

Mathematics in Science Centers

By Andrea V. Anderson

**With assistance from Virginia Thompson,
Mathematics Consultant**

**Association of Science-Technology Centers Incorporated
Washington, D.C.**

June 2001

About ASTC

The Association of Science-Technology Centers Incorporated (ASTC) is an organization of science centers and museums dedicated to furthering the public understanding of science. ASTC encourages excellence and innovation in informal science learning by serving and linking its members worldwide and advancing their common goals. Through a variety of programs and services, ASTC provides professional development for the science center field, shares best practices, supports effective communication, strengthens the position of science centers within the community at large, fosters the creation of successful partnerships and collaborations, and promotes equity and diversity.

Founded in 1973, ASTC now has a membership that includes more than 580 science centers, museums, and related organizations in forty-three countries, making it the largest organization of interactive science centers in the world. Museums and science centers are sites for informal learning, places to discover, explore, and test new ideas about the natural world, and to develop positive attitudes about science. They function as unique resources for families, school children, teachers, and individual citizens. In increasing numbers, these institutions are also places where people of all ages, cultures, and education levels can find common ground. These diverse educational needs are also met by ASTC's many other member organizations, such as zoos, botanic gardens, nature centers, aquariums, planetariums and space theaters, natural history and children's museums.



This research and publication were completed on behalf of the Association of Science-Technology Centers Incorporated. The project was supported by the National Science Foundation (#ESI-9906982). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

© Copyright 2001 Association of Science-Technology Centers Incorporated, 1025 Vermont Avenue, NW, Washington, DC 20005-6310. All rights reserved.

Cover photograph provided courtesy of the Louisiana Arts and Science Center.

ISBN 0-944040-64-0

Association of Science-Technology Centers Incorporated

1025 Vermont Ave., NW, Suite 500

Washington, DC 20005-6310

202/783-7200

www.astc.org

Table of Contents

Acknowledgments.....	ii
Case Studies of Five Institutions.....	1
Background	1
Small Grant for Exploratory Research (SGER).....	1
Method	1
Included in the Report.....	3
Lawrence Hall of Science	5
Equity and Mathematics.....	6
Challenges	7
Mathematics at Lawrence Hall.....	8
Curriculum Products.....	8
Mathematics in Public Programs	14
Teacher Education in Mathematics	21
Lessons Learned.....	23
The Exploratorium.....	27
An Inquiry into Mathematics at the Exploratorium	28
Teacher Education.....	28
Mathematics on the Exploratorium Web Site.....	31
Mathematics Publications.....	36
Mathematics Exhibits.....	37
Partnerships	40
Evaluation.....	40
Lessons Learned.....	40
Fort Worth Museum of Science and History	43
Extraordinary Learning Environments for Mathematics.....	44
Committing to Relationship Building.....	45
Learning Is a Verb.....	45
Mathematics at the Museum.....	46
Teacher Education.....	46
Exhibits and Public Programs	50
Preschool Programs.....	53
Lessons Learned.....	55
Pacific Science Center	57
Mathfinder and the Museum	58
Mathematics at Pacific Science Center	59
Mathfinder Van.....	59
Mathematics Exhibits and Public Programs.....	67
Lessons Learned.....	77
Ann Arbor Hands-On Museum.....	81
A Tale of Two Exhibits.....	82
Mathematics at the Museum	82
Evaluation	96
Lessons Learned.....	96

Findings, Emerging Issues, and Recommendations	99
Findings	100
Emerging Issues	107
Recommendations	111
References	114
Appendix	115
<i>The Principles and Standards for School Mathematics</i>	
National Council of Teachers of Mathematics	116
About the Author	131
About the Consultant	131

Acknowledgments

The author wishes to thank the many individuals who took an interest in, and contributed to, this project. The support from the Association of Science-Technology Centers (ASTC) was particularly valuable, and I wish to express my appreciation to two people who provided significant support and guidance.

I thank Bonnie VanDorn, ASTC Executive Director, for her support in launching a study of mathematics at science centers.

I also thank DeAnna Banks Beane, who helped conceive the project, stimulate interest among science-center people, involve educators from the K-12 public-school system, and secure the funding. She has also been instrumental in visualizing the role science centers might have in helping children understand mathematics.

There were many people from science centers, universities, school districts, and from private and public organizations who contributed to the project. In particular, I wish to acknowledge the site-visit team members and to thank them for their time, insights and their contributions made to the report.

