a variety of responses. Some people stare in disbelief at a woman for whom math was apparently stimulating rather than intimidating. Others “confess” that they barely made it through math or that math was the most difficult subject they ever took. I hear of high school teachers who wrote tirelessly on the board without explanation, or of the never-forgotten embarrassment of “freezing” when called on in math class. For those who suffer from math phobia, these hours spent struggling and feeling unsuccessful have left a false impression of what mathematics is. They have never felt the excitement math can engender when presented in creative, thought-provoking ways.

I like to believe that one day the reputation mathematics has acquired will change, that math literacy will be as valued as reading and writing literacy. I further hope that math will be appreciated for its beauty as well as its utility. One need not understand the intricate mixing of oil paints or the scientific reasons for flower coloration to appreciate the beauty of a painting or a rose. So, too, with math.

The question then becomes, How can the image of mathematics be transformed? Where can educators, families, and society go to explore, build their confidence, and learn to appreciate mathematics?

One answer is science centers. You can do math without science, but you cannot do science without math or its tools. That is why, at the University of California–Berkeley’s Lawrence Hall of Science (LHS), we have endeavored to make mathematics an integral part of the museum and its programs.

As soon as visitors walk into LHS, giant-sized games from around the world invite them to play. Young and old together use patterns, logic, and reasoning to develop strategies and solve problems. Nearby, an entire exhibition, Math Rules, is designed to engage visitors interactively with pattern, geometry, and discrete mathematics. Activities like What’s the Scoop?, which draws the parallel between permutations and the structure of DNA, and Shape Up!, which connects shape patterns to diatoms, move away from the traditional view of mathematics as computation to link math directly with science.

LHS also offers workshops that allow children and parents to do math together through activities like measuring a T. rex footprint and comparing it to their own. In summer, the Wednesday Fun Days include days focused on mathematics. The Family Math project has created resources for families to use at home with kids from preschool to middle school; its workshops for school and community leaders also promote family involvement with math.

In 1999, LHS and UC’s Berkeley Botanical Gardens collaborated on a project that uses the garden as the context for presenting and reviewing math concepts and skills. Designed for children aged 5–12, Math in the Garden accommodates a range of adult leaders, from the math whiz to the scout leader who last took math in high school. The response from participants has been enthusiastic: “[The program] ... was fun, easy to follow, and helped to answer that age-old question, ‘When will I ever use this?’”

These are some of the steps LHS is taking to put math’s best foot forward with the public. It will take a more collective social effort, however, to change entrenched perceptions. A key element of that effort is the mathematics education our children receive.

Because schools have the responsibility of helping students to acquire the math skills and tools they will need to approach and solve problems in real life, it is crucial that we support math educators. Science centers have the opportunity, through our teacher education programs, to create a positive image of mathematics and emphasize its importance. Let’s open the doors of our science centers to teachers, as well as to students and families, and invite everyone to be part of a new trend—math for all, and all for math!

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I must confess that I just published a math textbook. The interesting detail about this is that I cannot read it, and neither could you. Very few people could even recognize the mathematical notation used in it. The title that its collective authors chose is “A guide to keep investigating the way we ‘People from the Anaconda Snake’ count and measure things.”

They, whom we call Tuyuka and who live in the Upper Rio Negro region of Brazil’s Amazon basin, have not yet decided on a formal name for what we call mathematics. Do they need one? They know what they do when they create an ordering for their fishing nets according to the size of their mesh and the corresponding types of fish they catch or exclude. This math is in their book.

Also in the book are detailed drawings of pineapples. The Tuyuka women were happy to investigate the families of lines that appear on the pineapples they cultivate in their manioc gardens and to present their findings in a workshop for teachers and community members.

Acting as advisor to the community and working at the service of their culture, I solicited these investigations beginning in February 2001. Also assisting were the anthropologist who accompanies the indigenous teachers in their effort to alphabetize the kids in their father tongue, and the linguist who has been helping them keep their language alive by writing it down—everybody participating, without a strict standard orthography—so they can freely create their own literature.

My contribution was to propose that counting and measuring are just part of expressing oneself, specialized parts of a language within an overall way of thinking about life. I suggested a few “math” symbols to add to those that represented the sounds in words.

