



Ann Arbor Hands-On Museum
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Ann Arbor Hands-On Museum

A Tale of Two Exhibitions and Their Exhibits

The site visit to Ann Arbor Hands-On Museum, Ann Arbor, Michigan, permitted the team to see two exhibitions: Ann Arbor's frequently-traveled *Geometry in Our World* exhibition and *Fun, 2,3,4: All About A Number of Things*, an exhibition created by the Sciencenter, Ithaca, New York. We also heard about Ann Arbor's new *Solve It* exhibition.

Ann Arbor recently brought in a new director, Jim Frenza, who has been challenged with expansion and exhibit-development issues. The museum had recently opened its new space when the site team visited. An expanded area gave toddlers a play space and allowed the traveling exhibition *Fun 2,3,4* ample room for set up. Staff had then turned their attention to developing the oft-delayed *Solve It* exhibition.

Solve It, an NSF-funded project, was still in conceptual stages²⁰ at the time of the site visit. It had undergone significant revision from the time of initial proposal to the blueprint stage. *Solve It* is to be an exhibition on puzzles and problem-solving approaches. Rather than use existing (and consequently well-known) puzzles, the development team was working to create new items. Their intent is to engage the visitor in applying different strategies to obtain a solution.

The two mathematics exhibitions at Ann Arbor during the time of the site visit are the focus of this case study. *Geometry in Our World* is a permanent exhibition at Ann Arbor, with several copies available for traveling. It is an exhibition about shapes: polygons, polyhedra, and Tangrams. *Fun 2,3,4: All About A Number of Things* is an exhibition about counting, measuring, and graphing.

Mathematics at the Museum

Geometry in Our World

As the teachers' guide to the *Geometry in Our World* exhibition notes:

Geometry comes from words meaning "world" and "measurement." [It] arises from humankind's need to describe its surroundings. Many natural objects can be best understood as...geometrical concepts. Some striking

²⁰ *Solve It* opened June 2001. ASTC will help travel this exhibition, starting in 2002.

examples are shells...flowers and animals...soap bubbles and planets... .

Human-made objects are intimately related to the ideas: buildings, bridges...sculpture and painting...games and puzzles. The latest uses of geometry are provided by increasingly sophisticated computer tools.

The *Geometry in Our World* exhibition conceived under the leadership of Cynthia Yao, founding director of the Museum, provides examples of these geometrical objects and concepts. Some invite the visitor to manipulate objects to solve problems and to illuminate mathematical concepts. Some ask the visitor to read and conceptualize ideas. Others simply exist as awe-inspiring examples of geometrical concepts. In all of the exhibit elements, the developers paid attention to the NCTM Standards and the Michigan mathematics standards, including the Professional Teaching Standards²¹ concerning the choice of tasks, teacher and student roles, and the use of tools.

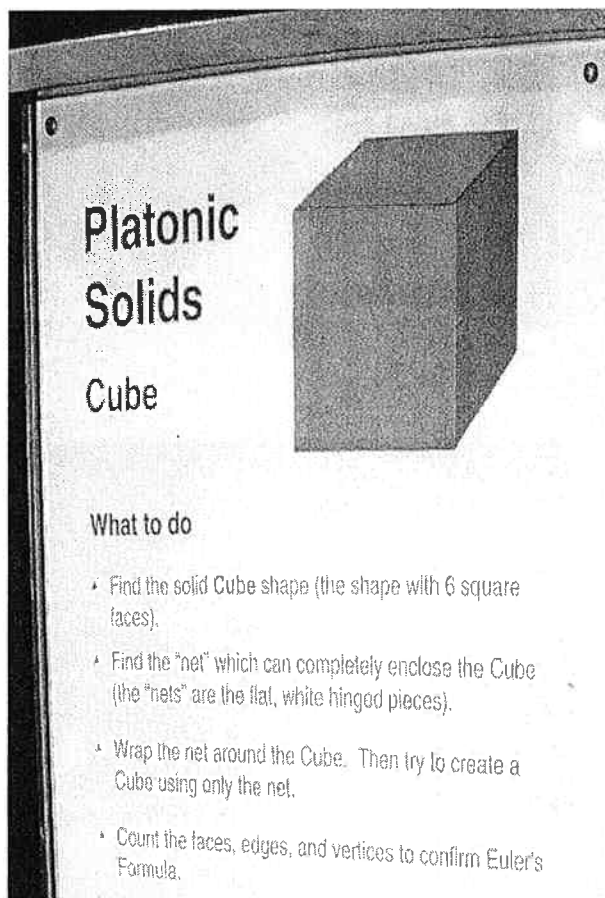
Polygons and polyhedra form a major section of the *Geometry in Our World* exhibition. As a collection of objects, polygons start with points and lines: for example, squares and triangles. If, when looking at objects bounded by polygons, the object appears three-dimensional (such as cubes or pyramids), it is called a polyhedron. The exhibition provides both hands-on components and text.

A kiosk provides a generic description of the five Platonic Solids. Each is a solid figure with outside faces made up of the same regular polygons, with faces, edges, and vertices (corners) exactly alike.

The *cube*, shown to the right, is familiar to most visitors and introduces the idea of faces and vertices. The cube has six square faces, with three squares meeting at each vertex.

