Memoirs of a Bubble Blower

BY BERNARD ZUBROWSKI

Reprinted from Technology Review,
Volume 85, Number 8, Nov/Dec 1982

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Shimmering and intricate as they grow and change, soap bubbles fascinate nearly everyone. And blowing bubbles is a rich but overlooked approach to learning, providing insights in areas from the perceptual to the philosophical.

IN teaching science to children, I have found that the best topics are those that are equally fascinating to children and adults alike. And learning is most enjoyable when teacher and students are exploring together. Blowing bubbles provides just such qualities.

Bubble blowing is an exciting and fruitful way for children to develop basic intuition in science and mathematics. And working with bubbles has prompted me to wander into various scientific realms such as surface physics, cellular biology, topology, and architecture. Bubbles and soap films are also aesthetically appealing, and the children and I have discovered bubbles to be ideal for making sculptures. In fact, looking over the past ten years I can see a certain philosophy emerging—a sort of Zen and the art of bubble blowing.

Patterns in Bubbles

Adults tend to think of bubbles as a visual phenomenon, but I suspect children are initially more intrigued by their kinetic qualities. Soap film is very sensual as it expands, moving like Jello, sometimes with the entire bubble swaying from side to side. In the film itself, amoebalike spots swim through stratified layers of brilliant color. And there is a special quality—artistic? scientific?—in the way bubbles clump together. Though they seem to have an intricate complexity, the bubbles in a cluster actually take only two basic geometric configurations.

Such bubble behavior is featured in exhibits I've developed at the Children's Museum in Boston. In one exhibit, children generate a froth of bubbles between two plexiglass sheets spaced half an inch apart. The bubbles form a two-dimensional hexagonal array similar to a honeycomb, with three bubble surfaces always meeting along a line at angles of 120 degrees. In another exhibit, the children go a step further by creating three-dimensional clusters of bubbles that rise up a plexiglass tube. These bubbles are not as regular as those in the honeycomb formation, but closer observation reveals that they have a definite pattern: four bubbles (and never more than four) are usually in direct contact with one another, with their surfaces meeting at a vertex at angles of about 109 degrees. And each bubble in the cluster will have roughly the same number of sides, a fact that turns out to be scientifically significant.

In the 1940s, E.B. Matzke, a well-known botanist who experimented with bubbles, discovered that bubbles in an array have an average of 14 sides. That is, the "average" bubble has the shape of a 14-sided polyhedron. And that's important because 14 is the number of faces of the so-called "Kelvin cell." Proposed by Lord Kelvin in the late 1880s, this is the ideal geometric shape for enclosing space, requiring the minimum surface area and tension to enclose a given volume.

This may seem to be another of those esoteric facts scientists bandy about, yet it bears on a wide range of structures. For example, scientists have noted a consistent similarity between soap-bubble arrays and such diverse things as human fat cells, plant cells, cells of dragonfly wings, spots on a giraffe, cracks in dried mud, the way lead shot compacts, and the granular structure of metals. Peter Pearce, in *Structure in Nature Is a Strategy for Design*, says that soap-bubble arrays "can be taken as the model or type of all systems—biological, physical, chemical—in which there is an economical association of cellular modules." What I hope children will gain from playing with bubbles is the realization that there are many patterns in both natural and human-made phenomena, and that discovering and explaining such patterns is a vital part of science.

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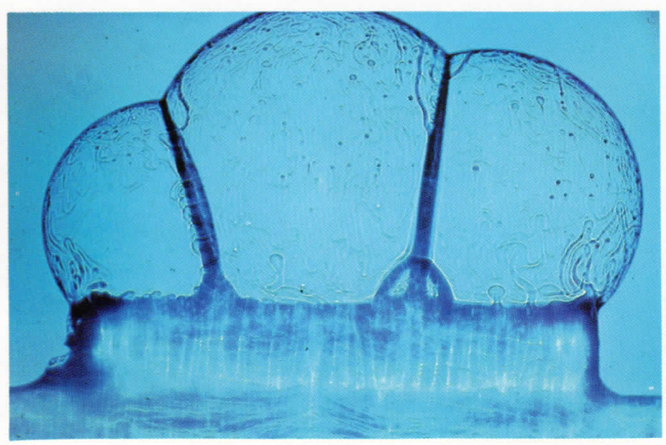


Children "at work" at the Children's Museum in Boston. Soap bubbles provide vivid examples of many geometric shapes and spark discussions of mathematical concepts. Architects also use bubble arrays, such as the simple cluster above, as structural models. The Pneu Dome (left) is an early product of Crysalis Corp., designed for those who want a bubble in their backyard.

