Memoirs of a Bubble Blower

Bernie Zubrowski

Bubbles have a strong association of with play and frivolity, even joy. By installing an exhibit about bubbles the museum was saying that bubbles are also worthwhile "educationally." But, the exhibit did more than just "display bubbles." How they were displayed was a big part of the message. Soap film had been exhibited previously in science centers. Usually, wire frames were dipped into a soap solution and then lifted out to show the way the film made interesting geometric intersections. However, in most science centers this activity all happened behind a Plexiglas container. The visitor could not do anything directly with the device or with the bubbles. In The Children's Museum bubble exhibit, all the manipulations were done by the visitor. It provided immediate and direct access to the phenomenon and invited the visitor to actively explore.

INTRODUCTION

Mike Spock

Bernie Zubrowski's life-long work was always grounded in the idea that doing science is not necessarily an exotic exercise, only practiced by scientists in lab coats with advanced degrees using expensive hi-tech equipment.

To Bernie, the essence of his "small science" can be experienced and grasped by kids, parents, and teachers using everyday stuff bought from a hardware or grocery store, or scavenged from under the sink. Half-gallon milk cartons, filled with ordinary sand, could work as sturdy classroom blocks for building structures. Paper towels and Easter egg dyes could allow families to separate colors in a kitchen chromatography experiment. Aluminum pie plates, spindled back to back with paper cups serving as turbine blades, could become waterwheels. Contraptions rigged from coat hangers, soda straws, string, and cafeteria trays would let visitors stretch or blow huge or tiny—but always elegant—bubbles using dishwashing detergent. (The secret: full-strength Proctor & Gamble Joy.)

These activities were mostly worked out by Bernie in community centers with neighborhood kids. They were built on his early experiments teaching science in Bangladesh villages using natural and salvaged materials, and later modified as curriculum units for the Education Development Center in the African Science Project, post Sputnik, when America was trying to catch up with the Russians.

What started in response to Third World underdevelopment became Bernie's passion and doctrine in Boston: keeping classroom and neighborhood science inexpensive, accessible, and understandable. Simple tools and materials were things to be treasured and celebrated.

But after a decade of curricular and afterschool outreach activities, there was growing interest from many sides to see Bernie's science at work on the museum's exhibit floors. Like all developers dependent on more than one source of income, Bernie divided his time among multiple projects: he did direct service with kids, families, and teachers; trained interpreters for floor duty; curated collections (his workspace always displayed a "collection" of handmade working models;) assembled curricular activities and resources for kits and books; conceived and worked out visitor exhibits and programs; and served as a subject matter specialist.

Developers were Renaissance people, comfortable with every intellectual challenge presented. But, of course, most of these experts had holes in their skills and interests, and all needed help from others, at least at some point.

John Spalvins, from Design and Production, was assigned to work with Bernie on adapting his activities from the gentler classroom/afterschool environment into the hurly burly of the Visitor Center. With engineering training, John served as Bernie's primary exhibit designer, builder, and maintainer. Janet Kamien functioned as their exhibit broker/project manager and Pat Steuert and Elaine Heumann Gurian as their division managers. Each stood ready to help make Bernie's exhibit translations rugged enough to withstand the wear and tear of unstaffed, interactive exhibitry.

Father and son use standard electric kitchen mixers to explore centrifugal forces in the *Tops* exhibit.

At the beginning of their two-decade working relationship, Bernie dug in his heels insisting that the essence of his work would be compromised when turned into more superficial, yet more quickly grasped and easily maintained experiences. A fifteen-minute exhibit encounter was just not equivalent to several unhurried afternoons with Bernie and neighborhood kids in a South Boston housing project. On the other hand, John saw Bernie's fragile working models as impractical and his approach to small science inadaptable to the Visitor Center. For what seemed like months of negotiation (one more try!) they hammered out their differences while the supremely practical Janet Kamien acted as the go-between trying to remain even-handed and patient.

Among the brightest and most inventive members of the staff, Bernie and John were worth the trouble! They used their considerable problem-solving capacities together with Janet's persuasive powers to find common ground, gradually adjusting to each other's quirks and prejudices, and even beginning to count on their complementary skills and insights to work themselves out of tight spots. They grew wiser and humbler about what they knew and what they didn't, and even more stubborn about fending off "suggestions" about what they had already tried and discarded.

You will find not a hint of discord in Bernie's story. But the other players shared more than one tale about how tough it was to deal with the disagreements that broke out from time to time while Bernie, John, and Janet created exhibits.

When they were about to be interviewed by me for *Boston Stories,* I prepared some slightly provocative questions meant to reveal the tensions obvious to anyone close enough to observe their early working relationship. But their interviews and stories revealed only a hint of the tension they initially lived with. Their remembered stories were about how they worked together to solve problems, not how difficult it was to negotiate their differences.

Memoirs of a Bubble Blower

Bernie Zubrowski

The beauty of The Children's Museum at this time is that it was an environment where experimentation and in-depth exploration of topics and methods was not only possible, but actively encouraged. And the results were broad, beyond my own personal and professional fulfillment: children were well served by museum programs, a rich mixture of creativity, research, and time-tested pedagogy.

—Bernie Zubrowski

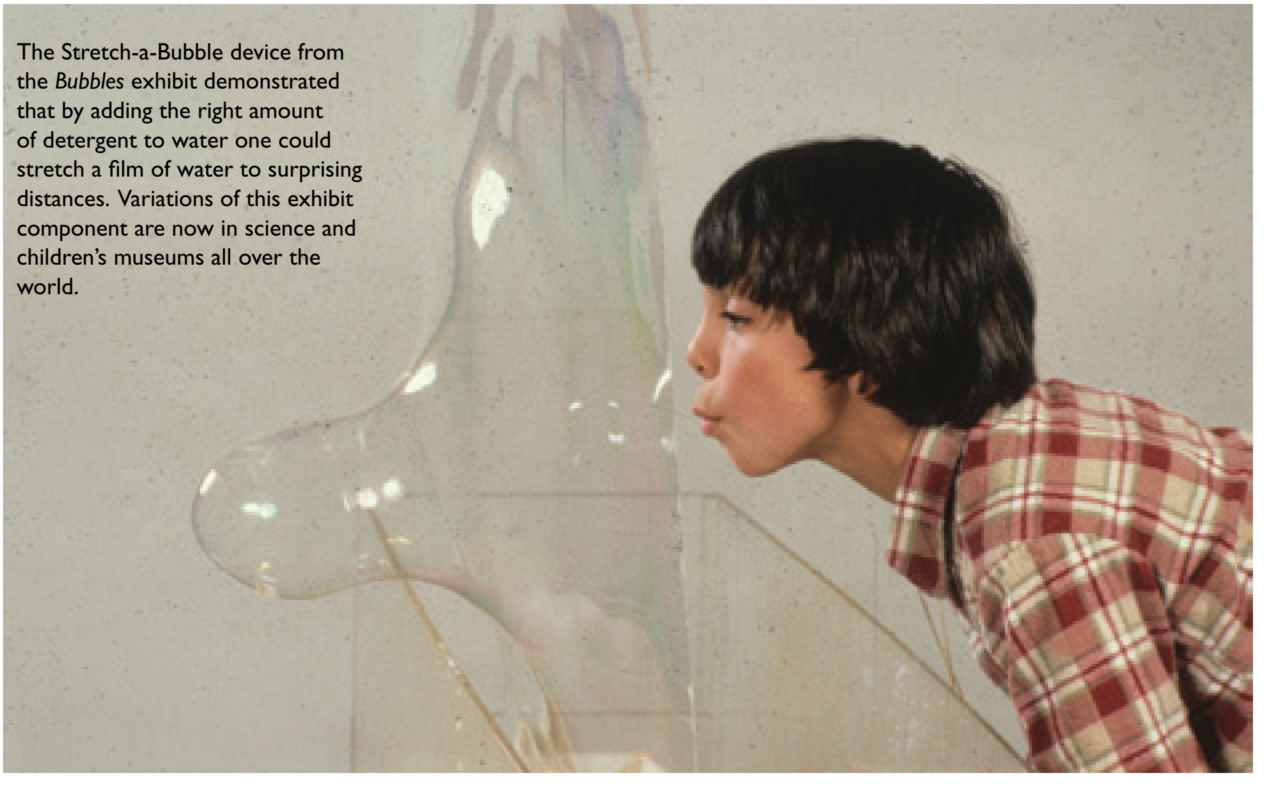
How I Came to The Children's Museum

I didn't deliberately set out to work at a museum. Hiring on at The Children's Museum was one of those events in life that just seem to happen and which then sets a course that somehow continues for a long time.