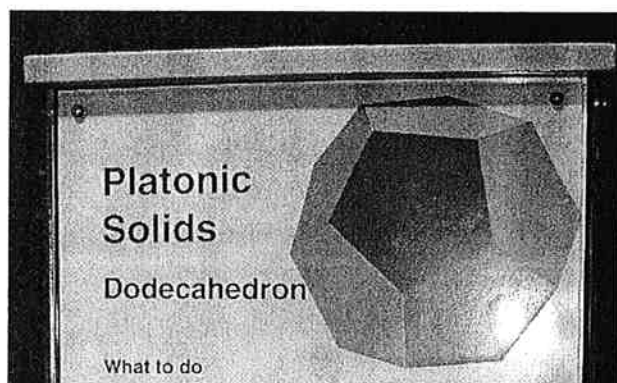
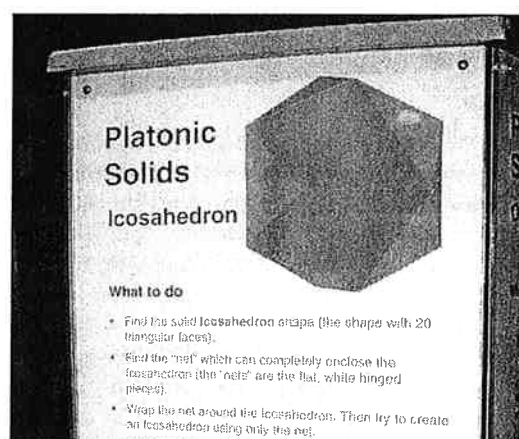
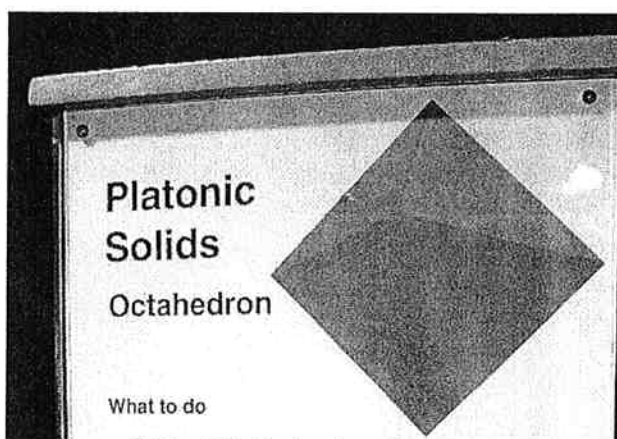
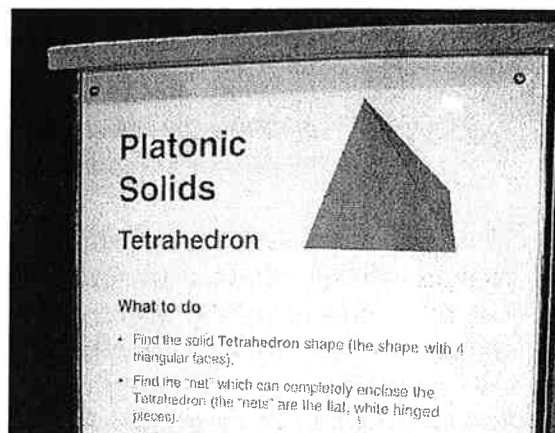
The applicable NCTM Standards are

- Geometry and Spatial Sense (items 3.1, 3.3, and 3.4)
- Patterns and Functions (items 2.1, 2.2, and 2.3)
- Measurement (items 4.1 and 4.2)
- Connections (items 9.1 and 9.2)
- Representation (item 10.3)



²¹ While the draft NCTM Standards, 2nd Edition, are included in the Appendix, the Professional Teaching Standards for Mathematics are not. Please refer to the NCTM web site, www.nctm.org, for more information.

A *tetrahedron* is built from triangles, as is the *octahedron* (below left) and the *icosahedron* (below right).



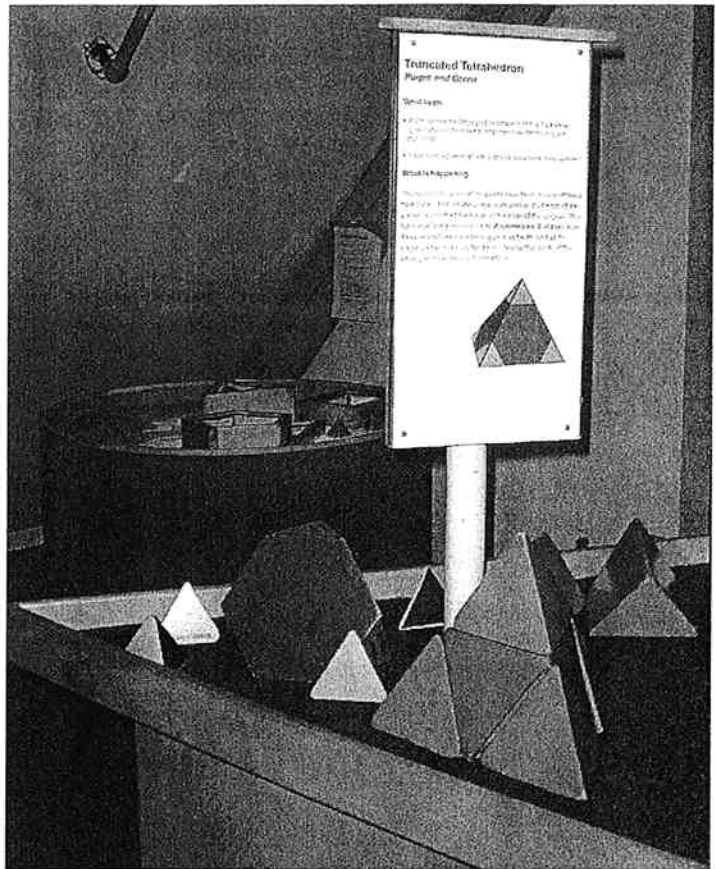
The *dodecahedron* (shown at left) is built from pentagons—five-sided shapes. Each sign asks the visitor to find the "net"—flat, white hinged pieces—which can be folded to enclose the object. Then the visitor is told to count the faces, edges, and vertices to confirm Euler's Formula, which is also described on the kiosk.

Visitors get a chance to “break apart” the solids they read about on the kiosk. In the exhibit at right, the tetrahedron is truncated. The directions tell the visitor to put together the large purple shape and the four small green shapes to make a large tetrahedron (triangular pyramid), then take them apart and look at the faces where they connect.

The copy explains that “truncated” means that the points have been sliced off like a tree trunk. It labels the polyhedron as an Archimedean Solid, and directs the visitor to notice that each of the small green pieces is a tetrahedron.

The corresponding NCTM Standards are

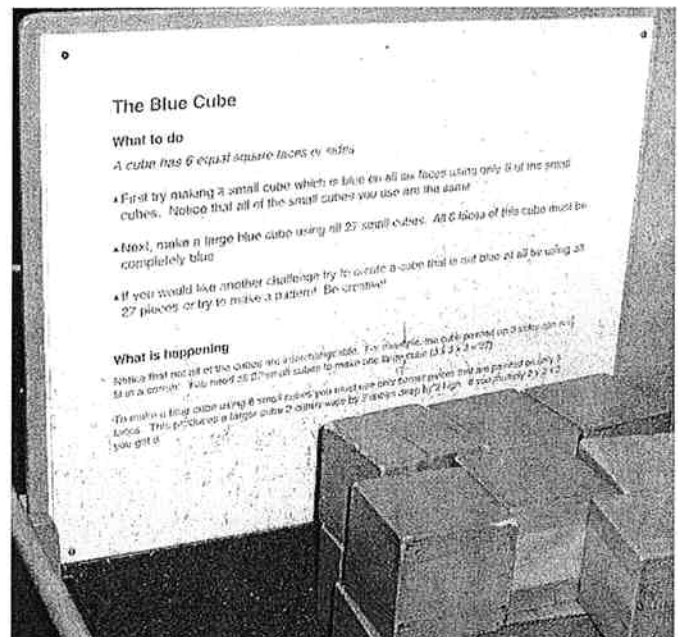
- Standard 2 – Patterns and Functions (items 2.2 and 2.3)
- Standard 3 – Geometry and Spatial Sense (items 3.1, 3.2, 3.3, and 3.4)
- Standard 4 – Measurement (item 4.1)
- Standard 6 – Problem Solving (items 6.1, 6.2, and 6.3)
- Standard 9 – Connections (items 9.1 and 9.2)
- Standard 10 (items 10.1 and 10.3)



Another closely related experience permits the visitor to break apart one large cube, which is painted on the “outside,” into multiple cubes. There are challenges, such as building a 3x3x3 uncolored cube or building a 2x2x2 colored cube.

