Science Is an Activity

How we came to focus on science thinking skills

Background

The Museum of Science experienced rapid expansion in the mid 1980s: new educational programs and outreach activities, presentation of blockbuster traveling exhibitions, and the addition of a new wing that included an Omnimax theater. Annual attendance grew from 823,000 to 2,233,000 in four years. But the work that built this rapid attendence growth distracted us from developing new long-term exhibits. In fact, we allowed the existing exhibits to deteriorate significantly as we focussed our efforts on building expansion and temporary exhibitions.

So in 1987, after the opening of the *Mugar Omnimax Theater* and the traveling exhibit *India: Festival of Science,* Museum staff began to return its attention to long-term exhibits. At the same time, the Museum administration decided to initiate a strategic planning process for the Museum as a whole. We identified a lot of questions about exhibits in the future that we felt the strategic planning process should answer, but the biggest and most important were about how the exhibits should be organized in our very large museum and what overall message the Museum conveys through its exhibit experience.

Organization of exhibits

When the Museum of Science was established on its current site in 1950, it was decided that the exhibits would not try to be a comprehensive three-dimensional text book. Instead a plan was devised that later became known as the "smorgasbord" approach, a sampling of the most interesting displays from many areas of science side by side. In this way visitors were exposed to a wide range of sciences wherever they went in the Museum. In addition the Museum could demonstrate with the "smorgasbord" the inter-relationships among all of the sciences.

By 1987, the Museum had grown tremendously since its early days at Science Park. And while a random smorgasbord arrangement of the exhibits once suited us, in the larger Museum of 1987 the reaction of the public, teachers, staff, and advisors all point toward the need to better organize the visitors exhibit experience. If possible, we wanted to do this without losing the positive qualities of the smorgasbord that led the Museum in that direction in the first place. So we searched for an organizational scheme that was not strictly by discipline: biology here, physics there, and so on.

Museum main message

The Museum of Science was the first science museum anywhere to combine all the sciences under one roof: natural history, medicine, science and technology. The whole purpose was to show a common thread that ran through all of these diverse disciplines. The overall message created by the Museum was that science is fun: interesting, surprising, satisfying, thought-provoking, intriguing, and accessible. Exhibits were chosen to create positive visitor experiences that perhaps would stimulate a new or expanded interest in science. Our marketing slogans said "Museum of Science, where your horizons broaden" and "Museum of Science, where it's fun to find out."

During our expansion in the 80s a number of new ideas were suggested as main messages for the Museum. " Science is the culture of our times." "The Museum is a powerhouse of science." "Making science is fashionable." "The Museum is a cathedral of science." The notion of cathedral of science was particularly jarring. It suggested that we were a place in which people could come to worship and be in awe of something that was mighty and ultimately unknowable." But the whole attitude of our educational programs and hands-on outreach activities was to convey the notion that science is a way of understanding the world that everyone could participate in, not ultimately unknowable but universally doable.

Science is an activity

As Roger Nichols explained to people the special learning opportunity that the Museum represented, he told a story about a child who came home from school and told his parents what he had learned in school that day. The child said "I learned how to play basketball today." The parent said "Did you learn how to dribble?" The child said "We sure did. We learned that you have to push down on the ball with enough force so that when it hits the floor it will bounce back up to your hand. And you can keep bouncing it over and over again. We learned that you can dribble with your left hand or with your right hand, but never with both hands at once."

"Did you learn how to shoot baskets, too?" the parent asked. "Yes, we learned that, too" said the child. "We learned that you have to throw the ball so that it goes through the hoop. And you can bounce it off of the backboard to get it in. We learned that if you do that you have to get the angle and the force of the ball just right or the ball will miss the hoop."

"So how many points did you make when you played?" the proud parent asked. "Points, I didn't make any points. We didn't play a game." "Well, how many baskets did you make when you practiced?" the parent asked. "We didn't practice" said the child. "We read about how to play basketball in our textbook. Then the teacher gave a short talk about it. At the end, we had a multiple choice test and I got all the answers right. The teacher wrote 'Congratulations, you know how to play basketball better than anyone else in the class.'"

You as a parent would be outraged if your child came home with this story. It is as plain as can be that the teacher in this story had not taught the child how to play basketball. And yet this is exactly what is happening to us every day in the teaching of science. Science is an activity. And yet we too often teach it as a set of facts in the book to be memorized and repeated on exams.

An understanding of science may best be found in a realization of science as a process for understanding the world and for learning new things. It may be more important for visitors to acquire experience with observation, perception, experimentation, imagination, discovery, and thinking like a scientist than to learn any specific facts in any specific fields of science.

This story and the case made by it became the focus of our thinking about the two key questions in our exhibit strategic planning: how the exhibits should be organized and whatthe overall message should be.

Distiguishing science from non-science

The vast majority of the information we have about science, what we were taught in school and the content in textbooks, is about what science has learned about the world around us. If you try to think about how to organize the vast body of knowledge associated with science, everything we have been taught leads to thinking about astronomy, biology, chemistry, geology, physics and do on. And people argue about whether psychology is a science, or even more so about whether sociology is a science.

And what about astrology? What distinguishes astronomy from astrology? Both are grounded in mathematical calculation, both describe and predict, both involve expert knowledge, both have something to do with the planets and their positions and motions. Both astronomy and astrology reach conclusions that are derived from rules and formulas, but in astronomy those rules and formulas are themselves derived from the evidence: from observation, measurement, and experimentation. What distinguishes them is the process by which new knowledge is generated.