Architects have also capitalized on bubbles as what Pearce calls "an elegant demonstration of minimal principles." (Bees, nature's superb architects, demonstrate minimal principles at work: the configuration of a honeycomb contains the greatest amount of honey with the least amount of beeswax and requires the least energy to construct.) Frei Otto of Germany is a pioneer in this field, with numerous bubble-inspired structures to his credit: large balloonlike buildings and huge tents with sweeping lines. Although Otto doesn't simply build a scaled-up version of a small bubble array, he finds soap-film models useful in determining such things as the minimal surface area and the stresses that will occur in his structures. Indeed, "bubbles" are becoming an increasingly familiar sight in many cities, with tennis courts and other athletic facilities sporting air-supported domes based on the structure of bubble arrays. So soap bubbles are useful in understanding structural arrangements from the micro to the macro.

Lessons to See and Feel

Having played with bubbles for so long with children, I am convinced that educators are overlooking a rich opportunity. Manipulating soap films involves both the visual and the haptic senses; that is, what we see and how our bodies sense movement. The shapes that bubbles take are similar enough to encourage the search for patterns, yet they are always different enough to arouse anticipation. These properties prove to be irresistable to almost everyone, from children in African villages to those in suburban Boston. The educational value is that the material, not the teacher, is the motivator. This doesn't negate the teacher's role, but suggests that here is something worth exploring for its own sake.

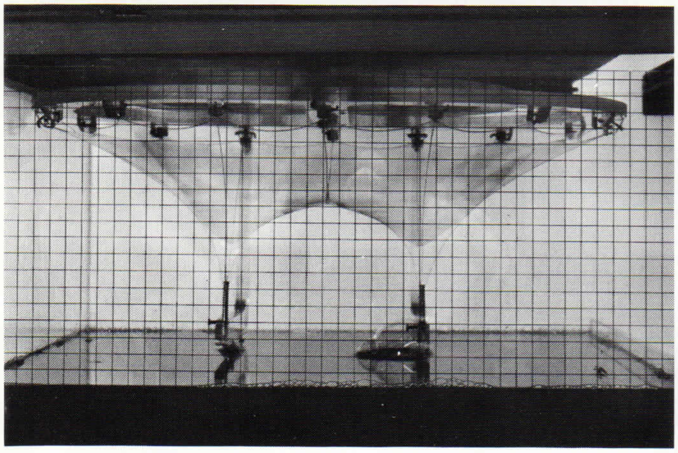
These qualities were dramatized for me as I blew bubbles with a blind child. He would wet one hand with soapy film and then, by blowing through a straw, would form a bubble on his hand. He could sense when the bubble began forming and how big it grew. And when it broke, the warm air in the bubble would disperse—a clear indication that it was gone. The boy grew excited each time a bubble expanded to cover his hand, and afterward he exclaimed that he had never experienced bubbles so large.

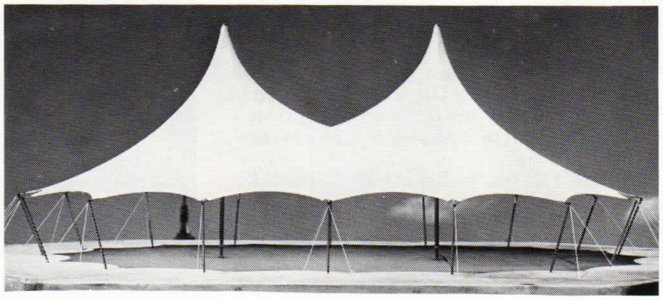
In another instance, I videotaped children playing with the exhibits in the Children's Museum and observed a girl who spent 45 minutes with the same contraption. It was simply some sticks and string that, when pulled out of the soapy water, made a two-by-three-foot film. I discovered that the girl developed a repertoire of manipulations that produced a variety of curved surfaces and geometric shapes. Though I am sure she could not have explained exactly what she had generated, her face and gestures indicated deep concentration and satisfaction.