In their own language then, the Tuyuka organized the results of their counting lines on pineapples. They discussed, chose symbols, and noticed the rule among what our culture calls the Fibonacci numbers. They looked for patterns in the world around them and in the tools developed by their ancestors. They uncovered the math hidden in woven baskets. Gradually, they discovered their own math, defined by the language they express themselves in, and became as much at ease within this ethnomathematics as they are within their ethnoreligion.

In the official Brazilian world of formal education, mathematics is part of a globalized pedagogical technique of grading, examining, and discriminating. Indigenous education, imposed by distant secretariats of education, has tried to reproduce this white man’s schooling. But recently some indigenous groups, using the Brazilian constitution’s recognition of an indigenous right to a “differentiated” education, have succeeded in defining their own way of doing education. A new system of indigenous teachers has been created, paid for by the official government bureaucracy.

Almost all of these teachers were previously “educated” by the missionaries who invaded the Amazon basin in the mid-20th century. Forbidden to use their own languages, the students were instructed in Portuguese, mathematics, geography, and history. Quietly, they resisted, dozing through their lessons and never acquiring the white man’s skills. All that the new Tuyuka teachers remembered of math was “the four operations”—and that is what I was invited to help them review.

When I arrived, I asked them to recall their earlier contact with math. They all confirmed that they “did not learn it.” Thus they had not acquired the fear of it common in some Western cultures. I proposed that we look through the stuff of their daily lives for repetitions, regularities, or special organization. And so began their adventure in math discovery.

Thirty-five years ago, Frank Oppenheimer took a similar route, opening the doors of the Exploratorium and inviting visitors in to explore and discover organization and relations in things familiar to them. I did some work of that kind there in the 1990s, exploring multicultural math with teacher colleagues in the Exploratorium Teacher Institute.

This, then, is what the Tuyuka did with their fish nets and their basketry and their food plants. Patterns on objects woven with strips require multi-
examples to fit into a whole; the branching of plants reveals the concept of fractal growth. All of this made sense to them because we did it within the context of their culture, their life, their language.

I was glad then for my time at the Exploratorium. I spoke of what I had learned from other cultures, from Tsalagi weaver Kim Shuck’s “corn numbers” and Inca quipu databases. After discussion, the Tuyuka chose Mayan notation to represent their numbers since their counting also gives special roles to 1 (the Mayan dot), 5 (the Mayan bar), and 20 (the Mayan base and vertical positioning choice).

It is fun to research one’s own culture in all its aspects. The process we engaged in was neither frightening nor painful. No one was being drilled in something, and there were no more teachers as “prison guards.”

That was the term used by one of the indigenous educators, a Tuyuka man who had been forced by the missionaries to teach ethnically different people in Portuguese. Describing to his colleagues and to me how he had just helped a bunch of children find a period among the spiraling leaves of a cassava plant, he said suddenly, “I was a prison guard for 30 years, but now I see the kids being happy.”

Recently, I visited the Tuyuka again for a week. This time, students were present with their teachers. They wanted to move forward with the use of “large numbers” to do operations. We ended up “reading” part of a Mayan book, the Dresden Codex, an activity developed at the Exploratorium for Spanish-speaking teachers.

The Tuyuka’s process of literacy is a true cultural literacy, and it is theirs. In our science centers, if we allow ourselves to think deeper, perhaps we can help our visitors to develop a true mathematical literacy, one based on doing, living, and feeling math amid a rich mix of natural phenomena.

By Suzanne Perin

Does that big coffee mug you prefer really hold more than another mug? Have you ever poured the contents of one into the other to check? What about a wine goblet and a margarita glass? How do they compare? With just such simple queries as these, a popular mathematics exhibition is conceived.

In Flip It! Fold It! Figure It Out! Playing with Math, a traveling exhibition developed at the Museum of Life and Science (see ASTC Dimensions, July/August 2005), visitors explore the mathematics of pattern, shape, and size in a broad cultural context. Activities are based on musical rhythms, paper folding (origami), quilting patterns, and explorations of dimension and volume.

Numbers and formulas are not integral to the design. That the exhibition is about math is made explicit through repeated use of the question “Where’s the math?” and through the use on the labels of easily recognized math terms, such as geometry, estimate, pattern, shape, and size.