After completing an undergraduate degree in chemistry at Loyola College in Baltimore in 1962, I spent two years as a middle school science teacher in the Peace Corps in Bangladesh. When I returned to the United States, I completed an MST (Master of Science in Teaching) at Boston College in 1967.

While in graduate school, I had worked on the Elementary Science Study (ESS), a major science curriculum effort of the 1960s, at the Education Development Center in Newton, Massachusetts, and then for the African Primary Science program in Kenya, East Africa. Both programs involved developing science curriculum and doing professional development with elementary school teachers. I spent two years in Kenya developing science curriculum for elementary schools and worked with local teachers in the implementation of that curriculum. These early experiences were formative in shaping my thinking about how to develop science education activities and how to relate to people of other cultures. The learning gained from these experiences became directly relevant to my early years at The Children's Museum.

After returning from Kenya in 1969, I held temporary jobs as a science teacher in Washington, DC, and in Arlington, Massachusetts. I was desperately looking for work in the winter of 1970 (I had a wife and two children) when someone at MIT, who I had contacted about finding a job in science education, suggested that I talk to folks at The Children's Museum. I had an interview with Jim Zien and Phyl O'Connell. They were about to receive a new grant from the National Endowment for the Arts (NEA) that I could work on; however, they didn't have the money in hand yet. Phyl asked me what was the minimum amount of money I could survive on while waiting for the grant to come through. We agreed on an amount (I don't recall how much, but it was probably laughably low) and I started working at the museum.



The Stretch-a-Bubble device from the *Bubbles* exhibit demonstrated that by adding the right amount of detergent to water one could stretch a film of water to surprising distances. Variations of this exhibit component are now in science and children's museums all over the world.

Museum interpretters work with Bernie on building a catenary arch using sand-filled milk cartons, an activity they would later lead with visitors on the museum floor.

At first, working at a museum seemed to be a major departure from what I had been doing in my previous work, but I found that I could bring past experiences with me, add newly gained knowledge and apply this combination of skills in a different kind of environment and educational context. It wasn't clear to me exactly what I would be doing and if, in fact, I would be at the museum beyond this one grant. Thus began my long tenure at the museum.

During my twenty-three years at The Children's Museum I wore several hats and worked at several different jobs, just like most other museum staff. I had a vague job description. I was called a "developer," which was generic. At various times I was involved with community education, working with afterschool program leaders, doing extended programs at the museum with Boston elementary school students, teaching part of a course at Boston University, writing children's science books and science curriculum, developing and designing exhibits. Sometimes all of these roles happened concurrently.

The Early Years: Figuring It Out in Afterschool Programming and Working with Community Agencies

When I was hired in 1970, the museum had received an NEA grant to work with community agencies in the low-income neighborhoods of Boston. This funding initiative was part of a national movement in the museum world at the time to reach out to new audiences and make the resources of museums available to them. Concurrently, the mayor of Boston, Kevin White, had started Summerthing, a collection of summer programs that reached out to low-income urban communities, bringing to them special arts programming and related activities. There was a climate in Boston—and in the entire country—at the time that this was an effort worthy of attention and funding.

For the first eight years, as part of the museum's Community Service Team, I specialized in science programming; other team members focused on arts, crafts, and cultural awareness activities. This group effort mostly involved providing monthly training workshops for afterschool and summer program leaders, but some of us also went out and worked directly with children at various community centers around the city—an activity that was particularly interesting and satisfying to me.

Teaching Science with Simple Materials

Instead of designing completely new activities to fit the afterschool program environment, I drew upon past experiences working for the Elementary Science Study and the African Primary Science Program. I adapted activities from these curriculum units for my new Boston audiences. One of the major challenges I faced while teaching science in both Bangladesh and Kenya was the lack of materials. Schools in neither country had any budget for science education. Whatever science experiments you did had to draw on materials available from the local environment. This turned out to be a great discipline that served me well in later years. In Boston

Statement of Bernie Zubrowski's "Goals" in Doing Science Programming at The Children's Museum, June 1987

The essential purpose of the exhibits I design, the books I write, and the workshops and programs I conduct in schools and at the museum is to encourage children and adults to explore the natural and man-made world. I do this by presenting what I call intrinsically interesting phenomena. There are materials, natural objects and situations which have high aesthetic appeal, or counter-intuitive properties, or are directly related to practical aspects of people's everyday lives. The emphasis is on direct exploration of phenomena by way of carefully designed materials and thought-provoking questions. The basic pedagogical approach is to promote an interaction between the phenomena and the learner, with the teacher acting as a mediator guiding the exploration so that basic scientific principles emerge through dialogue rather than direct teaching. The materials are designed to engage children and adults at the sensual, affective and cognitive level for it is my position that the whole person has to be engaged if the learning is going to take place. The phenomena are presented in a variety of forms so that by repeated exposure the learner will be able to grasp the essential properties as they relate to basic scientific principles. Implied in this approach is that learning is a lifelong undertaking. The phenomena presented have been chosen because they represent concrete instances of conceptual archetypes that can be developed to various levels of abstraction. As a person moves along in their schooling these increasing levels of abstraction become more prominent in their learning, but reference is always to the basic phenomena.

Overall, the purpose is to engage children and adults in a satisfying exploration of their environment doing it by means of a framework that engages the entire person so that learning is meaningful and personally satisfying.

I introduced program leaders and children to drinking straw construction, bubble explorations, batteries and bulbs, dyes and pigments, cake baking and other kinds of topics that used relatively simple and readily available materials.

In the early '70s, in the context of afterschool programming, there was a great deal of emphasis on giving children a fair amount of freedom to choose activities and to follow their own interests. The educational challenge was to find activities that were seductive, could engage children beyond a one-shot session, and had some meaningful content embedded in them. In expanding and redesigning activities from my original curriculum guides, I took another look at topics that had proven to be successful in other, very different venues.

For simple drinking-straw activities where kids built houses, I researched the different kinds of structural systems used to hold up buildings. I discovered that the truss system was basic to many structures. This same system occurred naturally when children tried to keep their drinking straw house from falling down. Expanding on what had been previously written in the ESS curriculum guide on drinking straw structures, more emphasis was given in the afterschool science programs to analyzing the components of a model house or a bridge especially in terms of what constitutes a truss system. I began to see that there were ways of choosing materials and setting up problems that forged a middle ground between a totally prescriptive presentation and one that was completely open ended. Although the complete concept of a truss was hardly ever explicitly developed, the activity could provide children with an experience upon which they could draw when encountering this concept—or related ones—later on in the context of formal schooling. Activities were neither totally driven by children's choices nor totally prescriptive; but, given sufficiently interesting activities, children readily went along with the posed problems and then added their own personal ways of constructing a house or other kinds of structures.

What Holds Kids' Interest?

Even though it was a rocky start, I knew we were onto something. Initially somewhat frustrating, this process became a useful learning experience. When I went into an afterschool program to lead an activity, I was to a great degree completely at the whim of the children. If they found the activity less than compelling, they would

Bernie works with Tribe students over the course of many weeks exploring scientitifc phenomena, including siphons pictured above. The Tribe program was part of a specially funded larger initiative among cultural institutions working to help with the integration of the Boston schools after a 1974 court-ordered desegregation ruling resulted in unpopular bussing.

wander off to do some other activity or play a game with their friends. Some afterschool programs were run on a drop-in basis or were mainly recreational. The challenge then was to use materials and find ways of presenting challenges and problems that would immediately engage their interest. A bigger challenge was to sustain this interest over multiple sessions. I had made a commitment to come to these sites on a regular basis and I felt that the activities should be more than entertainment or passing the time. The activities should have some real science content although it would be implicit.

During this period I tried out variations of bubbles activities. I found that I could introduce new techniques to make bubbles or new materials to use with the bubbles and then let the children explore what they could do with it all. I could step back and observe, occasionally helping them master a technique or showing them how to produce interesting effects with the materials. I did not have to continually give instructions or lead them through the activity. In each successive session I introduced new ways of blowing bubbles. Sometimes this kept the same children coming back.

This early afterschool and out-of-school programming forced me to pay close attention to children's interests and motivations. What excited children, and what were they capable of doing? I learned that sometimes I had to modify materials and problems so that if the children were motivated they could work with the materials in a way that would allow them to produce interesting results—or to what they thought they wanted to produce—quickly. The afterschool environment was a real test of the curriculum activities I was designing and developing. If the activities went over well in this kind of informal learning environment, it meant that they would also engage children in other kinds of settings. This proved to be true in future years when I took some of the same activities and adapted them for use in museum exhibits and in the development of curriculum for use in schools.