NCTM connections are

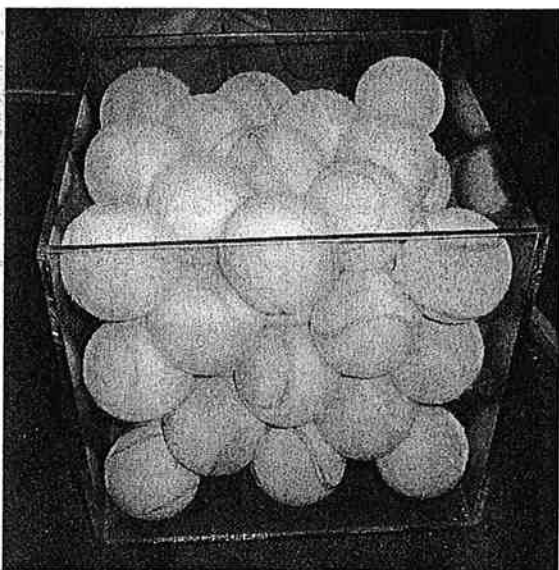
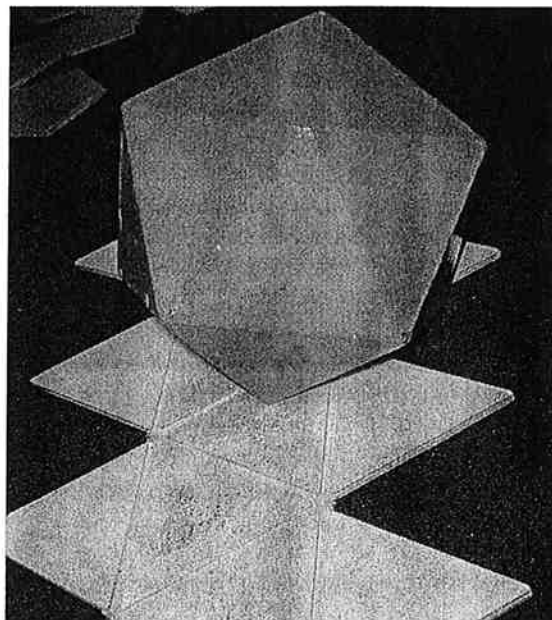
- Standard 1 – Numbers and Operations (items 1.2 and 1.3)
- Standard 2 – Patterns and Functions (items 2.1 and 2.3)
- Standard 3 – Geometry and Spatial Sense (items 3.1, 3.3, and 3.4)
- Standard 4 – Measurement (items 4.1 and 4.2)



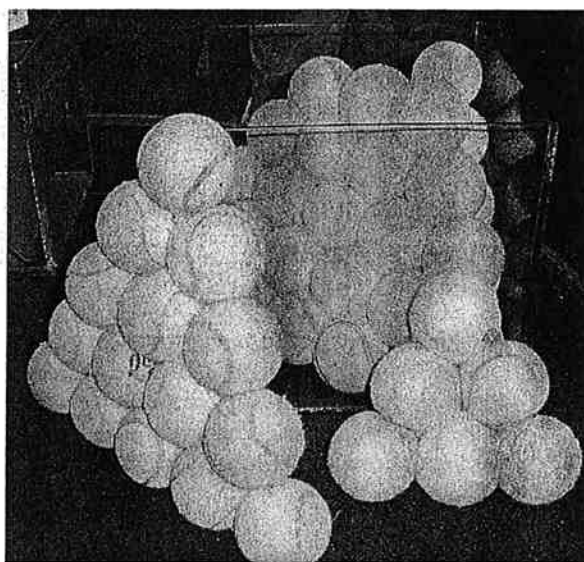
With this exhibit, the visitor sees how a two-dimensional “net” can be folded into a three-dimensional object. The exhibit reinforces the reasoning that connects two and three dimensions. Younger children can explore folding the nets into the corresponding three-dimensional objects. Middle school students can tackle making the nets for three-dimensional objects.

The exhibit reflects

- Standard 3 – Geometry and Spatial Sense (items 3.1, 3.3, and 3.4)



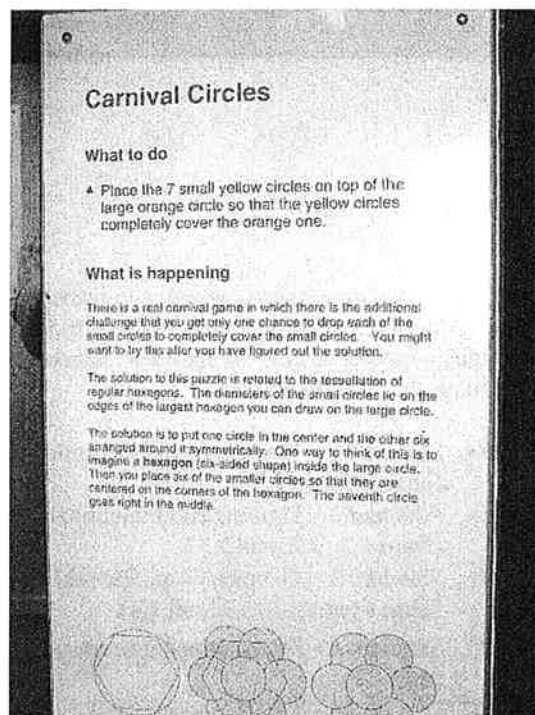
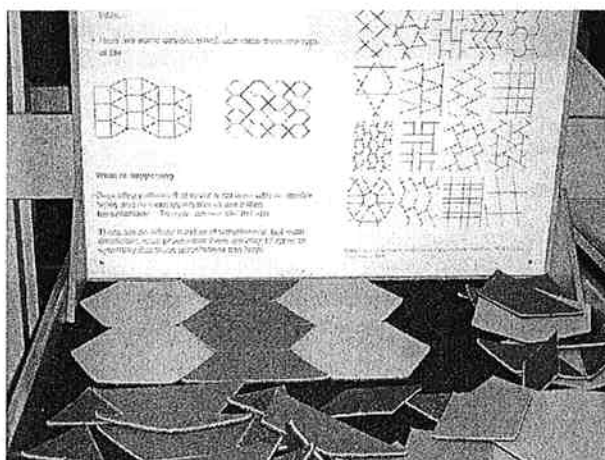
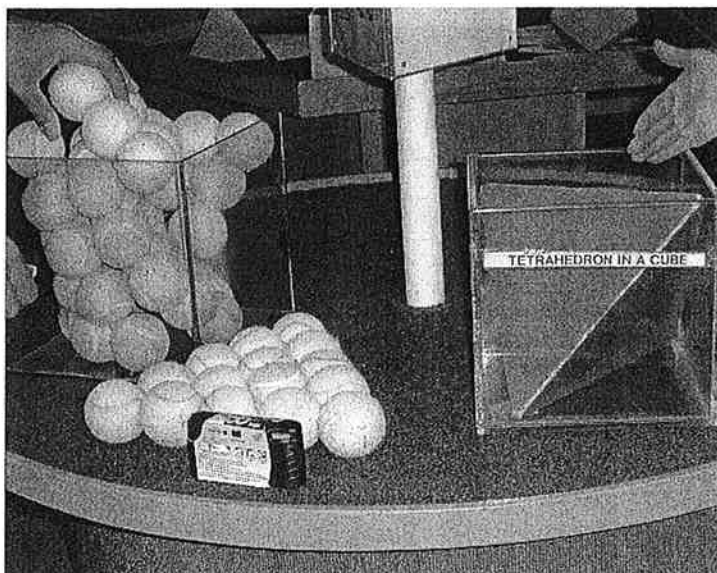
Starting with a clear plastic box filled with tennis balls, the visitor quickly discovers that the balls are fused into triangular shapes. Once the clusters are taken out of the box, the challenge is to replace them.