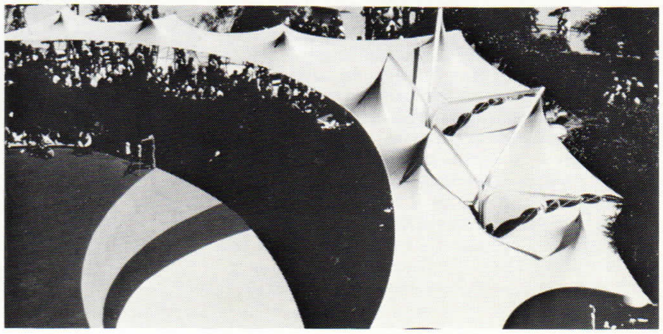
Geometry in Action

On a conceptual level, bubbles can help illustrate a variety of mathematical relationships. In fact, mathematicians have studied the principles governing the geometry of soap films for at least two centuries. For younger children, bubbles and their arrays serve as vivid examples of many geometric shapes, such as the sphere, hemisphere, pentagon, and hexagon. Creating and feeling these shapes is much more dramatic than simply seeing them portrayed two-dimensionally in a drawing. With older children, bubbles will spark discussions of concepts such as angles, surface areas, perimeters, and volumes of various geometric shapes. For example, by making a bubble grow larger they can begin to see the relationship between volume and diameter—often a difficult concept to convey—and they can make direct measurements to confirm their observations.

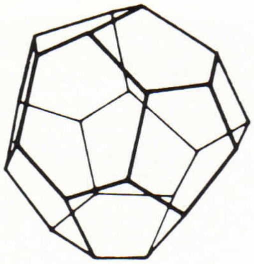
Indeed, I feel a bubbles "curriculum" could be developed that would span the educational time line from preschool to postgraduate. Students can return to bubbles time and again and delve more deeply into their geometry. This approach