This early afterschool and out-of-school programming forced me to pay close attention to children's interests and motivations. What excited children, and what were they capable of doing? I learned that sometimes I had to modify materials and problems so that if the children were motivated they could work with the materials in a way that would allow them to produce interesting results—or to what they thought they wanted to produce—quickly. The afterschool environment was a real test of the curriculum activities I was designing and developing. If the activities went over well in this kind of informal learning environment, it meant that they would also engage children in other kinds of settings. This proved to be true in future years when I took some of the same activities and adapted them for use in museum exhibits and in the development of curriculum for use in schools.

The Luxury of Time to Develop

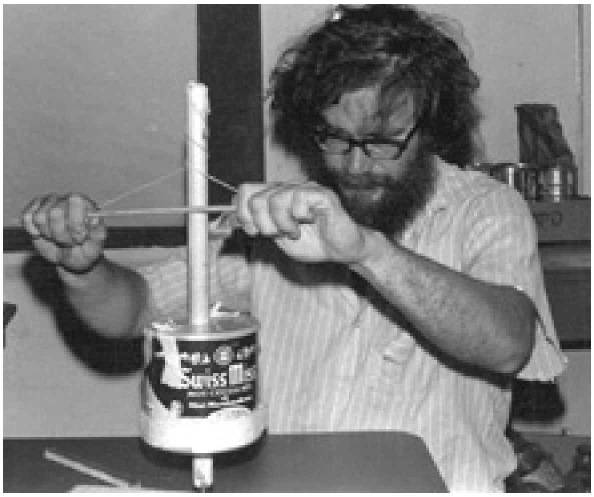
For what ended up being my life's work, these early afterschool programming experiences were an invaluable lab for curriculum R&D. But the greater significance to this part of the story is that I was allowed this leeway to experiment by the managers at the museum. The museum worked with several community agencies to provide afterschool programming. Museum managers, including Elaine Heumann Gurian, Dottie Merrill, Jim Zien, Pat Steuert, and even Director Mike Spock, trusted me to work toward delivering quality activities to the agencies with whom I worked—and to the children they served—and were confident that I would represent the museum in a respectable and sensitive manner. Having this kind of support was especially appreciated because in my previous work in the Peace Corps and in the African Primary Science program I worked very much on my own. I had grown accustomed to defining and directing my own work. The managers at the museum had created a culture in which my independent working style was not only accepted, but actively supported, both financially and philosophically. I had the opportunity to work directly with kids over a long period of time to develop the many programs—and eventually exhibits—for which the museum later became known.

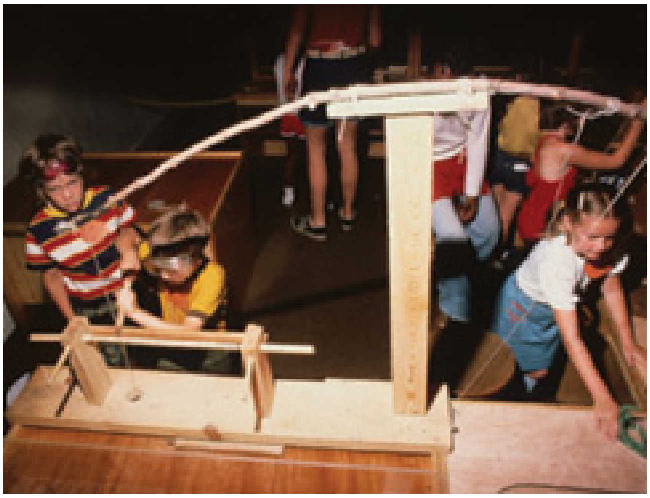
Working with Schools and Teachers

The 1954 landmark decision Brown v. Board of Education opened the doors to school desegregation, but it took many years to actually make it happen. Segregationists had claimed that neighborhoods determined the racial makeup of schools, and that discrimination was not intentional. Twenty years later, in 1974, when federal judge Arthur Garrity's controversial decision to end all Boston school segregation based on neighborhoods was handed down—and busing began—a significant opportunity opened up for museums and cultural institutions. At that time, legislators attempted to ease the transition by appropriating money for schools to draw on the resources of these community institutions. Museums could now offer extended field trips for students during which they were exposed in multiple sessions (sometime as many as eight) to specific topics in which the museums had expertise or special resources. At the children's museum, we offered a series of extended programs that combined physical science activities with natural history, cultural awareness, and art programs. Although some collaborative planning took place, individual content areas were guided by different people, resulting in independent, parallel efforts. I was still able to function fairly autonomously.

New Programs about Old Technologies

During this time I began to see the value of letting children construct and play around with working models of historical technological artifacts—water wheels, windmills, houses, bridges, pumps, and tools. There is a big difference between a working model and a replica. Lots of craft books, as well as some children's science/technology trade books, featured step-by-step instructions that showed you how to make a model of a water wheel or a house. The main point of the activity was to make something like these artifacts. But once constructed, there wasn't much you could do with these "models." You couldn't experiment to find out how a windmill worked or test a house to see where it was strong or weak. Because of my previous work in the Elementary Science Study and the African Primary Science Program, where kids actually explored scientific phenomena in simple but direct, hands-on ways, I felt that these models should be taken a step further. Another part of the impetus to do so came from a book I came across at that time called *Working Models of Historic Machines* by





Using accessible and inexpensive materials Bernie, left, builds a pump drill—a tool that goes back thousands of years—out of a coffee can, string, and a dowel. In the *Tools* exhibit, right, kids use a working model of a pole lathe to shape wooden dowels.

Not only kids were drawn to the working lathes in the *Tools* exhibit. Adults on their own or working with their kids spent considerable amounts of focused time on traditional wood-turning activities.

Aubrey F. Burstall. It showed a series of plans for making devices such as bow drills, lathes, and water pumps. These weren't just attractive models, but actual working models similar to the real things as they existed hundreds or thousands of years ago. There were no specific step-by-step instructions on how to build them but the plans were clear enough that it was possible to construct something close to a device that functioned like the real thing.

Having run a toolmaking program while working in Kenya for the African Primary Science Program, I thought it would be of interest to elementary school age children to make primitive tools and to work with primitive "machine tools" such as a lathe. Drawing upon the African experience and some models from Burstall's book, I designed a series of activities that followed the development of cutting and shaping tools over a period of several thousand years, starting with Stone Age implements and progressing to tools used as recently as 150 years ago. The overall concept was to have students experience the different ways in which people in the past made tools and how they used these tools to shape materials such as wood. My approach to science learning was becoming consistent: first, get kids to play around with real stuff. And that approach was already one of the hallmarks of The Children's Museum in all subject areas.

The toolmaking program became one of the programs offered for elementary school extended field trips. In the first session, students worked with stone tools trying to shape pieces of wood or cut scraps of leather. In the next two sessions, they became blacksmiths working with charcoal fires and shaping nails into drill bits. Somehow we managed to do these activities with only a few burns and scrapes. After forging these tools, they used the shaped nails they had made as drill bits to construct two kinds of primitive tools—the bow drill and pump drill. Eventually, the kids took their handmade tools back to their school classrooms. The sharp nails they had fashioned were inserted into sixteen-inch-long dowels that were used as cutting tools with two kinds of primitive lathes we had set up—a bow lathe and a pole lathe. The lathes were used to shape pieces of dowels into a curved surfaces which could later be cut and made into wood beads.

Working with very hot materials and primitive tools supplied real excitement to these projects. The students hammered away at hot nails held with pliers. They showed pride in honing the ends of the nails into sharp points. Even though they did not complete shaping a piece of wood in the two kinds of lathes, they still were

My approach to science learning was becoming consistent: first, get kids to play around with real stuff. And that approach was already one of the hallmarks of The Children's Museum in all subject areas.

quite excited to have the opportunity to use these real devices.

Over several years, similar programs were developed for other older technologies. Water-lifting devices and pumps took students through a series of activities where they constructed and operated very old water-lifting devices such as a *shaduf* and a *noria*—a reverse water wheel. They also explored devices such as the rag and chain water-lifting device and then moved on to a simple suction pump. They spent several sessions exploring how siphons work. The culminating activity was a demonstration of how water can be lifted using heat to create a partial vacuum in a jar. This was a simplified and primitive device representing the beginning of the steam engine. The earliest steam device was used to pump water out of mines. Thus, students were taken through a series of activities where they experienced several ways of dealing with the problem of moving water through a vertical distance. Through these activities, they experienced a history of engineering where different devices had been invented to solve this problem.

Other programs, devoted to exploring the historical development of technical devices by allowing students to construct and operate working models using simple materials, included the following titles:

- Wheels at Work (pulleys, water wheels, water turbines, and water wheel clock)
- Timekeeping (water clocks and exploring the functioning of mechanical clocks)
- Extractions and Other Chemical Processes (making perfumes and exploring fermentation)
- Dyes and Pigments (grinding rocks to make pigments)
- Wind Machines (making and testing models of sailboats and windmills).