The applicable Standards are:

- Standard 3 – Geometry and Spatial Sense (items 3.1, 3.3, and 3.4)
- Standard 6 – Problem Solving (items 6.1, 6.2, and 6.3)

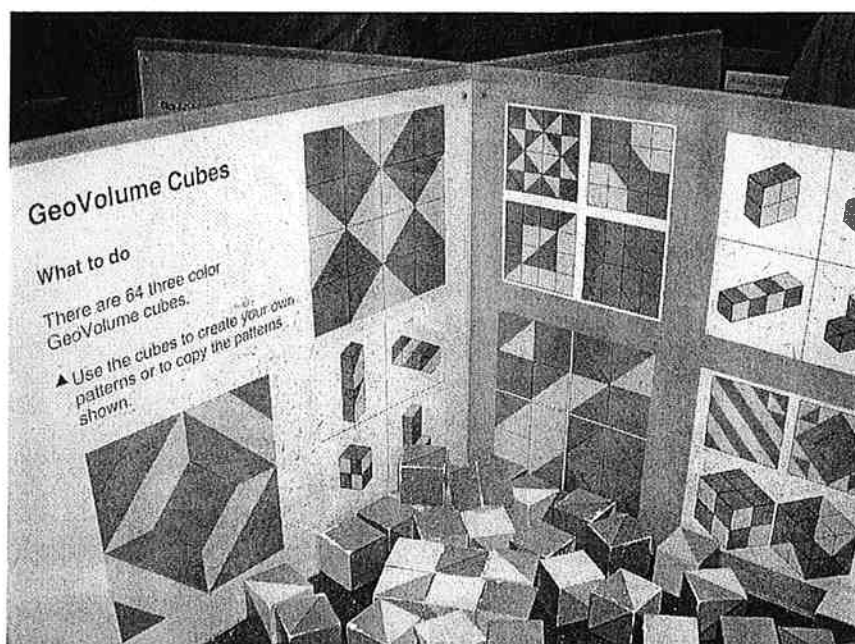
The hint is provided in the model sitting to the right, which includes a tetrahedron in a cube.



Geometry in Our World gives plenty of practice with two-dimensional shapes and patterns. One exhibit invites visitors to make tessellating patterns, which, according to the copy, are repeating patterns that cover a flat area with interior holes and no overlapping pieces. The other exhibit (shown at right) challenges visitors to cover a large circle with as few small circles as possible.

Standards corresponding with these two activities are

- Standard 2 – Patterns and Functions (items 2.1 and 2.2)
- Standard 3 – Geometry and Spatial Sense (items 3.1, 3.3, and 3.4)
- Standard 6 – Problem Solving (items 6.1 and 6.3)



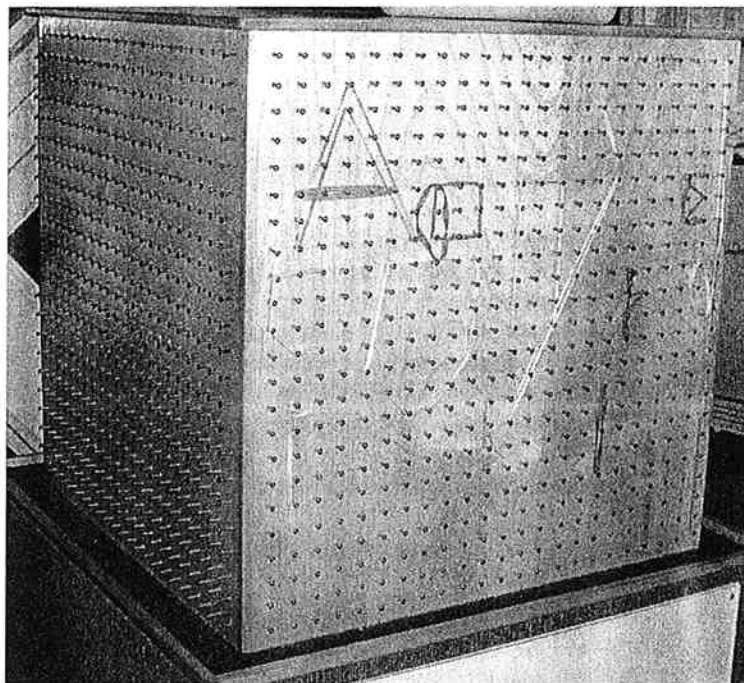
The visitor can also build designs using cubes, which the copy encourages the visitor to do.

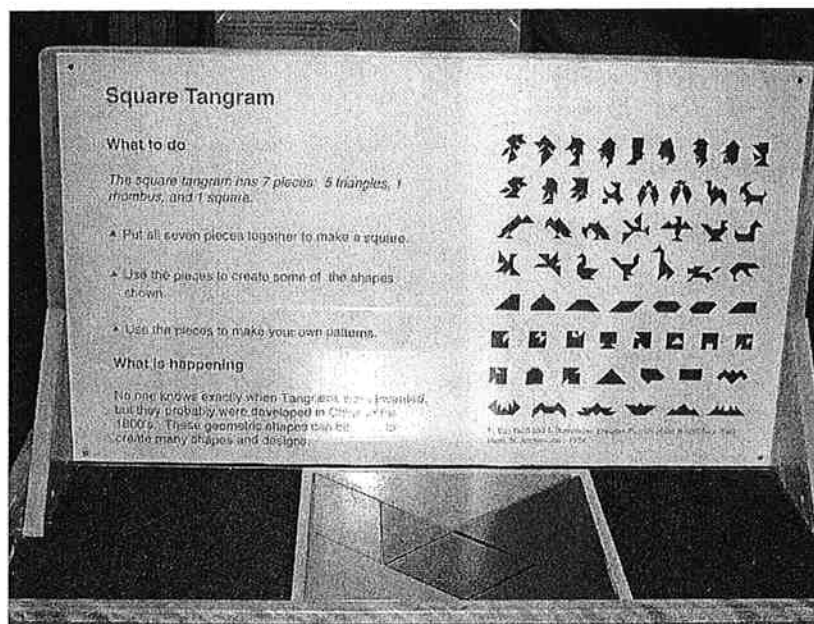
Corresponding NCTM Standards include

- Standard 2 – Patterns and Functions (items 2.1 and 2.3)
- Standard 3 – Geometry and Spatial Sense (items 3.1, 3.3, and 3.4)
- Standard 6 – Problem Solving (items 6.1 and 6.3)
- Standard 10 – Representation (items 10.1 and 10.3)