I once saw a respected astronomer and well-known astrologer together on a late night talk show. The host interviewed both on the strengths of each discipline and the audience reacted to what they each had to say. The astronomer, though highly knowlegable, qualified his comments, indicating the uncertainty associated with some new scientific ideas. The astrologer, a consummate showman, presented his position with certainty, confidence, and a savvy flair. The audience immediately concluded that the astronomer didn't know much and was of little use, while the astrology had exceptionally valuable knowledge.

Scientific knowledge is very valuable. What makes it valuable is the way in which that knowledge is generated. Scientific knowledge is useful because it is based upon the evidence. But if you do not know how knowledge can be derived from evidence, you totally misunderstand science. You think of it as dogmatic discipline, where answers are based on knowing the rules.

"Our nation is producing a generation of students who lack the intellectual skills necessary to assess the validity of evidence or the logic of arguments, and who are misinformed about the nature of scientific endeavors. . . . students (should) have abundant opportunities to question data as well as experts, to design and conduct real experiments and to carry their thinking beyond the information given. . . . the intellectual challenges inherent in scientific discovery are simply not present in most science courses."

--National Report Card on Science Education

Developing the idea

The mission of the Museum of Science is "to stimulate interest in and further understanding of science and technology and their importance for individuals and society." How could the exhibits further an understanding of <u>science</u>, rather than an understanding of rocks, or birds, or electricity, which is what we have traditionally done? And if in this goal is our new main message, how does that influence how we organize the exhibits in the Museum?

We looked to the writing of great scientists for insight into how we might define science.

"It is not possible to appreciate the deep conceptions that science has created, and the beautiful discoveries which express them, unless we do something to recreate them for ourselves. This is a hard saying but it is true."

-- Jacob Bronowski

science 1. The observation, identification, description, experimental investigation, and theoretical explanation of natural phenomena. 2. Such activity restricted to a class of natural phenomena. 3. Such activity applied to any class of phenomena.

(first three definitions from American Heritage Dictionary)

"The principle of science, the definition, almost, is the following: The test of all knowledge is experiment. Experiment is the sole judge of scientific "truth" . . . but also needed is imagination to create. . . the great generalizations -- to guess at the wonderful, simple, but very strange patterns . . .

(Richard Feynman, from the Lectures on Physics)

Phil Morrison argued in a lecture he gave here at the Museum for Science Frontiers a few years ago, that the great advancement of science in the short time it has existed, and its greatly increasing rate of growth, is the result of our increased ability to observe and perceive things that were not seen before. One of the great advances in science was made by Galileo when he used the telescope to observed objects in space that had not been seen before. Observation of the moons of Jupiter in 1610 cast serious doubt upon the belief that all heavenly objects circled the Earth. For here are some that circle Jupiter. Galileo's observations confirmed a different model and changed our entire understanding of the solar system.

"No scientific theory is a collection of facts. It will not even do to call a theory true or false in the simple sense in which every fact is either so or not so . . . . All science is the search for unity in hidden likenesses . . . . The scientist looks for order in the appearances of nature by exploring such likenesses.

-- Jacob Bronowski

Science is not a mechanism but a human progress, and not a set of findings but the search for them . . . . Science at last repspects the scientist more than his theories; for by its nature it must prize the search above the discovery, and the thinking (and with it the thinker) above the thought. In the society of scientists each man, by the process of exploring for the truth, has earned a dignity more profound than his doctrine.

-- Jacob Bronowski

Another value of science is the fun called intellectual enjoyment which some people get from reading and learning and thinking about it, and which other get from working in it. This is a very real and important point and one which is not considered enough by those who tell us it is our social responsibility to reflect on the impact of science on society. . . .

-- Richard Feynman

"The scientist does not study nature because it is useful. He studies it because he delights in it, and he delights in it because it is beautiful."

-- Jules-Henri Poincare

"During early encounters with science -- observing fire, light, magnetism, chemical changes, small animals -- students nearly always are fascinated and curious. Then as time goes by, and as science courses increasingly stress memorization, facts, and the study of subjects for which the student has no personal interest, the magic wears off and is replaced by boredom or, worse, outright rejection. Evidence of this inevitable alienation can be found in every high school science classroom in the United States.

Perhaps there is a lesson here. If the dream of scientific literacy for all now lies shattered, it is because it was an impossible dream to begin with. Acknowledging this might allow us to pursue a goal that appears less ambitious but, in the long run, is more promising. Is it not more desirable to nurture an appreciation of science and thereby keep open the possibility of full literacy for some individuals than to force-feed facts and formulas and thereby instill a distaste for science that probably guarantees life-long ignorance."

-- Morris Shamos

Science is a pleasurable activity to the good scientist. . . . Nevertheless, many people do not find it as pleasurable to read a theorem as to read a poem. And I am speaking of people who are capable of reading and following both. They have been taught science at school, they have tried from time to time to keep up with it, but now they find that the processes of scientific reasoning do not engage their deep interest. They may still like to read about a new discovery, but they no longer follow how it was made.

"They no longer follow how it was made": that clause reveals to us how it happens that people who want to be interested in science find it dull. They gape at the discovery from the outside, and they may find it strange or marvelous, but their finding is passive; they do not enter and follow and relive the steps by which the new idea was created. But no creative work, in art or in science, truly exists for us unless we ourselves help to create it."

-- Jacob Bronowski

What these writers had to say began to give us an idea of how to organize the Museum’s exhibits to help visitors understand science as an activity. After several versions, we settled for six groupings of science thinking skills as represented by the following working titles:

- Seeing the Unseen (observation)
- Finding the Pattern (classification)
- Making Models (description)
- Testing the Theory (experimentation)
- Putting It to Work (application)
- Playing with Ideas (imagination)