First and deepest thanks go to Virginia Thompson, of Port Townsend, Washington. Although recently retired from the Lawrence Hall of Science, she agreed to serve as the mathematics consultant to this project. She visited each site, contributed her mathematics expertise when reviewing exhibits, programs, curriculum and other publications, and also reviewed the publication chapter by chapter, correcting both grammar and mathematics errors. She also provided the extended explication of the mathematics and grade-level connections for many of the exhibits.

The other site-visit team members were:

Karyn Bertschi, OMSI, Portland, Oregon
Dean Briere, North Carolina Museum of Life and Science, Durham, North Carolina
Angelle Cooper, Scitrek, Atlanta, Georgia
Betsy Hood, COSI, Toledo, Ohio
Marlette Johnson, Scitrek, Atlanta, Georgia
Lori Lambertson, The Exploratorium, San Francisco, California
Jan Luth, Museum of Science and Industry, Tampa, Florida
Mike Naylor, Western Washington University, Bellingham, Washington
Craig Ogden, Atlanta Public Schools, Georgia
David Plude, Seattle Public Schools, Washington
Melissa Thompson, Pacific Science Center, Seattle, Washington
Cynthia Yao, Museum Consultant, Ann Arbor, Michigan

In addition, Francena Cummings, Director of the South Eastern Regional Vision of Education/Eisenhower Consortium for Mathematics and Science, provided a critical connection to K-12 education, gave intellectual direction, and supported certain site-visit team members financially.

I must also thank the directors of each of the science centers visited for their willingness to permit staff to meet with us and discuss their hard-earned lessons about doing mathematics. Likewise, at each science center we met with wonderful individuals who took the time to share their stories, insights and expertise. They are too numerous to note here, but I thank them most sincerely.

Finally, I thank the individuals who stepped forward from other sites and programs, such as the Houston Children's Museum, St. Louis Science Center, and the other institutions now offering mathematics, to share their work.

Andrea V. Anderson
June 20, 2001

Case Studies of Five Institutions

Background

The Association of Science-Technology Centers (ASTC), with funding support from the National Science Foundation (NSF), sponsored a study to ascertain the current status of mathematics in science centers and museums. The charge was to document examples of mathematics exhibits, programs, publications, and workshops in five case-study sites. In part the goal was to determine the feasibility of a mathematics initiative for science centers and their client schools.

A confluence of factors provided the impetus for the study. First came the results of the Third International Mathematics and Science Study (TIMSS), in which the mathematics scores for students in the United States dropped progressively from 4th grade to 8th grade and then finally finished near bottom in the 12th grade.

Second, the YouthALIVE!¹ program sponsored a two-day meeting in Edmonton, Alberta, following the 1998 ASTC annual conference for science-center professionals interested in mathematics. At the conclusion of the sessions, participants recommended further efforts in elevating the presence of mathematics in science centers.

Finally, there was an increased interest on the part of governmental agencies, such as NSF, to find ways to improve mathematics achievement and a willingness to support efforts toward that end.

Small Grant for Exploratory Research (SGER)

Based on the factors mentioned above, ASTC obtained a Small Grant for Exploratory Research (SGER) from NSF to investigate mathematics in science centers and to publish the findings for the museum field and others. The purpose of the SGER project was to find and present models of museum-based mathematics programs and exhibits with an eye toward determining the feasibility of a mathematics initiative for science centers.

Method

Five science centers involved in the Edmonton meeting were selected for site-visits based on

- the willingness of the science center to share its work in mathematics;
- the science center's commitment to explore the potential for a fieldwide mathematics initiative; and

¹ YouthALIVE! (Youth Achievement through Learning, Involvement, Volunteering and Employment) is an ASTC initiative, supported by the Wallace-Readers Digest Funds, that utilizes educational enrichment and employment to integrate adolescents from underserved communities into science center operations.

- the insights to be gained regarding mathematics exhibits, programs, and/or materials and diversity of audiences².

The selected science centers were the Lawrence Hall of Science, the Exploratorium, the Fort Worth Museum of History and Science, the Pacific Science Center, and the Ann Arbor Hands-On Museum. A site-visit team—comprised of museum staff, one or two mathematicians and/or mathematics educators, and the project investigator—spent one or two days at each science center. Data were collected through interviews, observations, and reviews of exhibits, programs, and materials. Each team member participated in a group debriefing following the visit, and several prepared written comments.

Through the site visits, the team intended to learn about the kinds of programs, the types of mathematics, and targeted audiences. In addition, the team wanted to know what modes of delivery were used, whether the science center used or applied *The Principles and Standards for School Mathematics*³ from the National Council of Teachers of Mathematics (NCTM) or state standards, and how effective the efforts were.

