The STARLAB Story . . .

STARLAB is the first truly portable planetarium invented back in 1977 by Philip Sadler and his class of middle school students in Lincoln, Massachusetts. Today STARLAB is the most widely used planetarium in the world. It continues to provide a universe of opportunity to many people who previously did not have access. Here is the story of how it all began as told by Philip Sadler:

STARLAB is the product of the efforts of so many different people: students, educators, family members, and friends. Many saw the promise of portable planetaria, and these teachers, museum educators, university professors, and school administrators have helped to guide and influence the development of STARLAB, its supporting materials and the unique ways it has come to be used in schools and museums around the world.

When I travel to conventions and workshops teachers often mistakenly view me as the sole developer of the portable planetarium. They somehow see the STARLAB and its uses springing fully-formed from my imagination. Nothing could be further from the truth. This wonderful device was shaped and molded by those with a much deeper knowledge than I have of how children learn science and by events totally out of my control. STARLAB was forged by astronomy teachers, many of whom individually worked with tens of thousands of children each year. Moreover, permanent planetariums are the backbone of precollege astronomy education. Without their having paved the way, our portable units would not have been welcomed into the community. [Therefore] I thought it would be useful to recall the development of STARLAB. I want to relate its unique start in a middle school science classroom and tell the story of how so many people have made it such a wonderful way for children to learn science.

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The Need for a Portable Planetarium

It seems like yesterday to me, although it was more than 25 years ago, when my seventh and eight graders clamored for a trip to the Boston Museum of Science. My kids were impressed most of all with the wonderful Charles Hayden Planetarium, learning all about the constellations in the night sky. I thought that was the end of that. What a surprise I was in for! My students became obsessed with planetariums. They talked about planetariums at lunch. They convinced their parents to bring them to the Hayden planetarium again. They went out and looked at the stars. Most of all they decided they wanted a planetarium of their own.

When I was a kid, my dad bought my older brother a little planetarium projector. We would sit for hours under the artificial stars of the planetarium trying to memorize the constellations. My older brother was seriously into astronomy. He ground his own telescope mirrors in the basement deep into the night. I remember the first time I looked at Saturn through a telescope of his making. Wow! What a delight to see that yellow planet surrounded by rings. So, I thought, why not? If a kid can have a planetarium projector, a school could certainly have one.

The class set to work writing letters to planetarium manufacturers far and wide. Not only were there no inexpensive planetaria available for schools, there were no medium-priced planetaria either. But my students were not deterred. We started building prototypes, first drawing them out on paper. We made a whole curriculum out of the project. We started off by making spherical structures out of clay, then out of paper, then out of toothpicks. We finally hatched the idea that we could make a geodesic planetarium dome. A few helpers and I went down to the dump, and came up with hundreds of pounds of used steel conduit. We set up a huge assembly line where we made all the parts for a large 16-foot dome.

It was going to be big — big enough to fit in my classroom — but we decided to assemble it first outside. We took the hundred or so pieces and started fitting them together with bolts. All covered with black plastic, it was impressive, but the *geodesic dome worked as a barely adequate planetarium dome because all the structure was on the inside. Whenever the stars were projected or moved they would show up on the pipes on the inside of the dome. But instead of giving up on this design because of its shortcomings, we decided to cover it with clear plastic. It became a greenhouse for the school. We were able to hold classes in the middle of winter on green grass in our 16-foot geodesic dome.*

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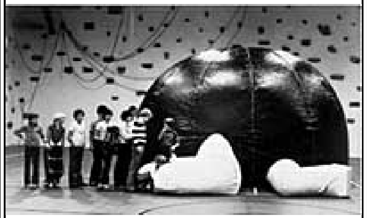

The Inflatable Dome

My students still would not let the matter rest. How were we going to build a planetarium dome, inexpensively, so that it did not interfere with the normal use of my classroom?