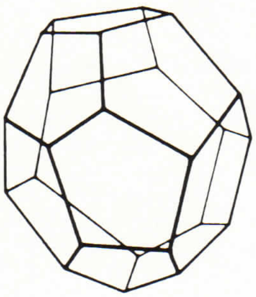


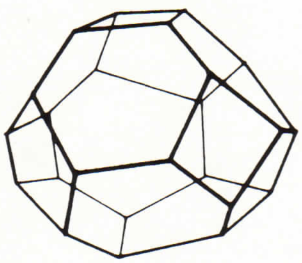


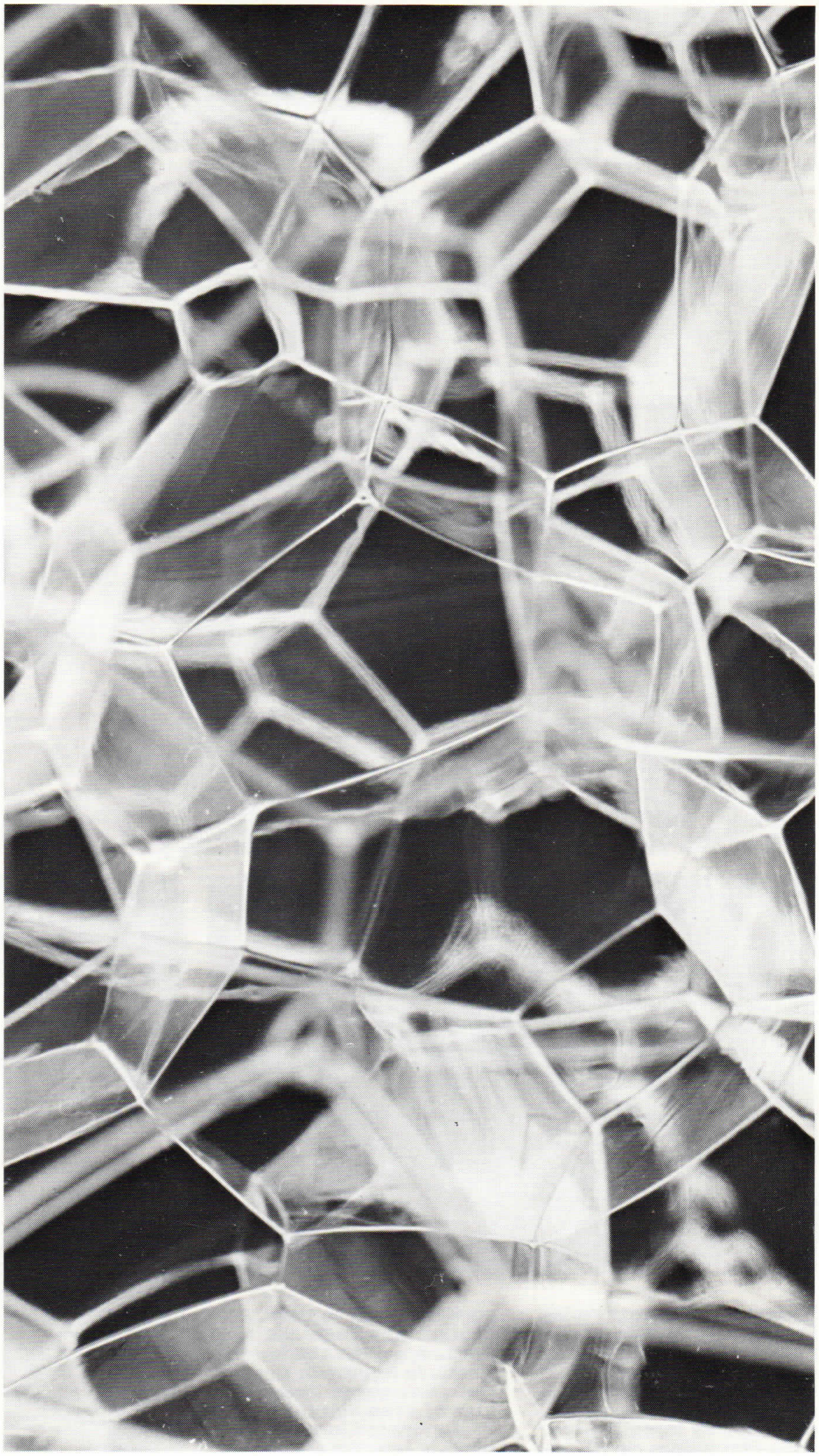


Soap films illustrate "minimal principles." The machine above enables designers to determine the surface area and stresses in the structure produced by inverting the soap film (upper right). The soap-film-inspired pavilion at lower right, designed by Chrysalis Corp., provides shade for Kennedy Square in Detroit. Any shape that bubbles or soap film take can be duplicated in an air-filled or tentlike structure.



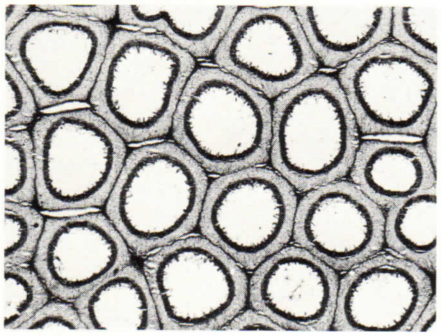


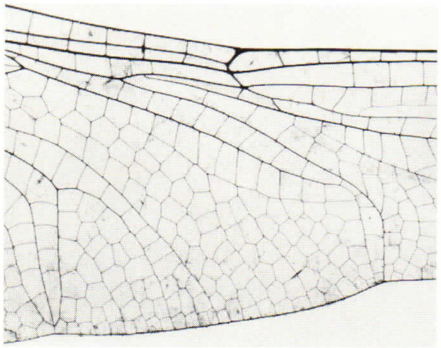


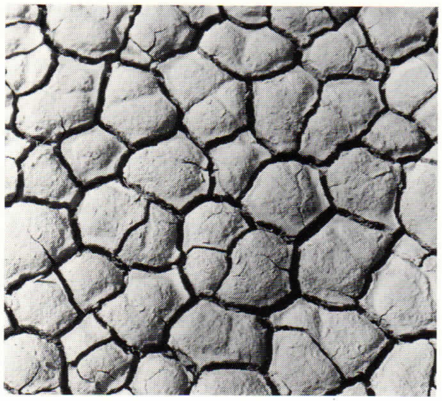


Bubbles in a cluster follow mathematical laws and take only two basic geometric configurations. Three surfaces can meet along a line at angles of 120 degrees, or the surfaces of four bubbles (never more than four) can meet at a vertex at angles of about 109 degrees.