Formative evaluation supported this approach, confirming that visitors did not need numbers on a label to believe they were engaged in a mathematical activity and that simply giving parents the appropriate language let them coach their children without having to explain an abstract formula.

There is only one exhibit where we did choose to include a formula on the label, and again that decision was made on the basis of formative evaluation. In Volume Exploration, visitors compare the volume of various cups, glasses, and shapes (yes, even a margarita glass and wine goblet). For young children, a low-to-the-ground free-play area contains five glasses of varying shapes. Using measuring cups, the children count the number of scoops it takes to fill one glass with beads versus another. A process of simple comparison reveals that the glasses all hold the same amount.

For older visitors, two raised workstations provide more structured experiments—and more of a surprise. In one activity, visitors estimate which of two cylinders has a greater volume, a tall, thin cylinder or a short, wide cylinder. The height of the former equals the circumference of the latter. As in the younger children’s activity, the comparison is made by counting the number of scoops it takes to fill the cylinders with beads (or by dumping one bead-filled cylinder into the other).

During formative evaluation, an 8¼-inch by 11-inch plastic sheet was used to demonstrate the relationship between the two cylinders. Rolling the sheet width-wise created a short, wide cylinder, while rolling the sheet length-wise created a tall, narrow cylinder. The relationship between the two was obvious, yet some users were clearly surprised to find that the shorter cylinder held more than the taller one. The notion that a small change in width can make a big difference in volume was lost.

This prompted the question “Why?” We added the formula $V = \pi r^2 h$ (height) to give visitors the clue they need to understand what is going on. Showing that the radius is squared to get the volume makes it obvious to visitors that width has a greater influence on volume than height.

Suzanne Perin, an exhibit developer at the Museum of Life and Science, Durham, North Carolina, was project manager for Flip It! Fold It! Figure It Out! Playing with Math. Evaluation of the project was carried out by Randi Korn & Associates, Alexandria, Virginia. ASTC is touring the exhibition; for information, visit www.astc.org/exhibitions.
Joining the Cyberchase: A Cross-Platform Math Opportunity

The Emmy-award-winning PBS television series Cyberchase, produced by public television station Thirteen/WNET New York, helps young viewers learn new math concepts. Combining mystery, humor, and action, the program features a trio of children, the Cybersquad, that includes female and minority role models. Jackie, Matt, and Inez are not “whiz kids,” but real children who approach mathematics with confidence. Together, the team works to outsmart the bad guys and save a world called Cyberspace. Each episode concludes with a live segment, “Cyberchase–For Real,” where kids learn to use math to solve real-world problems.

As part of its Math Momentum in Science Centers commitment, the Museum of Life and Science (MLS), Durham, North Carolina, developed a resource that incorporates footage from the TV series with companion math “Workshops in a Box.” MLS staffers came up with the idea after attending a workshop led by Thirteen, and Cyberchase producers were happy to help. The target group is students served in the museum’s after-school programming for schools in low-income areas of the city.

“Cyberchase was a great fit for the programming we do and the audiences we serve,” says Nancy Dragotta-Muhl, education resources manager at MLS. “It facilitates problem solving, strengthens content knowledge, and narrows the opportunity gaps that contribute to disparities in math performance.” MLS continues to work with the Cyberchase team as they produce new resources surrounding the show.

Another ASTC member, the Children’s Museum of Houston (CMH), Texas, has recently formed a partnership with the Cyberchase team. CMH has been working since 1998 to “mathematize” programs and exhibits, making math learning experiences more overt for visitors and transforming visitors’ (and staff members’) traditionally negative attitudes about math. The museum’s philosophy—that both children and adults can construct mathematical ideas and use math skills to solve problems in their own lives—aligns closely with the television series’ message. In 2004, the National Science Foundation awarded CMH $1.5 million to develop a traveling exhibition based on Cyberchase.

Visitors to Cyberchase: The Chase Is On! will join the Cybersquad’s adventures in Cyberspace, encountering challenges similar to those seen in the TV series. Visitors will construct, not recite, mathematical ideas by collaboratively solving the quirky problems they encounter. “Like their animated role models, they will develop knowledge and skills as they go,” says a CMH team member. Among these skills will be using nonstandard measurement strategies to solve problems; calculating and comparing area and perimeter of regular and irregular shapes; manipulating objects and numbers to create patterns and break codes; translating between fractions, percent, and decimals; and gathering and charting data to help in making decisions. Cyberchase: The Chase Is On! begins its tour at CMH in June 2007.