One day, driving down Memorial Drive in Cambridge along the river, I looked out the window and saw a big white blob that I had seen so many times before, but never noticed. It held the MIT tennis courts — a large inflatable structure supported with nothing but air pressure, and I thought perhaps something inflatable would work. I had no idea what the requirements for fabric or for the air power were for a 16-foot dome — something about the size of our geodesic dome. I set to work calculating away the weight of the material, the power of fans, the pressure of fans. The class started blowing tissue paper around the room to figure fan characteristics, wind velocity and measuring the force of fans with small scales. A window fan appeared to be quite adequate to hold up a big dome (theoretically). Then we needed to identify some plastic to make the dome out of — a roll of heavy black polyethylene construction plastic, turned out to be opaque enough to make the planetarium. Now, building something round (a dome) out of something flat (sheets of plastic) is not a trivial exercise. However, we were preceded in this challenge by hundreds of years of map-making. Maps are a flat representation of the round globe. Indeed, most globes, upon close inspection appear to be made from flat strips of paper. Cartography to the rescue, globe-like sinusoidal gores filled the bill.

We set about building a four-sided planetarium using the strangely-shaped gores. Now, this took my special team at the Carroll School several months to complete. We made it with glue and tape and by cutting all the pieces very carefully. It was an extraordinary math lesson for everybody. We had to graph out these giant shapes, roughly ten feet on a side, check them for accuracy, cut out the plastic, tape it all together, and glue the white plastic on the inside. Slowly, things started to come together. Eventually, we had a very large pile of construction plastic and a place where the fan could connect to it. We fastened the dome to the fan, turned on the power and held our breath. I don't think there was a person in the room who really believed that the tiny fan could actually hold up this huge dome. But true to the equations, the dome took about five minutes to inflate! Mouths agape, we all crawled inside into a pitch black environment. I brought in that very same toy planetarium projector from my youth. We turned it on and were impressed with the beautiful star show. We saw hundreds of stars and constellations that day. Everyone was very pleased and very satisfied.

We used this planetarium for several months. My students learned all the constellations. The class of builders soon became the planetarium presentation team and they gave planetarium/astronomy shows to every class in the school. Our principal brought in guests and visitors to see this extraordinary development. And slowly, I began to get phone calls at home about this strange thing I developed. People wanted to know more.

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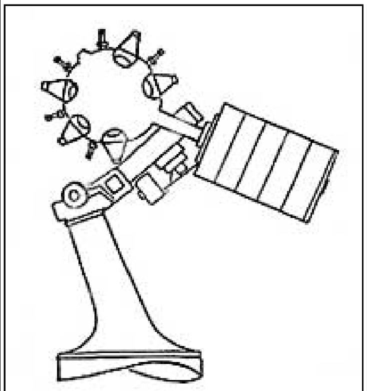

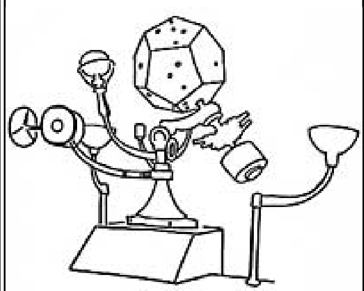

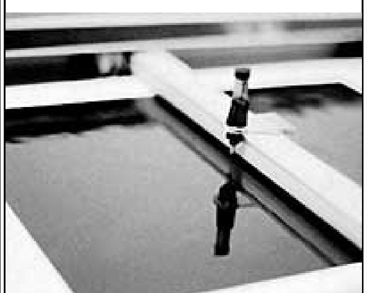

Projector Development

I started to write up exactly how we built this in case anybody else might want to try it, but I was still dissatisfied with the design. The planetarium projector of my youth projected only a few hundred stars. What I wanted was a simulation of the night sky, with thousands of stars, with all of the stars in the Little Dipper, with all the stars in Orion. I set about improving the planetarium projector by poking in more and more stars. The projector as it came from the factory had a lot of mistakes in it which made the sky look fairly inaccurate (e.g. it had only two stars in Orion's belt). But try as I might putting more stars in, and it did improve, it still was not satisfactory. To make a realistic sky, I had to think about a new way to project the stars.