Other topics I thought might be interesting to develop (before I ran out of funding) were: shelters, containers, weapons (yes, weapons in a children's museum!), weaving and weaving machines, musical instruments, clothing, and fire and light.

In the *Wheels at Work* exhibit, a boy tries to make a wheel spin. As the wheel spins, arms rise up; the faster it spins, the higher they rise.

Teaching Technology, Old and New

My work with kids in these toolmaking programs slowly revealed some pedagogical approaches that for me would change the structure of informal and formal science education activities. Two major emerging concepts were that: 1) technological devices could provide a context for introducing basic science concepts; and 2) extended activities over multiple sessions could be shaped into a learning progression.

In addition, I became convinced that the artifacts resting in cases in museums could become more meaningful when students had the opportunity to experience how these artifacts were made and how they functioned. But artifacts need to be contextualized to engender meaningful connections with students, and museums were the perfect places to provide that context. Students need to have direct experiences with similar kinds of artifacts that they have made themselves. Artifacts that are more than just replicas, but actual working models of tools as they were used in the past. In programs about water wheels or windmills, for example, basic science concepts could be introduced that grew naturally out of attempts to make a more efficient working device. Much later I took this thinking further, producing curricula that made these concepts more explicit.

In the mid 1970s when I was doing these kinds of afterschool activities, "technology" was not associated with the "high technology" of computers. Back in the 1950s, there was some science curricula, particularly at the elementary and middle school levels, that took a practical approach. Attention was given to how things worked and how scientific principles were exemplified in various technological devices. But the major reforms in science education that occurred as a result of Sputnik almost totally displaced the *Popular Mechanics* approach to figuring things out. During the 1960s and 1970s, ma-

Children with parents built towers with milk carton blocks, testing different ways of arranging the blocks to see how high they could stack them.

jor science curriculum development programs gave little attention to older technologies. There had even been a distinct emphasis on science divorced from technology. However, in the late 1970s, a movement emerged focused on the relationship between technology and its impact on society, although the focus was on the social and environmental impact. It seemed to me that older technological devices still offered certain pedagogical advantages.

- They were very accessible to students.
- Basic operations were visible and understandable.
- They provided a context where science, technology, math, and even history could be brought together in a natural manner.

Trade Books

Working with afterschool programs in the community and in the special extended field trip programs at the museum was a personal research, development, and design effort. To some degree I approached these programs with this function in mind, and the museum supported me in my pursuits. While involved with the African Primary Science Program, I also had tried out activities with school children so that I could write or co-write several curriculum guides. While blowing bubbles or doing other activities with children in afterschool programs, I was always thinking about writing them up and publishing them either as curriculum guides or trade books. Putting them into some kind of curriculum seemed out of the question during the '70s and '80s. One of the few sources of funding for such an undertaking at that time was the National Science Foundation, and its priorities did not include curriculum. In fact, educational funding at the foundation was cut way back during the late '70s and '80s.

But an alternative to curriculum guides existed in children's trade books. Museum staff person Jim Zien knew an editor from the well known and locally based publisher Little, Brown and Company. After some discussions with one of the editors, an agreement was reached where they would publish six science trade books. These first six titles were: *Bubbles, Drinking Straw Structures, Ball Point Pens, Milk Carton Blocks, Cake Chemistry, Water Pumps, and Siphons.* Some of the activities were carry-overs from the African Primary Science Program while others came out of new work in afterschool programs.

Little Brown decided to stop the series at six titles and although I continued to develop and refine content in my "live lab," it appeared that I wouldn't be able to put more of it into print. Fortunately, I ran into David Reuther, managing editor of William Morrow (WM), at a meeting in New York. Reuther liked the books that had been published and expressed interest in doing a similar series. He preferred to publish one book a year. So, over the next ten years I worked with WM editors to produce ten more books: *Balloons, Blinkers and Buzzers, Clocks, Mirrors, Shadows, Raceways, Tops, Wheels at Work, Mobiles,* and *Making Waves.*

Slow-Cooked Curricula

I continued working with museum-affiliated, community-based afterschool programming but unfortunately funding for the extended field trip museum programs ran out in the early 1980s. The opportunity to work with a large group of the same students over multiple sessions had been very valuable. I discussed with the museum managers the possibility of continuing my "lab work" in a Boston city school classroom as part of my regular museum work. They agreed it was a worthwhile effort. I contacted several teachers and principals who allowed me come into fourth and fifth grade classrooms several times a week over the course of a school year. Over an eight-year period, several teachers invited me into their classroom and worked along with me in the testing of different topics. In these arrangements, I spent the entire school year with one class and its teacher during which time I spent several weeks on one topic and then moved on to another. Over the course of the school year five to six topics were tested.

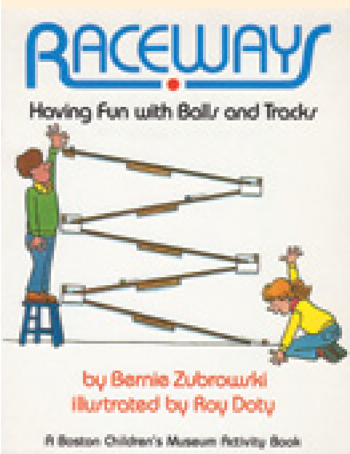
This work was valuable for a number of reasons. It allowed me to continue developing new activities for more books to be published, and I developed a real appreciation for the challenges of teaching elementary school children. This particularly helped me to develop the skills needed to manage discussions with children about what they were discovering in the activities and what they thought about these experiences. Some years I would repeat a similar set of activities with a new group of students in an attempt to refine the activities as well as to help me think about how all these activities could be used to introduce basic science concepts. Each succeeding year I came to a deepening realization of the complexity of what it means to teach and the great challenges of designing meaningful science experiences for children.

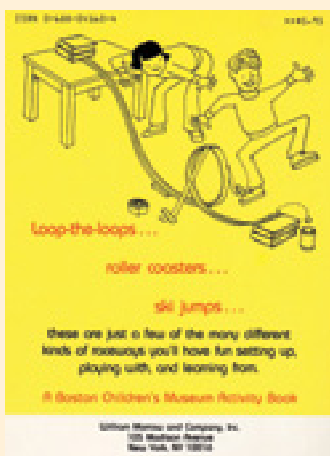
Working in one classroom, I tried out activities for topics such as Mirrors, Shadows, Waves, Balancing Toys, Air and Water Movement, Tops and Yo-yos. I ended up trying out similar activities on one topic five or six times. It was an iterative process where I gradually narrowed down the most effective and educational activities and discovered the best ways to sequence them.

Bernie's Books | Pat Steuert

When I worked at The Children's Museum, I was often asked at museum conferences, "How do you manage to fund so many subject matter specialists on the staff?"

Bernie came to the museum in 1970 and worked full- time or part-time for over thirty years. With the museum's relatively small budget, the only way this was possible was to distribute his salary between the operating budget and special projects funded by grants and contracts. In this way, subject matter specialists, who we called developers, were not as vulnerable to the cycles of soft money.





Bernie was so prolific in his development of physical science activities and curricula for school and afterschool programs that publishing his materials was one way to keep him at the museum. We began looking for publishers for his first series of children's books and later for educational publishers of middle school curriculum materials. Community Services Manager Jim Zien negotiated the first contract with Little, Brown and Company. After that contract ended and Bernie serendipitously made a connection with William Morrow's Managing Editor David Reuther, I negotiated a second contract and later a third with AAAS (American Association for the Advancement of Science). Dottie Merrill kept this pattern going with the Cuisenaire Company of America after Jim and I left the museum.

This system worked to keep six to eight developers at the museum for many years. Although they often complained that they had too many tasks—exhibits, training interpreters, teaching in schools, writing books, conducting professional development programs for teachers, working at community centers—Elaine Heumann Gurian and I, who jointly managed their time, tried to match their talents with opportunities. So, some developers published, others did training, etc.

In the early years when Bernie worked part-time at the museum he wrote books both at the museum and on his own time at home. We established a system of joint copyright ownership between the museum and Bernie and, after the museum used the advance to pay for his museum time, we split the royalties with him. I later discovered this was an unusual arrangement. But, like many of our strategies, we invented this plan and continued it through a series of publishers with the goal of keeping Bernie employed at the museum so we could use his science activities in exhibitions and make them available nationally to families and schools.