The producers of Cyberchase welcome other science center partners. For details, visit www.pbskids.org/cyberchase, or contact Macenje “Che” Mazoka, director of national partnerships, Thirteen/ WNET New York, at mazoka@thirteen.org.


Tips from the Math Forum

By Gene Klotz

Sponsored by Philadelphia’s Drexel University, the Math Forum @ Drexel (www.MathForum.org) was launched early in the history of the World Wide Web as a place where math teachers could talk about teaching. Students and non-school folks with their own interests and curiosities soon discovered the site and joined the conversation. Today, the Math Forum offers much more than discussion.

The following are a dozen math resources—six from the Forum itself, and six from the larger pool of the Internet—that our members would recommend to science centers looking to help their visitors see and understand the math all around them.

On MathForum.org

• Symmetry and Pattern, the Art of Oriental Carpets was created with Carol Bier of the Textile Museum. A nice answer to “Where’s the math?” in one particular world.

• Ask Dr. Math is indexed by grade level and topic, but don’t be put off. The volunteers who answer questions here bring experience and perspectives from engineering, business, government, law, biology, computer science, psychology, and many other areas of life. Post to Ask Dr. Math, making it clear that your question is museum-related, and you’ll get serious attention.

• The Internet Mathematics Library welcomes formal and informal learners (our search engine knows dozens of ways to spell “Pythagoras”). Check Applications/Connections at the end of Mathematics Topics, or look at the Museums section under Resources, subcategory Organizations (let us know how we can improve this area).

• The Internet Newsletter is in its 10th year of weekly reporting on Internet math resources. Many topics here have a science component—take a browse!

• Math Tools is a digital library containing over 3,000 software tools for teaching and learning mathematics. If you don’t see what you want, ask; perhaps a developer can answer your wish.
• Problems of the Week (PoWs) are creative, nonroutine challenges for students that might be helpful for after-school programs. *Technology Problems of the Week* (tPoWs) are now offered in Spanish.

**Beyond the Forum**

There are hundreds of mathematics resources on the Web. The following are a few recently featured in our Internet Newsletter. The first two are high quality and high level; the rest are more accessible.

• *Mathworld* (http://mathworld.wolfram.com) is “a comprehensive and interactive mathematics encyclopedia intended for students, educators, math enthusiasts, and researchers.” A nice resource if you know what you’re looking for; otherwise fun to browse.

• *MathSite* (http://mathsite.math.berkeley.edu/main.html) is an interactive source for seeing, hearing, and doing mathematics.

• *iLumina* (www.ilumina-dlib.org/) is a digital library of sharable undergraduate teaching materials; math downloads include applications for modeling real-world phenomena like world population growth, predators/prey, and marine pollution.

• *Faces of Mathematics* (www.ma.hw.ac.uk/~ndg/fom.html) focuses on 20 influential mathematicians alive today (including four women), revealing the human side of mathematical endeavor.

• *Phyllotaxis* (http://maven.smith.edu/~phylllo/) is an interactive site for the mathematical study of plant pattern formation.

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**Calendar**

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<td>19–25 National Engineering Week (USA). Details: <a href="http://www.eweek.org">www.eweek.org</a></td>
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<td>25– Mar. 5 National Engineering Week (Canada). Details: <a href="http://www.engineeringweek.on.ca">www.engineeringweek.on.ca</a></td>
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<td>19–21 Astronomy from the Ground Up. Tucson, Arizona. First in a series of NSF-funded workshops organized by the National Optical Astronomy Observatory, the Astronomical Society of the Pacific, and ASTC. Details: <a href="http://www.astrosociety.org/afga/">www.astrosociety.org/afga/</a></td>
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<td>8–10 Ecsite Annual Conference. Hosted by Technopolis, the Flemish Science Centre, Mechelen, Belgium. Details: <a href="http://www.technopolis.be">www.technopolis.be</a></td>
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* Information on ASTC RAP sessions is available at www.astc.org/profdev/. For updated events listings, click on “Calendar” at www.astc.org.