It turns out that planetarium projectors came in two basic flavors. Carl Zeiss invented one which is essentially multiple slide projectors — a bright light surrounded by dozens of metallic or glass slides, each with a separate focusing lens. These slides are imaged on the dome of the planetarium. Armand Spitz's design is basically a large pinhole projector with a bright central light source surrounded by a metal sphere in which are drilled tiny holes. Attached to the larger holes are lenses to make the stars brighter and smaller. Both of these designs take an extraordinary amount of machining and hand-work to produce. And, to get accurate images, a lot of care has to be taken to ensure that all the star positions are correct and everything is adjusted perfectly. Also, to project other images, constellations, an image of the earth, celestial coordinates, all have to be done by separate projectors. Now, what I hoped for was to find a way to make a planetarium projector without the use of a large amount of sophisticated machinery. I thought long and hard about this, thinking about how to make a sphere that would project the stars.

One day, staring at my cup of coffee (I really needed it to face my class of adolescents everyday) and munching on a donut, I remembered a lesson in one of my college mathematics courses. It was about topology and about how donuts are really the same shape as coffee cups. You could deform a donut into a coffee cup, even without punching any new holes in it. Since there is only one hole in the handle of a coffee cup, the hole in the center of a donut could be transformed into that and all the rest of the cup could be produced by pushing and squeezing. In the same way, a sphere with thousands of tiny holes in it could be transformed into a cylinder simply by stretching.

It's easy to imagine stretching a balloon into a cylindrical shape. Any holes on the surface would be stretched along with the surface. Each hole would represent a star. The holes near the edges of the cylinder would be a little bit bigger than the ones in the center of the sides or the top. But the most extraordinary thing about making a cylinder to project the sky, is that cylinders can be unwrapped into three pieces and flattened out. So no longer would one need special machinery to put holes in the projector, in the sphere, or in plates in exactly the right place. One could reproduce these unwrapped cylinders photographically and that's what we set about doing.

My classroom certainly didn't have the computer power to calculate all the positions of these stars using cylindrical coordinates, so my students and I did all the calculations by hand, transforming spherical sections into cylindrical sections, placing thousands of stars. My students turned out to be exceptional plotters and we built the projection cylinders using this design. From there, I went on to using a photographic master and computer-generated images so that the positions of the STARLAB planetarium stars are extremely accurate, all positioned by computer and reproduced photographically. This produced an extraordinary sky, one that *people tell me is equivalent to projectors costing many, many times more than the STARLAB projector.*

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Getting into Business

Once we finished the projector and the dome, many people began contacting me about possibly making these things for their school. And two colleagues prevailed upon me to leave school, to leave teaching and go into business producing planetariums. Well, it was a big step to go from being a teacher to being a businessman. I had never taken any courses in business. I was soon to embark on an adventure that would provide me with probably more knowledge I would have gotten by going to business school, but getting it the hard way.

I started Learning Technologies, Inc. Wow, now I had to name this thing. Cosmosphere, Starsphere, Cosmodome, Astrosphere, Starlab. Yes that was it, STARLAB. I decided to make the first professional prototype and took advantage of the MIT hobby shop which is an extraordinary place — a birthing ground for many, many businesses. As an MIT graduate, I could simply join the hobby shop and use it to build prototypes. Well, I built the first planetarium projector there. I managed to get enough fabric to build the first true dome prototype, printed up stationery, applied for a patent and I was off.

The first science teachers convention I attended was in December 1977 in Boston which made the cost very low for attending. It was the first time teachers had ever seen a portable planetarium. It could wrap down into a duffel bag and the projector was very small as well. By June of 1978, we had a number of orders and began producing these planetariums in my living room and in the hobby shop. Then during that summer we rented our first manufacturing space. It was a small factory (we have a much larger one now) and we made many changes in the planetarium to make it into a model that was useful for teachers.