Plane geometry is also presented in discovery fashion. Many visitors and students discover such concepts as the Pythagorean Theorem using the Geoboard Cube.

- Standard 1 – Numbers and Operations (items 1.2 and 1.3)
- Standard 2 – Patterns and Functions (items 2.1, 2.2, and 2.3)
- Standard 3 – Geometry and Spatial Sense (items 3.1, 3.3, and 3.4)
- Standard 4 – Measurement (items 4.1 and 4.2)

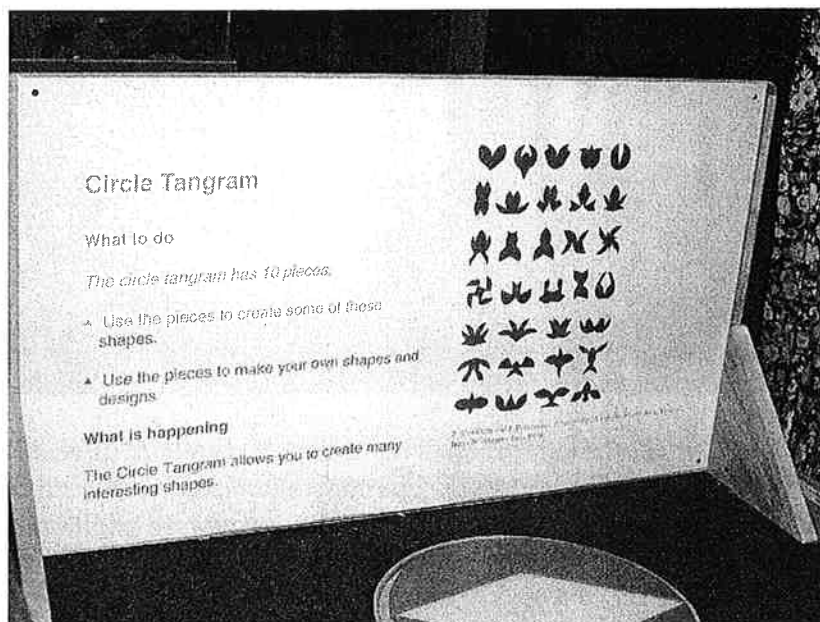




Two different puzzle activities let the visitor explore the polygon shapes in the *Square Tangram* (above) and the patterns resulting from the *Circle Tangram* (below).

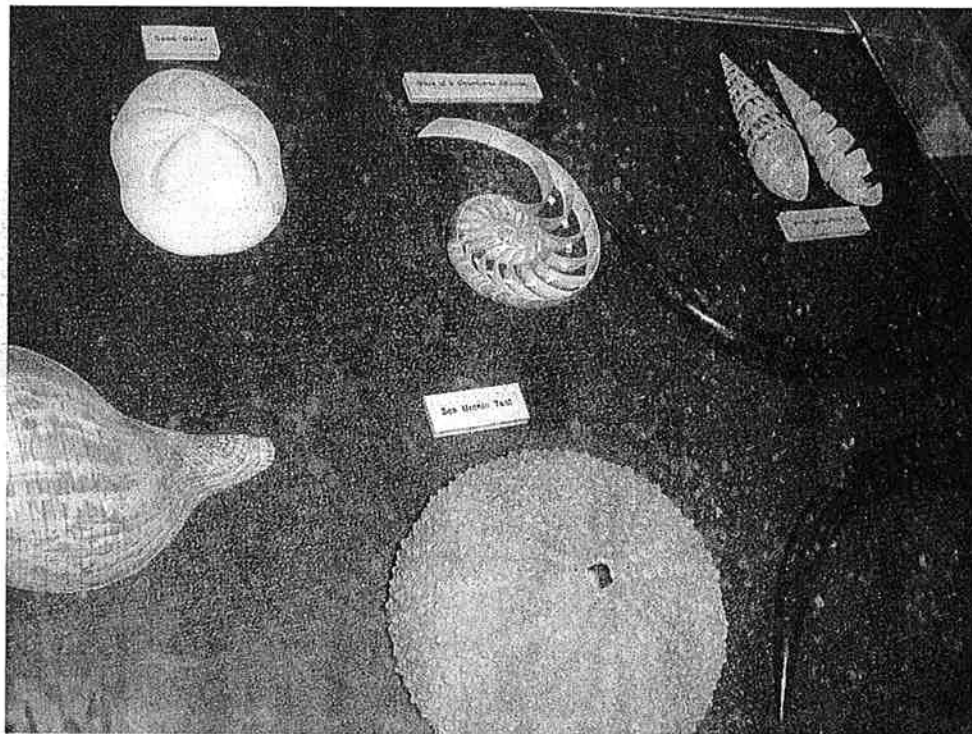
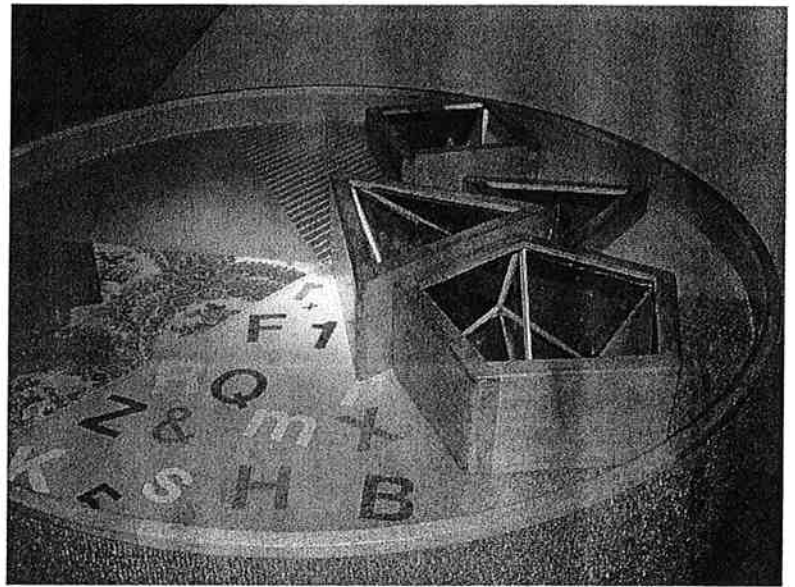
Both puzzles reflect Standards items:

- Standard 2 – Patterns and Functions (item 2.1)
- Standard 3 – Geometry and Spatial Sense (items 3.1, 3.3, and 3.4)
- Standard 6 – Problem Solving (items 6.1 and 6.3)



Mirrors in polygon-shaped boxes let the visitor develop ideas about symmetry. The concepts are then related to real-world objects, such as shells.