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Gene Klotz is the Buffett Professor of Mathematics, Swarthmore College, Swarthmore, Pennsylvania, and founder of the Math Forum @ Drexel. Science centers interested in partnering with the Math Forum are invited to write to him at gene@mathforum.org.
Hospitality Shines at ASTC 2005

We’re still smiling over our recent sunny sojourn in Richmond, where once again an ASTC Annual Conference host outdid itself to welcome science center colleagues. From grits, crab cakes, and oysters to streetcar rides, bluegrass music, and an artistic pig, the Science Museum of Virginia saw to it that everyone got a taste of the authentic American South.

A record number of volunteers (over 1,000 by one count) combined with museum staff to ensure that our October 15-18 gathering was also a memorable business and educational experience. Included among the more than 1,600 registrants were 156 delegates from 40 countries, with the largest non-U.S. contingents coming from Canada (60), the U.K. (20), and Japan (10).

If “Partnerships for Excellence” was the theme, then conversation was the hallmark of this year’s conference. Everywhere you looked, from the 162-booth Exhibit Hall to the first-ever large-scale World Café to the spacious campus at SMV, participants were constantly gathered in clusters, eyes alight, hands gesturing, as they shared their responses to the topics of the day—and perhaps found new partners for future projects.

New and nice this year were the Saturday box lunch in the Exhibit Hall, providing relaxed time for networking and visiting booths; the expanded “CEO Is In” sessions, which attracted early-morning interest from both aspiring leaders and seasoned veterans; and the returning Sunday night banquet, highlighted this year by the moving presentation of the first Roy L. Shafer Leading Edge Awards (for details, see ASTC Dimensions, November/December 2005).

The following are some additional notes from the conference.

Officers and directors installed
Incoming ASTC officers and Board of Directors members, elected in a mail vote by Governing Members, were introduced Saturday at the Annual Business Meeting.

ASTC’s new president is Wit Ostrenko, president of MOSI, Tampa, Florida. Nancy Stueber, president and CEO of OMSI, Portland, Oregon, assumes the vice presidency. Lesley Lewis, director general and CEO of the Ontario Science Centre, Toronto, is the new secretary-treasurer, and Bryce Seidl, CEO of Pacific Science Center, Seattle, Washington, is member-at-large. All of these officers will serve for one year. Science Museum of Virginia director Walter Witschey also passed his title as immediate past president to Per-Edvin (Pelle) Persson, director of Heureka, the Finnish Science Centre, in Vantaa, Finland.

Resigning as directors this year were Peter Giles, who retired from The Tech Museum of Innovation (see “People,” page 24) and Bill Booth, who left COSI Toledo to further his work as an independent consultant. Elected as directors this year were Joanna Haas, director of Carnegie Science Center, Pittsburgh (1 year), and Mary Sellers, executive director of the Science Center of Iowa, Des Moines (2 years). Thanks to all departing directors and officers.

Reelected to three-year terms ending in 2008 are Graham Durant, director of Questacon, the National Science Centre, Canberra, Australia; Erik Jacquemyn, CEO of Technopolis, the Flemish Science Centre; and Chevy Humphrey, president and CEO of the Arizona Science Center, Phoenix. New to the board this year is Charlie Trautmann, executive director of the Sciencenter, Ithaca, New York, whose tenure also expires in 2008. All terms officially begin at the end of the ASTC Annual Conference.

Grinell named ASTC Fellow
At the opening plenary session, the association presented its highest honor, the ASTC Fellow Award for Outstanding Contribution, to Sheila Grinell, former founding president and CEO of the Arizona Science Center (ASC), Phoenix, Arizona, and current interim CEO at California’s Tech Museum of Innovation.

Grinell began her science center career in 1969, when she was hired by Frank Oppenheimer, later an ASTC Fellow himself, to serve as co-director
of exhibits and programs at his newly founded Exploratorium. In 1978, she joined ASTC, later serving as executive director from 1980 to 1982. In 1984, she and Alan Friedman worked together to restart the Hall of Science of the City of New York, now the New York Hall of Science.

As a museum consultant, Grinell has written many articles and books, including *A Place for Learning Science*—a thoughtful analyst and writer, she has, for more than 30 years, offered inspiration to all who seek to start and sustain places for learning science. We honor her exceptional commitment, advocacy, and vision.”