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Change Was the Only Constant

Since the start of LTI, we have been the recipient of a tremendous outpouring of useful feedback. In my experience, most companies have a special department for customer feedback that is totally detached from the rest of the firm. Suggestions often go nowhere. STARLAB, having been developed by kids and their teacher, started as a company that was very sensitive to the needs of teachers and to their difficult job. Some teachers knew exactly what to do with a portable planetarium. Others wanted to build upon the experiences of others. Requests immediately came in for help with curriculum material for grades K-12.

Instead of inventing something new, we began by collecting planetarium materials that had previously been developed and could be adapted to this new type of planetarium. We found a gold mine — ***Under Roof, Dome, and Sky*** *— an extraordinarily comprehensive manual of planetarium activities for permanent school planetariums funded by a National Science Foundation-sponsored institute.*

The first curricula developed exclusively for the STARLAB in 1979 were the product of a grant from the Nebraska Department of Education that were aimed at helping teachers utilize the STARLABs supplied by Nebraska's Educational Service Units. These guides were found to be so effective that they became part of the materials we sent with every STARLAB. As classroom teachers and curriculum developers began to adapt the STARLAB to their own particular needs, Learning

Technologies maintained an exchange program to distribute these lessons free of cost to interested teachers.

Meanwhile, back in California, at the Lawrence Hall of Science in Berkeley, a revolution was brewing in the planetarium community. Many museum planetariums had lost much of their earlier interactive flair and were increasingly turning to recorded shows. The pressure on schools for similar 'canned' presentations had begun to build, characterized as a struggle between 'education and entertainment.' In response, Alan Friedman, Cary Sneider, Budd Wentz, Lawrence Lowry, Steven Pulos, and Dennis Schatz developed a program of planetarium activities with the help of the country's stellar astronomy educators. These were organized into a series of workshops that married current thinking in educational psychology with stimulating student activities. The result, a ***Planetarium Educator's Workshop Guide****, became the key sourcebook for all forward-thinking planetarium directors. It presented activities based explicitly on children's ideas and included classroom supplements and simulations. This volume revitalized the planetarium community, pushing small planetariums to the forefront of innovation.*

The follow-up to the ***Planetarium Educator's Workshop Guide*** *was an extensive project of summer institutes to prepare teachers to become planetarium workshop leaders. By the late 1980s, STARLABs had become popular enough for thousands of classroom teachers to have access to portable planetaria, yet many had little idea how to use them effectively in their own classrooms. The Lawrence Hall of Science, in collaboration with the New York Hall of Science, worked with teachers to develop workshops and prepare written materials. PASS (Planetarium Activities for Student Success) started with 6 volumes in 1990 and continued with 6 more in 1993, with a 13th volume published in 2003. To date, over 300 teacher leaders have been trained and countless others have attended these workshops. We are indebted to Cary Sneider, Alan Friedman, and Alan Gould and all those who had a hand in this extraordinary project.*

So you can see that many educators and students have contributed vastly to the STARLAB over the years. Much of the versatility of STARLAB came from the suggestions of others — from how to arrange the controls, to how to change the lamps, what to put in the various kits, and what to put in the user's manuals. Teachers suggested all of our new designs for cylinders and new ones are thought of every year.

In conclusion, I am pleased to say, that STARLAB has become a part of many peoples' lives. STARLAB originally started as a project in a middle school classroom and has grown to be the world's largest selling planetarium. On its way, it has been adopted by many different groups:

- *intermediate units, large organizations that serve many schools,*
- *school systems to use throughout their districts,*
- *science museums for outreach activities,*
- *individual schools, both public and private,*
- *camps and scouting groups,*
- *and individuals, often bringing astronomy to rural schools for the first time.*

STARLAB has been a group effort. It has been an adventure to build a business that serves the needs of children worldwide. We could not have done it alone. It has taken the ideas and efforts of teachers from every educational level and the hard work of our staff and network of field representatives. I am proud to be a part of this effort.

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