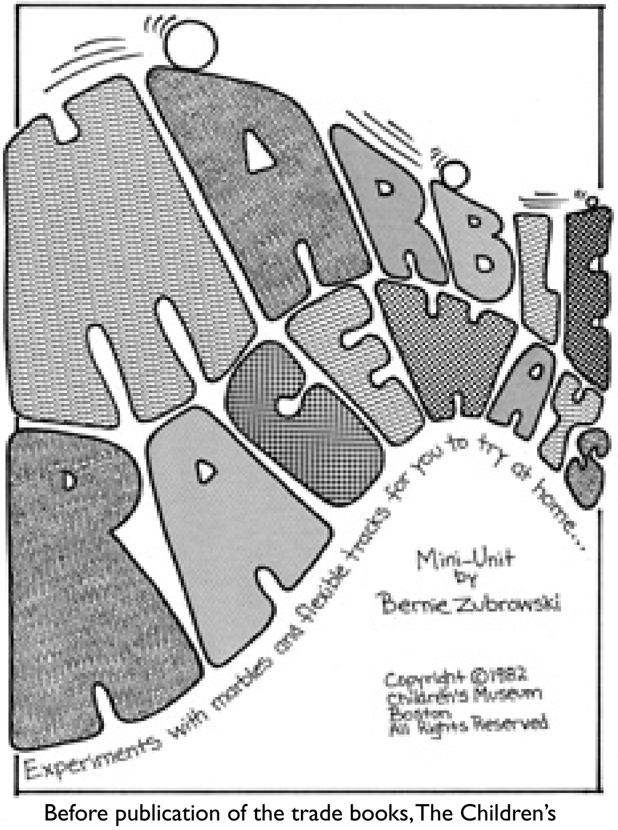
Business arrangements aside, I also worked with William Morrow and the books' designer to diversify the covers. The early volumes showed only white boys doing science. They said, "This is what sells." We eventually persuaded them to include girls and kids of color on the covers. If you look at the series, you can see the change over the years.

The museum and Bernie published sixteen books and two national curriculum series in his time at the museum. These publications and the traveling exhibitions produced later brought increased visibility to Bernie's work and to the museum nationally.

Early Research about the Role of Play in Learning

This development effort was more than just a materials-design test. Concurrent with this practical work I had been delving into research literature in wide-ranging fields such as the role of play in learning, the relationship between art and science, and the role of metaphor and analogy in scientific thinking. For a long time I had been interested in what researchers had discovered about the role of exploration and play in learning and child development. During the late '60s and early '70s, some attention was given to these behaviors by field biologists, child development psychologists, and anthropologists, including the work of cultural anthropologist Brian Sutton-Smith, which I found interesting and relevant. Curiously, most of this work focused on preschoolers or on animals. Very little work had been done with elementary age children except for some research on socio-dramatic play. Nevertheless, there were some findings that I felt could be applied to the way science education could be conducted.

The beauty of the museum at this time is that it was an environment where experimentation and in-depth exploration of topics and methods was not only possible, but actively encouraged. And the results were broad, beyond my own personal and professional fulfillment: children were well served by museum programs, a rich mixture of creativity, research, and time-tested pedagogy. These museum-based experiences were further disseminated in science education courses I later taught at Lesley College and Boston University. (I have written about these applications in the 2009 book *Exploration and Meaning Making in the Learning of Science.*)



Before publication of the trade books, The Children's Museum developed four-page "mini-units" on teaching science with simple materials. These publications were sold in the gift shop. *Marbles Raceways* featured a cover illustration by R&D team member Andy Merriell.

A New Approach to Science Curriculum: The Pitsco Guides

In the early '90s, my last years at the museum, we received funding from the National Science Foundation to develop science curriculum for middle schools. This was an involved effort. Over the course of three years we pilot-tested topics ourselves in various museum programs and then asked Boston city school teachers to field-test the final eight topics. I drew heavily upon all of my previous curriculum development work in this new effort. Some of the topics were recycled from the already published trade books, such as *Drinking Straw Constructions, Tops,* and *Yo-Yos.* Other topics, included and refined during these three years, were extensions of a great deal of previous work.

The guides, eventually published by Pitsco Education, a kits and curriculum publishing company, are: *Drinking Straw Constructions, Toys and Yo-Yos, Inks and Papers, Salad Dressing Physics, Ice Cream Making, Air and Water Movement, Water Wheel,* and *Wind Mills.* All of these curriculum guides developed physical science concepts by using guided inquiry in which students are led through projects by means of starting questions that trigger new discussions about additional ideas and methods.

The pedagogical approach in the Pitsco guides differs from most curricula published over the past twenty years. A lesson started with a phenomenon or technological artifact from which the concepts emerged through a series of structured activities. This is in contrast to what nowadays is called a "backward design" approach where you first determine what concepts you want to teach, then enumerate ways of assessing the learning of those concepts and, finally, find activities that will bring this about. In the Pitsco guides the approach was more dialectical: I went back and forth among the phenomenon, the students, and the targeted concepts.

The Pitsco partnership ended, and a new publisher, KELVIN, resumed publication of the guides; that partnership, too, ended after a couple years. I still run into teachers—especially middle school teachers—and museum educators who continue to use my books, and some activities in the trade books have been adapted for use in museum exhibits.

Exhibits

After working with science programs and curriculum development for ten years at the museum, I finally became involved in the design of exhibits. My first effort,

In the groundbreaking *Bubbles* exhibit, the simplest and most appealing of materials—detergent and water—were used to introduce visitors to complex scientific phenomena like surface tension. Clockwise from top left, kids use wide tubes to blow big bubbles on a table top full of soap and water; kids raise a bar dipped in bubble solution to produce a large bubble sheet; a young boy directs an air hose into a bubble solution; and two boys check out the size of a bubble wall produced by the Stretch-a-Bubble exhibit component, now seen in children's and science museums all over the world.

the *Tools* exhibit, opened in 1980. It was rather simple but very interactive and successful. Essentially, it was a collection of tables on which were placed some primitive tools and lathes. (See video of traveling version of this exhibit on the Media page.) The visitor could operate a bow drill, a pump drill, a bow lathe or a pole lathe. The visitor could either make holes in a wood surface on the table or shape pieces of dowels using the two different lathes. Sometimes programs were scheduled in the exhibit in which visitors cut up pieces of dowel shaped on the lathes and made them into wood beads. This was an example of transplanting activities that had been done in afterschool programs to an exhibit context. The exhibit could have displayed some tool artifacts or included graphics that showed how these tools were used in the past, but the budget was very limited. Eventually, in a later version of the exhibit a case with tools was included.

I am not sure if this kind of exhibit could be done today. There was always an interpreter in the exhibit overseeing and assisting visitors. There were issues of safety—the tools had sharp points on them. Surprisingly, there were no accidents during the exhibit's run at the museum. In fact, it traveled for two years without any accidents. Why? I think *Tools* gave kids the opportunity to do something interesting and real, and it implied that we trusted them. Children knew that sharp tools

Creative Differences: Two Perspectives | John Spalvins & Elaine Heumann Gurian

I'm sure we both had the same objectives in mind: to teach people about science. But Bernie went at it from the teacher's standpoint, and I went at it from the technical, designer, engineering standpoint. Bernie's concepts were always tried out with very simple pieces of materials: milk cartons and straws and you name it. But his work involved direct interactions with the public. He did demonstrations, went to schools—he tried these things out. And consequently he got the idea that, well, this is the direction we want to go, and these are the materials we want to use. He didn't quite understand that what you use with a school group or with a limited number of people while you're standing there directing them in an activity is not how things work on the museum floor where 400,000 people a year are interacting with an exhibit. I kept trying to convince Bernie—and this is where the brokers came in—that "I can't use your milk carton, Bernie. It's not going to hold up." And a lot of times he just kept saying, "Well, why can't you use the milk carton? Make the milk carton stronger or something." Fortunately, virtually all the time we were able to work it out.

We finally reached a compromise where we'd use heavier-duty materials in the exhibit, then we would place lighter materials—the paper cups, the straws, the milk cartons—in a display case arranged as demonstration pieces with graphics saying, "See what we've got here with the water wheel? Well, you can go home and take a milk carton, cut it up like this, take two paper plates, and this is what it should look like." So that was kind of a compromise. I'm not sure if Bernie was entirely satisfied with that, but we went in that direction.

The one exception, of course, was the *Tops* exhibit where handheld, homestyle mixers would activate the top to get it to spin. Try as I might—we even rigged up a couple of what we thought were foolproof mechanisms where you just dropped a lid and it would spin—they didn't look at all like a homemade mixer. So we used real mixers, but I don't know how many hundreds of them we bought over the time that the exhibit was running. Because it was a traveling exhibit, too, we had to keep dozens of spares that we kept sending out. Because a real mixer would only last for a couple of weeks. But, yeah, we went with the real mixer.