The ASTC Fellow Award goes to individuals who merit special recognition for significant contributions to the advancement of public understanding and appreciation of science and technology or ASTC itself. First presented in 1974, the award was last given in 2003 to Alan Friedman, director of the New York Hall of Science, and Barbara Mikulski, U.S. senator from Maryland and a long-time supporter of science centers.

Pelle Persson presented the award and read the Board and members’ commendation of Grinell: “A respected leader, a passionate teacher, and a

New fellows this year included
- *Regina Fitch*, communications coordinator, New Jersey Academy for Aquatic Sciences, Camden
- *LaNesha DeBardelaben*, associate education curator, Sloan Museum, Flint, Michigan
- *Jasmine Maldonado*, senior science instructor, New York Hall of Science, Queens
- *Rachael Anchel*, education and exhibits programmer, Markham Museum, Markham, Ontario, Canada
- *Myron Bennett*, program director for “Healthy Cleveland,” Health-Space Cleveland, Cleveland, Ohio.

Alumni Fellows attending were Jennifer Correa, manager of Explainers at the New York Hall of Science; Cheronda Frazier, manager of youth and community programs at the New Jersey Academy for Aquatic Sciences; and Valerie R. Oguss, education programs manager at Kidspace Children’s Museum, Pasadena, California.

Our thanks to the four veterans of the field who generously gave their time to work with the fellows at the conference and during the year: Julie Johnson, consultant and former NSF program director; Chip Lindsey, vice president of creative development,
**2005 IMLS AWARDS**

In September, 26 ASTC members were among 161 U.S. museums and libraries that received grants in the following two categories from the Institute for Museum and Library Services (IMLS).

**National Leadership Grants:**
- **Field Museum of Natural History**, Chicago, Illinois: $423,374 to enhance the Cultural Connections program, a partnership of 21 community-based ethnic museums and cultural centers.
- **Peggy Notebaert Nature Museum**, Chicago: $505,080 to expand TEENS (Teenagers Exploring and Explaining Nature and Science) in cooperation with the Field Museum and other environmental and educational organizations.
- **New York Hall of Science**, Queens: $866,674 for Volunteers TryScience (VoTS), a model for ways in which museums can provide training for local scientists and engineers wishing to volunteer their services to education. ASTC is a partner in the project, along with IBM, IEE, and AskNSDL; additional science centers are expected to participate.

**Museums for America:**
- **Berkshire Museum**, Pittsfield, Massachusetts: $100,500 to create a computerized database of its collections in art, natural science, and history.
- **COSI Toledo**, Toledo, Ohio: $148,787 to create and evaluate its interactive Science Café.
- **Denver Museum of Nature & Science**, Denver, Colorado: $118,197 for Project Curiosity; a 13-month effort to increase the museum’s long-term capacity to provide high-quality science content.
- **Explorit Science Center**, Davis, California: $74,800 to boost outreach programs for K-6 students in a 12-county region of north-central California.
- **The Health Adventure**, Asheville, North Carolina: $149,364 to enhance its theatrical outreach program bringing health education to local schools.
- **Kern County Museum**, Bakersfield, California: $60,000 to install an interpretive overlay for its 16-acre outdoor site.
- **Lakeview Museum of Arts and Sciences**, Peoria, Illinois: $140,985 for audience research related to a new regional museum.
- **Maryland Science Center**, Baltimore: $150,000 to develop Cellular Universe, an immersive exhibition focusing on the structure and function of cells.
- **MIT Museum**, Cambridge, Massachusetts: $101,150 to enhance its system for managing collections by expanding capacity, providing more access, and planning for future digital management.
- **Museum of Science**, Boston, Massachusetts: $149,484 for Predicting the Future: The Science and Technology of Weather Forecasting, a project comprising an exhibition, a web site, television spots, live programs for public audiences, and programs for school groups.
- **New York Botanical Garden**, Bronx, New York: $150,000 to expand and enhance the range of educational activities for the garden’s Family Fun Project.
- **North Carolina State Museum of Natural Sciences**, Raleigh: $149,982 to continue its nature and environmental outreach programs to low-resource counties.
- **Peabody Museum of Natural History**, New Haven, Connecticut: $149,800 to expand the scientific scope and reach of the Peabody Fellows Program.
- **San Diego Natural History Museum**, San Diego, California: $139,804 to increase research accessibility to its botanical specimens.
- **Science Museum of Minnesota**, St. Paul: $150,000 to fund programs associated with the traveling exhibition Understanding Race and Human Variation.
- **Staten Island Children’s Museum**, Staten Island, New York: $24,999 to refurbish Bugs and Other Insects.