- Standard 3 – Geometry and Spatial Sense (item 3.3)



The *Geometry In Our World* exhibition is old and well used, but quite effective in supporting visitors in learning concepts. The copy associated with each component helps the visitor explore the activities and understand the concept. In addition, there is a Teacher's Guide, which expands the activities for classroom use and further explains the concepts.

Fun, 2,3,4: All About a Number of Things

Fun 2,3,4 started when the Sciencenter was a storefront museum in Ithaca. Initially calling it “*Counting on You*,” the museum offered the components as prototype exhibits on counting. When the Traveling Exhibits at Museums of Science (TEAMS) consortium was formed, Charlie Trautman, the director of Sciencenter said, “We have these prototypes and can do a mathematics exhibition.”

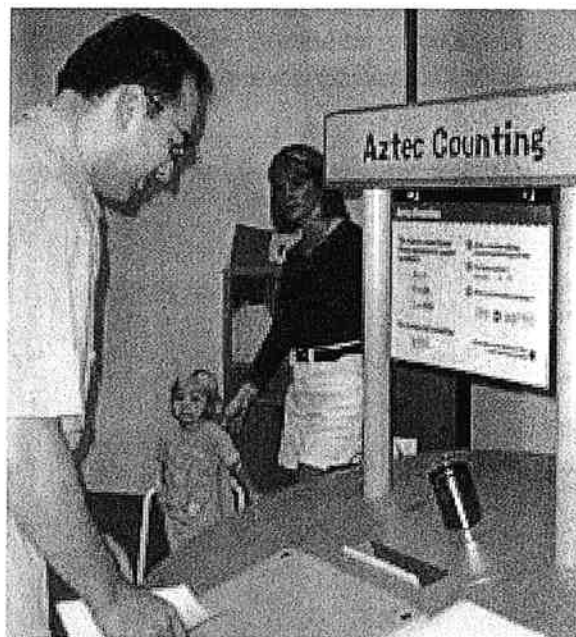
The prototyping process allowed the developers to observe visitor reactions for a significant period of time. In this case, the museum spent 2½ years testing exhibit components. But exhibits tested for a permanent exhibition do not necessarily translate into items for a traveling exhibition. Thus, when the collaborative was formed, Sciencenter used the support from NSF to develop the standards for exhibitions that would travel. Changes were then incorporated into the *Fun 2,3,4* exhibition.

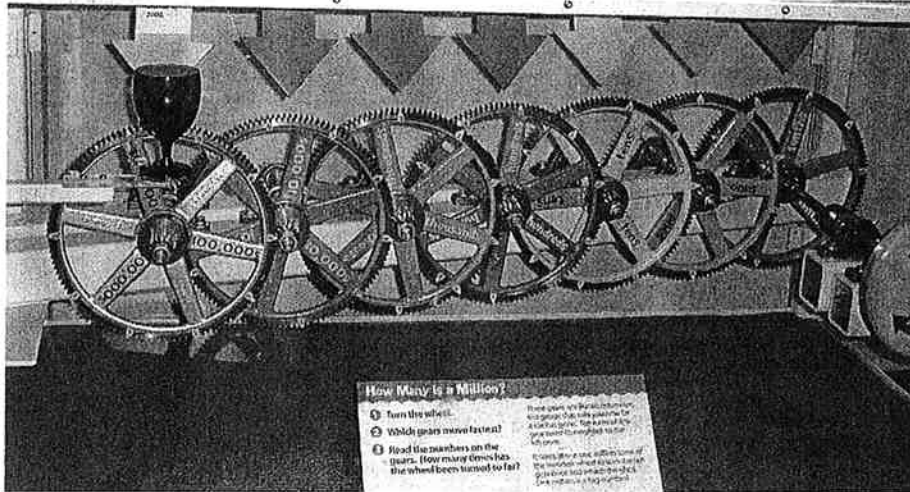
Ultimately, the design team settled on three concepts to address in the exhibition: Counting, Measurement, and Graphing.

Several exhibits in *Fun, 2, 3, 4* help the visitor think about what it means to “count.” Exhibits, such as Aztec Counting (to the right) help visitors see different cultures deal with counting.

Although the NCTM Standards were not used to construct the exhibition, exhibits can be matched to the specific items. Aztec Counting corresponds with Standards items:

- Standard 1 – Numbers and Operations (items 1.1, 1.2, and 1.3)
- Standard 2 – Patterns and Functions (item 2.1)
- Standard 4 – Measurement (item 4.1)
- Standard 10 – Representation (items 10.1 and 10.3)





How Many Is a Million? corresponds to

- Standard 1 – Numbers (item 1.1) and
- Standard 4 – Measurement (item 4.1)

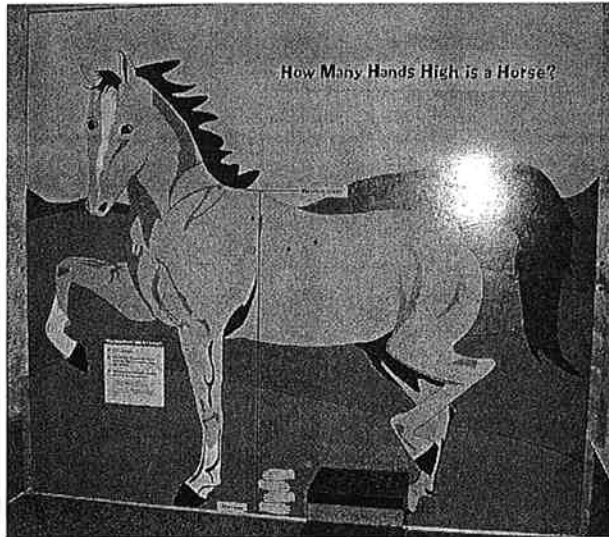
How Many Is a Million? was uninteresting to visitors until the exhibit was modified. Initially, visitors were asked to turn a crank that rotated gears and ultimately counted to 1 million. Essentially, visitors looked at it, tried the crank one or twice, and left. Motivation came when staff placed a wine goblet in such a way that when the count reaches 1,000,000, it shatters. Visitors at first believe they will be the ones to break the glass. Soon they discover how big a million is!