Essentially that was our relationship. It was never adversarial. We were both working for the same goal. We did seven traveling exhibits, and they were all hits. Everybody liked them. And they traveled way beyond their life expectancy. If fact, if you look at the *Raceways* exhibit at the museum now, after all these years, it is just a slightly modified version of the original traveling exhibit. A lot of the traveling components were actually in that exhibit. You know, they last. They were quite successful.

—John Spalvins

Bernie worked for Pat Steuert primarily on after-school projects, so I had very little to do with him for many years—until he wanted to do exhibitions. He worked with Anne Butterfield and me on writing a National Science Foundation (NSF) proposal, which was rejected—repeatedly—for reasons I cannot remember. We were frustrated but it became a matter of honor to keep resubmitting. We eventually wrote the proposal to produce a series of *traveling* exhibitions and NSF finally agreed.

In his science programs, Bernie used easy-to-obtain materials. This approach was rooted in his deeply held beliefs about access to science learning. We all understood that, and because the museum also featured *RECYCLE,* which I had started, his philosophy was institutionally ingrained.

Bernie and his work were fabled. He was a "developer's developer." But he wasn't very interested in (or good at) the minimal bureaucracy required to run the institution, including compliance with any "mickey mouse" conformity required of him. Pat was more used to his maverick attitude than I was, but basically we all loved Bernie: he was sweet, stubborn, never mean and always principled.

Since Bernie believed that kids could do science with simple materials anywhere, he was less interested in the exhibition format. But the basic problem was that exhibitions cannot be made out of the easy-to-obtain stuff Bernie used. Exhibition materials needed to stand up to the rigors of heavy use. Exhibit designer John Spalvins, stubborn as Bernie although perhaps more voluble about it, was every bit as inventive at his craft. John already worked with the rest of the developers, all frustrating in their own ways, and he had his own set of idiosyncrasies. While John and Bernie were often at odds, each maintained a high level of creativity. The final exhibitions were very much a collaboration: neither could have done it without the other. They were both extremely gifted.

Bernie's exhibitions, fabricated by John, became deeply beloved and much copied and although much of the recycle nature of the materials was lost, the discovery nature of the science remained. Bernie partnered with John every inch of the way, selecting and tweaking workable materials. They fussed for exactitude, driving each other crazy while deeply respecting each other's skills. Their clash wasn't any sharper than the one Jeri Robinson had in making *Playspace* or Sylvia Sawin in making *Grandmother's Attic*. In all of these developer/designer relationships, each person started at different sides of the equation, stuck to their guns, got closer and closer, and built masterpieces.

The process was tedious and exasperating, involving endless private meetings with the aggrieved. Brokers Janet Kamien and Dottie Merrill were good at getting folks to work together; managers Pat and I were equally good at championing "our" staff. But no one was ever threatening or mean, and in the end, they were all proud of themselves and each other. We were all devoted to the museum, the mission, and each other.

—Elaine Heumann Gurian

In *Wheels at Work,* left, a girl uses a lever to try to manipulate a water wheel. In the initial design of *Tops and Yo-Yos,* right, four paper plate yo-yos of different sizes and unequal weight distribution, were hung on hooks. But Bernie noticed that visitors were not picking up on the challenge of comparing how the different yo-yos moved up and down the strings. He then added a metal bar that extended out from the back of the exhibit on which the yo-yos were suspended. This small change enabled visitors to roll the yo-yos side by side, cueing them to make the comparisons.

could be harmful. They were not at home but in a public space. Therefore, they acted carefully and responsibly.

The Bubbles Exhibit

Five years after *Tools,* I helped develop another museum exhibit called *Bubbles,* which opened in 1985, to provide an opportunity for visitors to get acquainted with a phenomenon that they had probably already encountered but most likely had not fully explored. The original exhibit had six activity stations. Aside from the now ubiquitous activity of stretching a soap film vertically, visitors could blow small bubbles on a table with soap solution, make a large bubble dome using a piece of tubing from which air came out, dip wire frames into a container of soapy water, blow small bubbles in a narrow space between two sheets of Plexiglas, make a soap fill sheet that could be manipulated into different shapes, and make a string of small bubbles with a narrow diameter piece of tubing from which air escaped. (See videos of *Bubbles* exhibit on the Media page for these activities in action.)

These six stations were more than a collection of activities. Each activity provided opportunities for the visitor to explore the different properties of bubbles, but we hoped that the aggregate experience would be even more powerful. Visitors could see that soap film could be stretched surprisingly to a great length, that it formed various geometric shapes, and that these shapes would join together in a regular pattern. They could observe how soap film would pull itself together; that this tendency to shrink is an example of surface tension was not explicit. This is a difficult concept to grasp even for people who have science background.

The goal of this exhibit was not to illustrate scientific concepts but to draw attention to a fascinating phenomenon and to incite the visitors to go back to their homes and schools and explore bubbles on their own. Museums are viewed as respected educational institutions. The children's museum was recognized as a serious but engaging educational environment. When the museum displayed something—especially simple, often overlooked, everyday somethings like bubbles—it was like saying, "this is something worthwhile, something to pay attention to." Bubbles have a strong association of with play and frivolity, even joy. By installing an *exhibit* about bubbles the museum was saying that bubbles are also worthwhile "educationally."

The Intersection of Art + Science | Peggy Monahan

In college, I worked at the Museum of Science, Boston, as an Explainer and loved it. When I graduated in 1990, museum jobs were scarce, but I eventually found one at The Children's Museum, (TCM) working on a National Science Foundation-funded science curriculum project led by Bernie Zubrowski. I knew I was fortunate to find a museum job, but at the time I had no idea how lucky I was to find that job.

From the beginning, The Children's Museum was very different than the Museum of Science where my job was to explain scientific concepts to visitors. At the children's museum, Bernie didn't explain much at all, and there seemed to be more going on than just science.

When Bernie introduced an activity to a class of kids, he would show them some everyday materials, point out a couple of ways they might use them, and then oh so simply lay out the central challenge of the activity—all in about six sentences. He told them very little, but opened up everything. His economical introductions left room for the kids' own ideas. Rather than explain scientific facts, Bernie offered invitations to explore, question, wonder, and create. Often, those explorations were aesthetic as well as scientific. Bernie invited kids to look closely at the zip of a golf ball on a track, the shapes of bubbles and their interior rainbow swirls, the way water moves, and the wiggles of connected pendulums. Kids' curiosity was piqued as much by beauty as by utility.

At first a little taken aback by the emphasis on aesthetics over science, I relaxed when I realized it was a powerful way to learn. Even though kids framed their questions around what they wanted to do rather than what they wanted to discover, discover is what they did. In trying to create the perfect drinking straw house, they wrestled with structure until they stumbled on the strength of a triangle. By aiming for the most beautiful swirls of color in a tray of food-colored water, they developed ideas about how fluids move. Their works of art motivated the work of science. In their attempts to control the scientific effects on their product, they fully explored scientific content, and as a result of these personalized experiences, they usually ended up with an artifact—the artwork—to remind them later of what they had done.

Eventually, I began to see the way that art impacted my work in more ways than just aesthetic explorations. One of my roles in the curriculum project was to research and gather materials for teacher kits. I bought drinking straws to build houses, paper plates for tops and yo-yos, cardboard boxes that became cake ovens, and pipe insulation to make roller coasters. The objects took on more significance as I looked at them not for their intended use, but for what they could become. I trolled art stores, hardware stores, and restaurant supply stores for the perfect pizza pan or the ideal drop cloth. I compared subtle qualities and organized the kits based on the unexpected uses of the materials and the relationships among them. I developed a rich material literacy that enabled me to see possibilities in everything around me. As I combined an expansive material sensibility with the idea of aesthetic expression, I got a glimpse of what it must be like to be an artist. These were heady experiences worth passing on.

I stayed at The Children's Museum after Bernie's curriculum project was over and he had moved on. Eventually, I moved on, too, and have since worked at several children's and science museums, developing many exhibits and programs for visitors of all ages. Based on my experiences with Bernie and the multidisciplinary stew of TCM, I've always tried to incorporate both aesthetic explorations and expressive opportunities into exhibits and programs. I often use art as a way of helping visitors see beyond the obvious and take that first step toward creating something they want to see in the world—discovering some science as they work. I'll always be thankful for the way Bernie helped expand my definition of the work of science to make room for the deep importance of art.

Currently, as exhibit projects creative director at the New York Hall of Science, I am creating a series of spaces in which to facilitate design programs on the floor. For this project, I am deliberately conflating my scientific and artistic goals for visitors' experiences—I want them to do both.