**Fort Worth Museum of Science and History**; Patrick Lopez, associate director, Explora; and Angela Wenger, executive vice president and COO, New Jersey Academy for Aquatic Sciences.

**Credit where it’s due**

As always, we end with a thank-you to the sponsors who generously support our conference. Total contributions this year came to more than $400,000, with nearly $300,000 of that raised by the Science Museum of Virginia.

Donors contributing $5,000 or more included Silver partners Riggs/ Ward Design, Philip Morris USA, Mr. and Mrs. T. Fleetwood Garner, Barbara Thallhimer, James H. Whiting, and Mr. and Mrs. Robert L. Thallhimer; Emerald partners Natural History, Spitz, Graphics-3, and Kusser Aicha Granitwerke; Turquoise sponsors Panasonic and the Smithsonian Institution’s Lemelson Center for the Study of Invention and Innovation; Jade level donors Dr. and Mrs. D. Rae Carpenter Jr., Dr. Deborah Trainer, Dr. Timothy Hagemann, and Mr. and Mrs. Thomas A. Sneed Jr.; and Jade sponsors Antrak, Ansel Inc., Covington International Travel, Howard Hughes Medical Institute, Jeff Kennedy Associates Inc., LandAmerica, Media General, Spatial Adventures, Survey-Works, and Ukrop’s.

To all of them and to the many additional sponsors of ASTC 2005, we extend our sincere appreciation for your continuing support of the field.

And so it’s on to Kentucky in 2006, for bluegrass, thoroughbreds, and the many “Worlds” of the Louisville Science Center. Gail Becker and her lab-coated friends in Richmond gave us just a glimpse of what’s in store in as we meet October 28-31 to consider “Appropriate Growth: Sustaining Institutional Advancement.” Here’s looking at you, Louisville—save a bourbon ball for us.

Audio tapes ($12 each) or CDs ($15) of many ASTC 2005 sessions are available. Visit www.conventionrecordings.com to see a list or to order. U.S. shipping included; add $1 per item for international.
REAL KIDS, REAL SCIENCE—In April, DragonflyTV, a Public Broadcasting Service (PBS) science show for middle school students, will introduce “Going Places with Science,” a series of seven episodes filmed on location in U.S. science centers. Following the “Going Places with Science,” a series middle school students, will introduce lines at Berkeley’s Bakken Museum and Library this season are electricity” exhibit at Minneapolis’s Science Museum, in partnership with the Cartoon Network. The 6,000-square-foot exhibition, launched at OMSI last October, invites visitors to explore the process of animation and create their own animated sequences through a series of hands-on exhibits.

Science Center, Los Angeles. DragonflyTV is produced by Twin Cities Public Television, St. Paul, Minnesota. Funding for “Going Places with Science” is provided by a $1.5 million grant from the National Science Foundation. A second season, featuring smaller U.S. science centers, is planned. Details: Joan Freese, DragonflyTV manager of promotions, publications, and Web, jfreese@chtpt.org

READY, SET, DRAW—Math, science, and technology complement art in Animation, a new traveling exhibition developed by the Oregon Museum of Science and Industry (OMSI), Portland, in partnership with the Cartoon Network. The 6,000-square-foot exhibition, launched at OMSI last October, invites visitors to explore the process of animation and create their own animated sequences through a series of hands-on exhibits.

A visitor to Animation adds sound effects to his animation sequence. Photo courtesy OMSI

The exhibition has six themed areas:
• History: Visitors can crank out animations on a Penny Arcade mutoscope.
• Animation Studio: Aspiring artists can draw characters, create scenes, and develop a storyboard using layered cels and moving backgrounds.
• Art in Motion: Math emerges as a tool of animation, from the use of geometric shapes in drawing characters to the importance of frame rates in creating the illusion of movement.
• Dexter’s Laboratory: Computers, digital cameras, and time-lapse video combine to create special effects.
• Sound and Stage: Visitors match song phrases to mouth shapes and select background music for a scene.
• Cartoon Museum: Clips of classic and recent animations include The Flintstones and The Powerpuff Girls.