Counting (adding and doubling) forms the basis for the *Double My Allowance* exhibit. Corresponding NCTM Standards include

- Standard 1 – Numbers and Operations (items 1.1, 1.2, and 1.3)
- Standard 2 – Patterns and Functions (item 2.1)
- Standard 4 – Measurement (item 4.1)
- Standard 5 – Data Analysis and Probability (items 5.1 and 5.3)
- Standard 9 – Connections (items 9.1 and 9.3)

Closely related to the counting area, measurement applies counting strategies to understanding “How much?” or “How big?” The following exhibits ask the visitor to make measurements using nontraditional standards.



How Many Hands High Is a Horse? asks the visitor to measure the height of a horse by counting the number of hands from floor to the horse's withers.

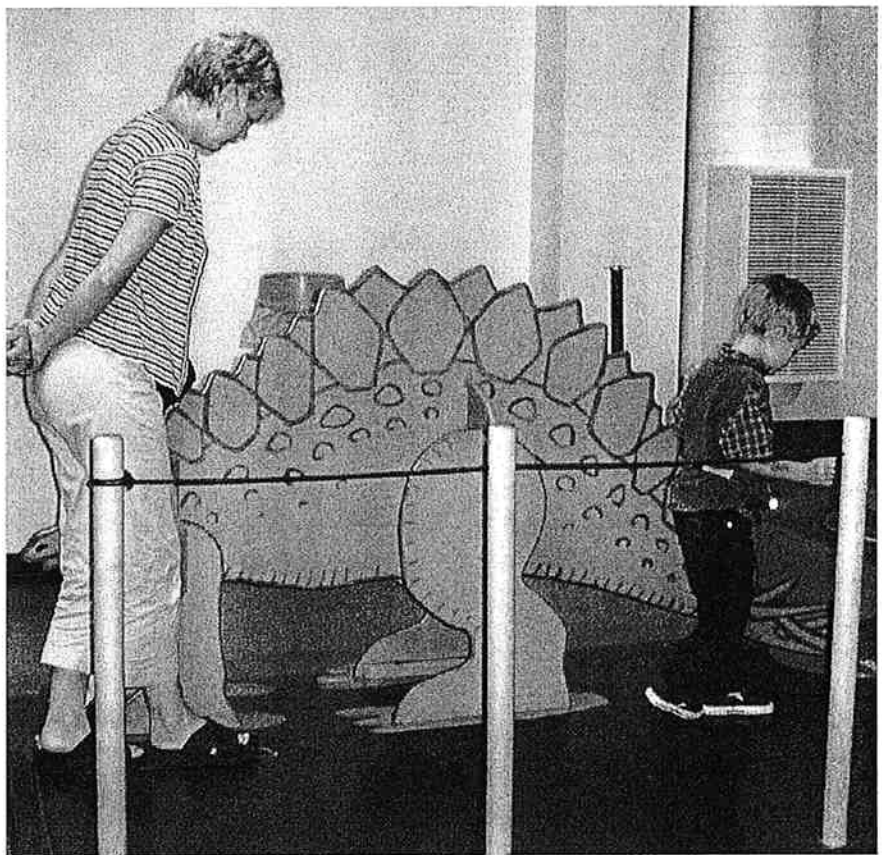
The Standards connections are:

- Standard 1 – Numbers and Operations (items 1.1 and 1.3)
- Standard 4 – Measurement (item 4.1)

Children walk beside the dinosaur, measuring its length in “kid feet.” Very young children have the opportunity to measure using nonstandard units. For older children and adults, the activity opens the door for them to ponder the inverse relationship between the size of the unit (a person's foot) and the number of units needed to measure a set length.

The Standards applied are

- Standard 1 – Numbers and Operations (items 1.1 and 1.2)
- Standard 4 – Measurement (item 4.1)



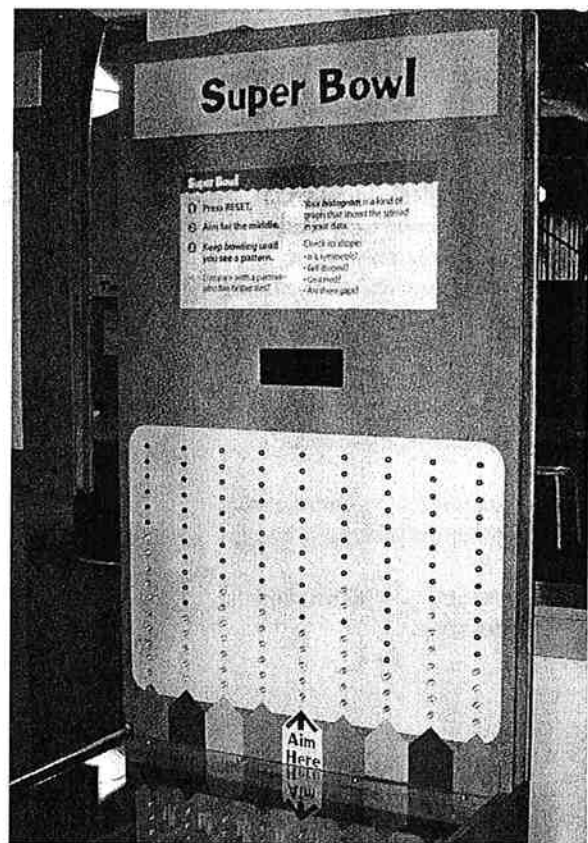


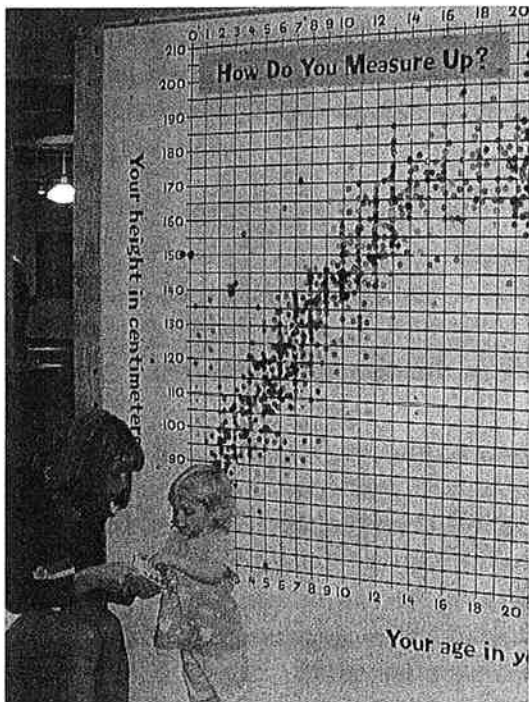
Double the Doggie asks visitors to double the size of the sample plastic-cube dog. It requires that the visitor consider what it means to expand the size of an object in three dimensions.