I have always been interested in the meanings that people make for themselves, rather than what was "correct." Working with Bernie and others at TCM helped me realize that visitors' meanings are the *only* ones that matter. Sure, any scientific explanations we offer need to be "correct," but even if we tell people something, that doesn't mean that they grasp it. They only know what they've figured out for themselves. I absorbed this nuanced view of learning from Bernie without ever hearing the word "constructivism"—a term I never learned until years later.



Some of Bernie's recent work, seen on www.zubrowskib-sculpture.com, has included Spirals, Moire Patterns, and Mist Sculptures. Center, Peggy Monahan in the office shared with Bernie and full of shelves of stuff for making cool science experiences.

But, the exhibit did more than just "display bubbles." How they were displayed was a big part of the message. Soap film had been exhibited previously in science centers. Usually, wire frames were dipped into a soap solution and then lifted out to show the way the film made interesting geometric intersections. However, in most science centers this activity happened behind a Plexiglas container. The visitor could not do anything directly with the device or with the bubbles. In The Children's Museum bubble exhibit, all the manipulations were done by the visitor. It provided immediate and direct access to the phenomenon and invited the visitor to actively explore.

But like the *Tools* exhibit, *Bubbles* had special challenges. Several of the activities required soap solution in open containers. In fact, on one of the tables the whole surface was covered with soap solution. Obviously, soap solutions are wet and can be messy. A special floor had to be put down so that the spilled soap solution would not be a major problem (visitors slipping, water leaking to floors below or floors simply rotting out from being constantly wet). John Spalvins of the museum's design and production department found a material that in general worked.

Supplementing the *Bubbles* exhibit activities were programs conducted by interpreters that could be done at times of day when it was not too busy. The interpreter had access to a kit of materials and a guide for how to use them in the exhibit. One of these activities involved blowing bubbles in a large container with dry ice in the bottom. When large bubbles—ten inches in diameter—blown by the interpreter or by a visitor, were launched, they would float a foot or so above the bottom of the container. The visitors could observe that even large bubbles were spherical and could observe the colors in the soap film. These simple add-on activities provided even more ways of understanding the properties of bubbles.

There are now bubble exhibits in many children's museums and science centers around the world, but they usually include only a few bubbles activities, if not just the big Stretch-the-Bubble activity. Multiple examples of the same phenomenon are missing in many of these exhibits leading me to wonder whether our original and broader pedagogical approach is ignored, misunderstood or undervalued. Over the years, since the museum's first version of the *Bubbles* exhibit, I have thought about the relevance of our pedagogy. In addition to its value in the exhibit, it was also relevant to the development of the science activities for the trade books and eventually in the middle school science curriculum that I designed at the end of my museum tenure in the early '90s.

Exhibits about Phenomena and The Process of Discovery

The success of *Tools* and *Bubbles* led to the design of other phenomenon-based exhibits during my last years

In addition to simple exploration of the phenomenon itself, simple experiments or comparisons of visitor behavior could be done in some of these exhibits. In *Raceways,* for example, the golf ball could be placed on different parts of the tracks. Activities were deliberately designed on two parallel tracks in order to prompt the visitor to make comparisons. At the exhibit's Ski Jump and Loop-the-Loop, the visitor could place the ball at different parts of the track to see what would happen when they flew off the end of the track. By placing buckets at the end of the track, this became a type of game in which the visitor could take up the challenge of sending balls into each of the buckets.

This early *Ancient Tools and Technology* exhibit shows John Spalvin's tabletop exhibit components for Bernie's activity-turned-exhibition that featured real tools.

at the museum. Adopting a pedagogical approach similar to that used in the development of *Bubbles,* new science exhibits such as *Raceways, Tops and Yo-Yos, Salad Dressing Physics,* and *Waves* found their way to the museum floor. Each of these exhibits focused on one phenomenon, used a limited number of materials, and was made as interactive as possible. *Salad Dressing Physics* was the least interactive because of the nature of the materials. We had to constrain the manipulation of the containers of liquids since there was always the possibility that some visitors would break the containers spilling very messy liquids on the floor.

In addition to simple exploration of the phenomenon itself, simple experiments or comparisons of visitor behavior could be done in some of these exhibits. In *Raceways,* for example, the golf ball could be placed on different parts of the tracks. Activities were deliberately designed on two parallel tracks in order to prompt the visitor to make comparisons. At the exhibit's Ski Jump and Loop-the-Loop, the visitor could place the ball at different parts of the track to see what would happen when they flew off the end of the track. By placing buckets at the end of the track, this became a type of game in which the visitor could take up the challenge of sending balls into each of the buckets. In *Tops and Yo-Yos,* visitors could compare the spinning of four different kinds of tops, or tops of different diameters but same weight, or two different tops of same diameter but different weights. Likewise, they could compare yo-yos of different diameters or weights. In *Salad Dressing Physics,* visitors could compare the properties of density and viscosity in five different liquids, and the collection of stations in that exhibit in effect presented an example of how one could investigate properties of liquids overall. In the *Waves* exhibit, visitors could make soap film wave or vibrate several different ways and in the process discover how a surface reacted to these vibrations. So, in most of these exhibits the implicit message was not just information about this or that scientific phenomenon but how a phenomenon could be investigated.

I had been a student of nonverbal behavior for a long time while developing activities in community afterschool programming and in the special school programs at the museum. I had always been interested in designing experiences that required a minimum of verbal directions or written instructions. The challenge in exhibit design was how to design the materials or devices to take advantage of the visitors' intuitive responses to the way things are designed. This is related to the design of everyday things about which designers and environmental psychologists have written reams about responses to the physical environment. Placing two tracks alongside each other is one example of the way in which the physical design of an exhibit subtly directs visitors to explore and experiment. Making some of the activities into games is another way to use the physical layout to prompt behavior.

Another example of designing the materials to maximize interaction occurred in the *Tops and Yo-Yos* exhibit. When *Tops and Yo-Yos* was first installed I noticed that visitors were not doing much with the yo-yos at one station at which four yo-yos hung from hooks. One pair of yo-yos was composed of a two plastic plates, each six inches in diameter; the second yo-yo pair was made of two plates each twelve inches in diameter. Each yo-yo pair weighed the same, but one yo-yo had washers bolted in the middle while the second one had washers bolted on the diameter. The question was: Did these yo-yos behave differently when they moved up and down on the string because of the placement of the washers?

My experience in Kenya with the African Primary Science program was sort of like my Peace Corps experience in Bangladesh in that there were very limited materials—there was hardly anything. The schools has no budget for science. Whatever materials you used had to be from the local environment. Which was a great discipline. One time I was visiting a school that had mud as walls, mud on the floor, and grass thatching as the roof. I was looking at the grass, wondering, "Where does the grass come from?" It grew in a lot of African countries, at least many of the ones we were worked with because the program involved seven English-speaking countries. I realized that if you asked kids to bring in some grass and then got some pens, you could do construction activities. And that was one of the units I developed: kids built houses and other stuff with pens and grass. We tested the strength of the structures by hanging sand-filled cans above them and pouring sand on them until the house broke.

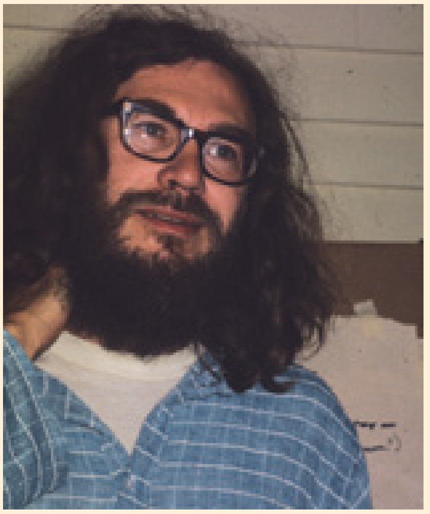
—Excerpted from Mike Spock's interview with Bernie Zubrowki, 2005

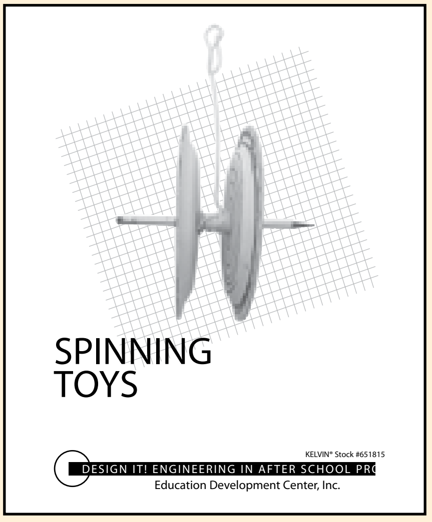
What Bernie Hath Wrought | Tim Porter

Great ideas have a lasting resonance that often belie their humble beginnings. It's hard to imagine that Bernie could have pictured what his simple act of blowing a few bubbles would lead to, and the millions of children and adults whose lives would be impacted in small but significant ways. In the nearly two decades since Bernie left The Children's Museum (TCM), we have continued to build on and learn from his work. *Science Playground,* the exhibit temple to Bernie's tinkering continues to serve as one of the most beloved spaces in the museum, while *Bubbles* and *Raceways* invite children to investigate alongside parents who may have visited the same exhibits when they were children.