The following protocol of questions and concerns was used to guide the inquiry. However, the team was advised, prior to the site visit, that the current staff from the science center might be unable to answer all the questions.

- **Exhibits, programs, and materials description**—Identify the type, focus, and specific content of the exhibits, programs, and/or materials; the goals or intent behind the development of the program; and how explicit/implicit the mathematics is.
- **Development process**—Who was involved in the development (museum staff, school teachers, university faculty, community or business members, special interest groups)? How involved they were? If there had been a pilot effort, who selected the content and chose the medium?
- **Audience**—What age/grade level was intended? Was the audience intended or serendipitous? Was equity a consideration?
- **Role of standards**—The use of either school, district, state, or NCTM Standards.
- **Research or evaluation data**—Does research evidence support achievement of intent?
- **Lessons learned**—What insights should be shared when advising others about replicating the effort? Were these insights either unintended benefits or unintended consequences? What pitfalls can be avoided?
- **Funding sources**—How? Who? How much?

² The sites represent a cross-section of museums, including science centers, a university-linked institution, and natural history and youth museums. A range of “products” was sought, including exhibits, teacher inservice and/or preservice programs, curriculum, trade books, web-based mathematics, and programs for school groups or children with parents.

³ Unless otherwise identified as a state-level framework or standard, all references to Standards, or NCTM Standards, in this report will be in reference to this document.

Included in the Report

Case Studies

The case studies included in this document are intended to give the reader an image of how mathematics can be presented at a science center. For each site descriptions of the mathematics exhibits, programs, or materials are provided. Captioned photographs help the reader understand how the mathematics is portrayed. For some photographs, captions describe what the visitor does and learns in mathematics. Where possible, contextual information is provided about the science center to help the reader understand the philosophy and intent behind the development process.

The reader should be advised that these case studies are not an exhaustive catalog of mathematics offerings at each site. Also, while the corresponding NCTM Standard for each component is provided, the reader should be aware these linkages are after the fact. That is, the science center may or may not have relied on the Standards in the design and development of the exhibit, program, or materials.

Lessons Learned

At the end of each case study there is a section called Lessons Learned, which illuminates issues, ideas or opportunities that emerged during that particular site visit or during the reflections and debriefing of site visitors. The lessons learned helped frame the more general findings summarized in the next section.

Findings

The findings of the entire study are summarized below for the benefit of the reader. However, a more complete discussion of findings and emerging issues can be found beginning on page 99 following the case studies. The findings grow out of the lessons learned and the contributed insights of the site-visit team members, the professionals from each site, and the perspective of the authors.

- Science centers produce various kinds of mathematics exhibits, programs, and materials that serve multiple audiences.
- Science centers provide an important experiential component to the formal mathematics instruction provided by schools.
- Linking exhibits and programs to NCTM and/or state standards makes the science center a valuable resource for the K-12 school population.
- Highest-quality exhibits, programs, and materials come from “intentionality”—where the products were designed in concordance with a particular philosophical or theoretical stance and with commitment to achieving the intended outcome.
- The human resource—staff and advisors—is the science centers most valuable asset for engaging in mathematics conversations and experiences.
- Science centers choose to do mathematics exhibits, programs, and materials type based on what they already do well.

- The exhibits, programs, and materials are more successful and effective when relationships are built with end users as partners, and when partners are equal contributors to the outcomes.
- There is almost no research or evaluation of mathematics learning in science center exhibits, programs, or materials, although the potential is enormous.

Recommendations

Finally, the list of recommendations is reflective of ideas and suggestions offered by site-visit team members, as well as the professionals at the different sites. The reader is urged to review the discussion about each recommendation in the final section of this report. It is recommended that ASTC undertake the following:

- A capacity-building initiative that would enable science centers to offer more and better mathematics in more institutions, nationwide.
- A showcase (conference or workshop) of the current best mathematics exhibits, programs, and materials in science centers.
- Staff development for science-center professionals seeking to include mathematics in their exhibitions, program offerings, or materials.
- The creation of a working relationship with the National Council of Teachers of Mathematics and the American Mathematics Associations.
- The creation of a presence for mathematics by inviting mathematicians or mathematics-educators to address the science center field.
- Evaluation to find out if doing mathematics in science centers makes a difference in visitors' learning or attitudes about mathematics.
- An effort to reach out to universities, colleges, education organizations, and the K-12 school system as partners in achieving improved mathematics understanding by children and adults.