Standards applied are:

- Standard 3 – Geometry and Spatial Sense (items 3.1 and 3.3)
- Standard 4 – Measurement (items 4.1 and 4.2)

Counting teams up with graphing in the *Super Bowl* exhibit. The visitor rolls a ball down the alley. Where it enters the end point, the mark is scored and graphed. Lights indicate how frequently the ball hits that particular spot.



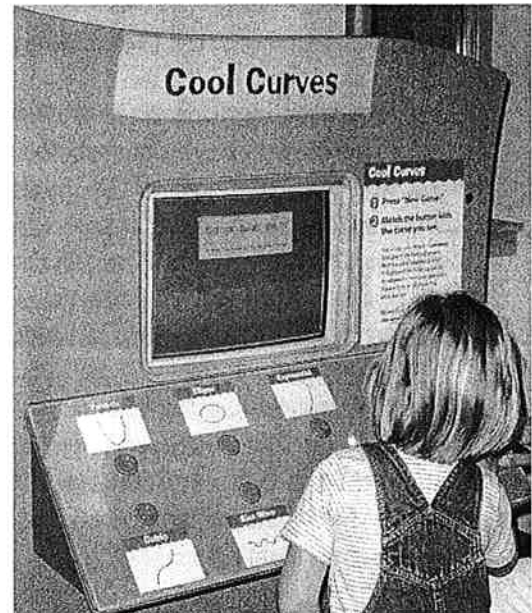


Some of the more popular exhibits are those with graphing components. Visitors of all ages spent time at these exhibits.

In *How Do You Measure Up?* visitors have a chance to compare the pattern that results when each person records his or her height and age in a single point on a coordinate graph. Even young children can see the trend as the number of data points increase. Older children and adults can discuss how the graph is made and the appearance of a correlation between the two measurements.

The graphing components address the following mathematics standards:

- Standard 1 – Numbers and Operations (items 1.1 and 1.3)
- Standard 2 – Patterns and Functions (items 2.1 and 2.2)
- Standard 3 – Geometry and Spatial Sense
- Standard 4 – Measurement (items 4.1 and 4.3)
- Standard 5 – Data Analysis, Statistics and Probability (items 5.2 and 5.3)



Evaluation

Not all exhibitions are evaluated. However, Mark St. John of Inverness Research Associates conducted a summary evaluation of *Fun 2, 3, 4*. The findings from this evaluation are published on the Sciencenter's web page at <http://www.Sciencenter.org>.

Lessons Learned

People use exhibits as they want, not necessarily as the designer intended.

Despite every good intention of an exhibit designer, people use exhibits in the manner that most intrigues or pleases them. This may, in fact, be counter to the intention of the designer and contradictory to the exhibit copy. The difficulty comes when the visitor mistakes the consequences of his or her actions for the concept the copy articulates. For example, in *Super Bowl* most of the young people using the exhibit sought to spike each of the lines of lights. The resulting rectangular block of lights does not exemplify the intended bell-shaped curve. The potential for misconception exists.

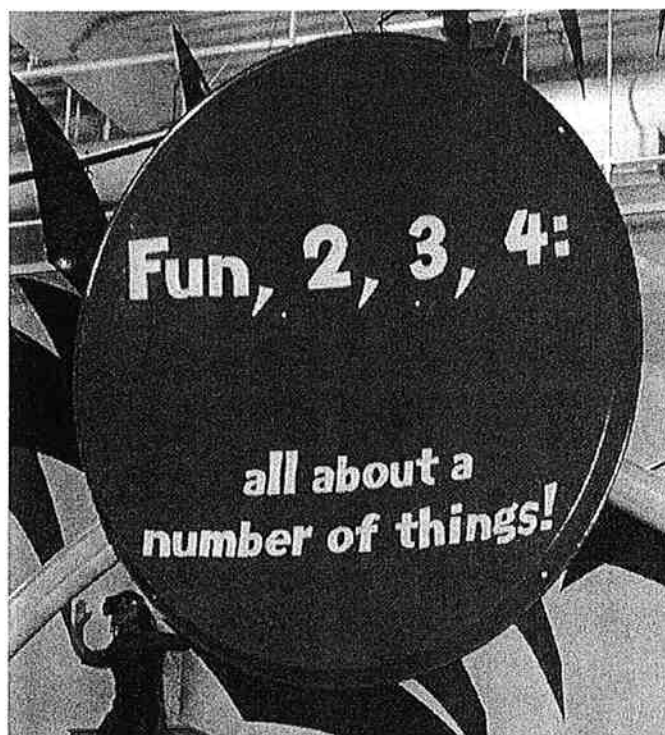
What should be done about an exhibit that shows potential for misconceptions? What is the responsibility of the science center when visitors leave with a misconception generated by an exhibit experience? These questions became a serious topic of discussion among the site-visit team and museum staff. Many professionals in science centers are satisfied if visitors engage with an exhibit. From their perspective, the activity will create a "placeholder" in the person's mind, such that when the idea is revisited in a different context, the concept will then make sense.

Other observers have been more critical of exhibits that, from their point of view, don't work. The exhibit may not work for several reasons, including the fact that the user may be too young to understand the underlying concept. Such was the case for the little girl pulling up the tubes in the *Double My Allowance* exhibit. Until her mother came over to intervene, the child simply pulled the tubes up, looked at the contents, and shoved them down again. Also visitors often do not spend enough time with a given exhibit to construct the exhibit's intended meaning.

More problematic are exhibits in which signage misdirects action, is contradictory, or is simply wrong. The ideas conveyed may cause even sophisticated participants to misconstrue the concepts involved. While not pointing to components of either exhibition presented here, these issues are serious enough to warrant an extended discussion among science center professionals.

Does the word “mathematics” cause people to avoid the exhibits?

The names of both these exhibitions demonstrate point-counterpoint with an issue that surfaced at every site we visited: Do you tell visitors that the exhibit or exhibition is about mathematics? In developing *Fun, 2, 3, 4*, the Sciencenter felt that using certain words, such as “mathematics” or “arithmetic,” would avert interest in the exhibition. They chose the title to be inviting, and clearly there is enough information here to make the mathematics connection. This is not always the case with math exhibits.



On the other hand, Ann Arbor chose *Geometry in Our World* for its mathematics exhibition title. The title seems not to have hurt attendance to the exhibition, but the site-team encountered conflicting attitudes on this issue:

If you use mathematics words, people won't come. If you don't use mathematics language, you trick people—people might come and find the exhibit fun. But they may not decipher that they are doing mathematics.

If a well-used mathematics exhibition is still useful, it should be refurbished, not retired.

There is a tendency among museums to retire exhibits when they show their age. The *Geometry in Our World* exhibition is to be retired, although at this point Ann Arbor Hands On Museum is considering refurbishing its copy with components from the multiple traveling copies. From the content point of view, *Geometry* is still a relevant and useful exhibition. Revitalizing quality mathematics exhibition, such as *Geometry*, is something science centers should consider.