After closing at OMSI in April 2006, Animation will travel to the other members of the Science Museum Exhibit Collaborative (SMEC):
Franklin Institute, Philadelphia; California Science Center, Los Angeles; Museum of Science, Boston; COSI Columbus, Ohio; Fort Worth Museum of Science and History, Texas; and Science Museum of Minnesota, St. Paul.

Details: Elaina Medina, public relations manager, EMedina@omsi.edu

BANKING ON SCIENCE—After operating for several years as a “science center without walls,” Discovery Station at Hagerstown, Hagerstown, Maryland, opened to the public in May 2005. The center now boasts nine hands-on galleries housed in an unusual setting—a 19th-century bank.

Two floors of white marble halls have been converted into a 17,000-square-foot informal learning space. The largest bank vault is now an exhibit area where visitors can examine semiprecious stones and fossils from the nearby C&O Canal. The gallery also includes space for traveling exhibitions.

Two smaller vaults function as a coatroom and library space, and eight converted teller stations will soon house mathematics exhibits. The museum’s Transportation Hall is home to the 2,000-square-foot Hagerstown Aviation Museum. The content in other galleries ranges from dinosaurs and machinery to health science.

Funding for Discovery Station, which currently is run entirely by a volunteer board and staff, is provided by a combination of private and public sources. Many of the exhibits were loaned by Baltimore’s Maryland Science Center or donated by the Smithsonian Institution, Washington, D.C.

Details: Marie Byers, president, bmarbyers@juno.com
The Science Place, Dallas, Texas, appointed **Julio E. Vallella** president and CEO, in September 2005. After a 32-year career as a biomedical electronics engineer, primarily with Texas Instruments, Vallella came out of retirement to accept the position vacated when **Diana Hueter** resigned last July. Hueter continues to serve on the institution’s board.

**Peter Giles**, who retired last March as president and CEO of the Tech Museum of Innovation, San Jose, California, has accepted the directorship of the Mauna Kea Astronomy Education Center, Hilo, Hawaii. He replaces **Marlene Hapai**, who resigned in August. The Mauna Kea center is operated by the University of Hawaii at Hilo.

**Johnetta Stevens** is the new vice president of development and **Phil Lindsey** is vice president of exhibits and programs at The Tech Museum of Innovation, San Jose, California.

Steve was previously vice president of development at San Jose State University, and Lindsey was most recently director of exhibits and design at the Franklin Institute, Philadelphia.

**Frank Steslow** is the new executive director and chief executive officer of the Da Vinci Discovery Center of Science and Technology, Allentown, Pennsylvania. Formerly executive vice president and COO of the New Jersey Academy for Aquatic Sciences, Camden, Steslow replaces **Linda Erickson**, who resigned last March after her husband was appointed president of Ohio’s Wittenberg University.

**Steve Bishop**, former director of the Kirby Science Discovery Center, Sioux Falls, South Dakota, has been appointed vice president of the HarSCO Science Center at the Whitaker Center for Science and the Arts, Harrisburg, Pennsylvania. **Steve Hoffman**, executive director and CEO of the Washington Pavilion of Arts and Science (parent of the Kirby Science Discover Center) will serve as interim director in Sioux Falls.

The Science Station–McLeod/Busse IMAX Dome Theatre, Cedar Rapids, Iowa, announces the appointment of **Joseph Hastings** as executive director. Hastings was previously director of the Center for Museum Partnerships at the Exploratorium, San Francisco. He replaces **Joseph Nolte**, who left in January 2005 to become director of development at Cedar Rapids’ African American Museum.

The new chief executive officer of the National Science Center, Augusta, Georgia (operator of Fort Discovery), is **Norwood R. (Rob) Dennis**. Dennis was previously chief operations officer for CATscan 2000, the Georgia-based mobile health screening company. He replaces **Joe F. Edwards**, who left last January to work for Electronic Data Systems.