When the museum underwent a renovation in 2007, *Science Playground* was positioned as the first exhibit families would visit when they walked in, a sign of not only the popularity of the space, but also its deep roots in the museum's mission. Bernie's emphasis on intrinsically interesting phenomena and on presenting those phenomena in a variety of scenarios allows for deep and memorable experiences—the kinds of "sticky" experiences that museum educators seek, and the kinds of experiences that cause us to often hear parents reflecting on memories of bubbles blown and balls rolled in their own youth.

The resonance of Bernie's work is also felt in the museum's close and lasting connection with the afterschool field. Bernie, Diane Willow, Dottie Merrill and others' collaborations with afterschool educators serve as forerunners to an expanded array of resources and services created by the museum for the out of school time field. This work in the '70s, '80s, and '90s laid the foundation for the Massachusetts Cultural Council-funded CATS (Culture Art Technology and Science) kits in the '90s, which provided materials-rich science activities through a cultural context to afterschool educators in Boston, eventually reaching thousands of children across New England. Bernie's influence is felt in ongoing professional development trainings run by museum staff for afterschool educators regionally and nationally. And





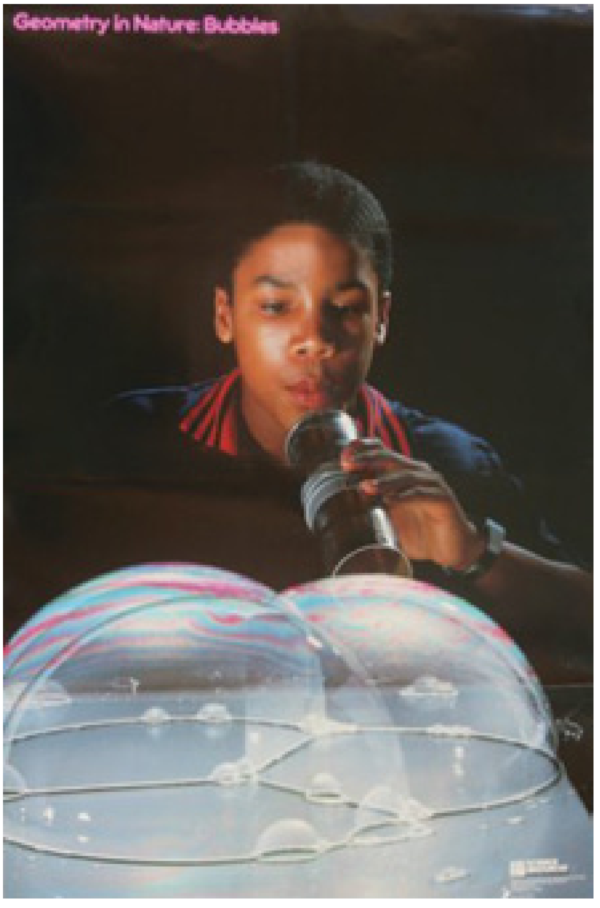
The beauty of the museum at this time is that it was an environment where experimentation and in-depth exploration of topics and methods was not only possible, but actively encouraged. And the results were broad, beyond my own personal and professional fulfillment: children were well served by museum programs, a rich mixture of creativity, research and time-tested pedagogy.

—Bernie Zubrowski

Bernie's philosophy and activities served as some of the inspiration for the creation of the museum's KIDS@fterschool curriculum and Beyond the Chalkboard website in 2008-2011. KIDS, the first free, full-year online curriculum created specifically for afterschool educators, is being used in every U.S. state, and has been accessed in more than 100 countries around the world. This curriculum contains hundreds of activities, many of which were inspired by Bernie's tinkering. None of these activities would have been possible without Bernie's pioneering afterschool work.

Bernie's impact is seen in the work of many individuals as well. When I began collaborating with afterschool programs in the '90s, I was introduced to Kenny, a teacher at a local program with deep ties to the museum. Not long into the introduction I discovered that Kenny was one of the children with whom Bernie had conducted many of his early investigations as he developed his ideas, activities, and philosophy. Kenny grew up with distinct and salient memories of those investigations, which colored his choice to teach and his approach to how he engaged children.

Personally, I was drawn immediately to the experiences in *Science Playground* when I began at the museum in 1992. *Bubbles, Raceways, Tops & Yo-Yos,* and *Salad Dressing Physics* sang to me. After my first year at the museum, I got the chance to work briefly with Bernie before he moved on to the Education Development Center, and that brief connection taught me a lot. In later years, Bernie and I worked together again, through his development of the *Design It* and *Explore It* curricula, which took the topics and ideas from his books and curricula created at The Children's Museum and brought them to a broader afterschool audience. I am very much a "Zubrowskian" in how I seek to provide experiences for children and families, in how I talk to educators through professional development trainings, and in how I think about the kinds of learning opportunities I will provide for my son as he grows from infancy to adulthood. And all of this thanks to a few bubbles.



Mark Carter blows a huge tabletop bubble in this dramatic 1984 photo, taken by John Urban. The image was featured on a poster that was included in the AAAS Science Resources for Schools "Bubbles" activity packet.

Which one of the pairs would move longer? Since visitors did not seem to be readily making the comparisons, I decided to anchor the yo-yos on a bar that extended from the wall. Now the visitor could easily roll up the yo-yos side by side, release them at the same time and see what happened. This slight alteration of the exhibit design led to a change in visitor behavior: now more people manipulated the yo-yos in attempts to make this comparison.

The fact that all of these exhibit phenomena were played out using simple or familiar materials suggested that similar investigations could be carried out at home or school. Some visitors appeared to get the idea. When videographer David Smith taped visitors using the *Tops and Yo-Yos* exhibit, two people explicitly commented on this implicit message. One woman, a teacher, said that when visiting the museum and exploring exhibits such as *Tops and Yo-Yos* she got ideas for science activities in her classroom. A man noticed and commented on the fact that simple materials were used in *Tops*. He noted that one could go home and easily duplicate these activities in some way. Many classroom teachers used scientific phenomena-exploring exhibit like *Tops* as either the starting or ending point for their class visits to the museum. Students could visit the museum, become intrigued by the science they "played with" there, and then go back to their classroom to do more investigation. Or, a visit to the museum could be the culmination (or reward) for science work previously done in school.

In Retrospect

As one gets older, hindsight helps us take the long view of past experiences and attempts to put these experience in a positive perspective. Working at The Children's Museum afforded me the opportunity to combine a variety of interests in a way that allowed me to build on past experiences in a productive manner. In an interview with Mike Spock, I summed it up: "...a great thing about the museum? I could work with kids, I could do design, I could do science, I could do art. It was a place where a lot came together, and I like to pursue all those interests." There are very few places where I could have worked that would have allowed me to proceed in the manner in which I did. Mike Spock, and managers with whom I worked—Elaine Heumann Gurian, Pat Steuert, and Jim Zien—created an institutional culture that gave a fair amount of leeway to people like myself and an ongoing support system that let us be creative. They deserve a great deal of credit for bringing this about and keeping it going for an extended period.

The Children's Museum culture attracted like-minded people who became professional colleagues and friends. We shared a common educational philosophy and pedagogical approach. In addition, the museum was at the nexus of a variety of educational and cultural programming that resulted in my meeting other museum and educational professionals. These acquaintances became part of my professional network and put the museum's work and mine in a broader local and national context. After years of developing and refining afterschool science programming, designing exhibits such as *Bubbles* and *Raceways,* and just being part of The Children's Museum, I ultimately received invitations to share my experiences and travel to England, Italy, even Baharain and India, as well as to a number of museums in the United States. Although I was not paid as much as I might have earned if I had continued as a scientist, or worked at more high-powered institutions, the benefits of working with this group of people more than compensated. I was fortunate to have worked at The Children's Museum during this very interesting and exciting time of its development.

Photo Credits: Jon Goell, 93; Joel Hoo, 83 (right), 94; Nancy Dolinich Hope, 80, 82, 83 (left), 86; Richard Howard, 79; David Merrill, 95; Frank Siteman, 77, 78, 84, 85, 89 (upper left), 91 (both); John Urban, 96