In the 1940s, botanist E. B. Matzke discovered that bubbles in such an array have an average of 14 sides. Examples of the shapes he noted are shown above. A 14-sided polyhedron is the ideal geometric shape for enclosing space, requiring the minimum surface area and tension to enclose a given volume. Bubbles, then, provide a model for many natural and human-made phenomena in which structure follows "minimal principles." Examples on the opposite page: spots on a giraffe, underside of a mushroom, cells in a dragonfly's wing, and dried mud. By playing with bubbles, children will learn that discovering and explaining these patterns is a vital part of science. (All illustrations from ***Structure in Nature Is a Strategy for Design,*** **by Peter Pearce, M.I.T. Press)**







to learning may be quite different from conventional methods but is just as valid. Teachers usually explain concepts and then try to illustrate them through demonstrations or experiments. But with bubble blowing, the concepts arise out of the materials—much closer to the way we learn in everyday life. And all the while students are working with a beautiful and intrinsically interesting phenomenon.

I have yet to mention all the possibilities that stem from a soap film's interaction with light. Only by practice does a child develop the perceptual skills important in cognitive growth. Playing around with soap film—watching how the patterns of colors change in subtle ways—is a pleasurable way of exercising such skills. And aside from encouraging their aesthetic sensibilities, children can learn about the phenomenon of light interference. One interesting experiment is to make a film in a closed container and let it sit for an hour or so. The liquid will gradually evaporate, leaving a film that doesn't reflect any light. Nothing like this can be seen outside of a laboratory!

Underlying all these educational possibilities is the poetry of bubbles, which can provide philosophical insight into life itself. A bubble isn't a bubble if it lasts for a long time—part of its fascination is that you never know when it will pop. If you try to "capture" bubbles, by taking their picture or enclosing them in a bottle, you have a different kind of experience. Some of the best moments in life are like that. A festival, a play, a concert is exciting and wonderful partly because it is short-lived. The first moments of love, an intense conversation with a friend, the birth of a child are there and then gone. We can't hold on to them, even though many of us try. Blowing bubbles is a continual reminder that we would do well to savor those fleeting experiences.

Reforming Science Education

Now, I certainly encourage everyone to blow bubbles. But my greater concern is the education of children. Too much of their formal education is dull and rote—the learning of formulas and methods. Some of this is useful and necessary, but it often dominates the school day and most of the school year. Teachers often devote little time to the fascinating human-made and natural phenomena right around us. Exploration just for its own sake, and manipulation just because something is beautiful and fun, seem to be left at the school door.

For example, I once tried out some of my ideas in a suburban school system noted for its innovative and enlightened programs. In one school, the principal put me in a basement room more like a closet. Not only was it out of sight, but I suppose it was also out of smell: the odor of dishwashing soap tends to hang around, no matter how well one washes up afterward. And many of the teachers got curious looks on their faces whenever I talked about my "math" class.

But curiously, both teachers and parents look much more favorably on bubble blowing at the Children's Museum. Everybody is always very enthusiastic during special programs for visiting school children. And parents usually encourage their children to get involved, often asking how bubble blowing can be done at home. I have seen this happen with other "unconventional" educational activities—there is a tolerance for "frivolous" activities when done in the "proper" context. I think there is an important message here.

Recent years have seen a well-documented decline in student interest and abilities in science and mathematics—and this apparently starts early on. In one study, for example, nearly half the third-grade students interviewed said they did not want to take more science. Only a fifth of the eighth graders expressed a positive attitude toward science courses, and this percentage remained constant throughout high school. But the students said they liked science when they learned about it outside school—through museums, planetariums, "marine worlds," and the like. Maybe these places are onto something.

Perhaps schooling and play are incompatible, especially when it comes to playing with messy materials. If so, we ought to provide other opportunities for children to keep alive their fascination and wonder. After-school child-care programs offer such opportunities. However, I'm not convinced that education can't be more fun. The joy, as well as the learning, that I've seen come from blowing bubbles tells me that we need to reawaken the spirit and the energy that went into reforming schools in the 1960s. If we encourage a basic sense of play, the work of school will provide more lasting rewards. □