Fulldome Video

By Linda E. Law

Fulldome video, also called immersive projection, can help teach subjects ranging from geology to history to chemistry.
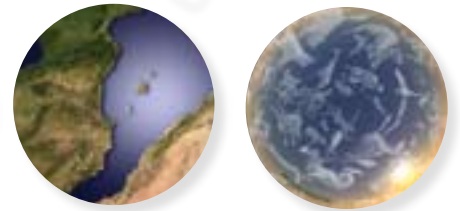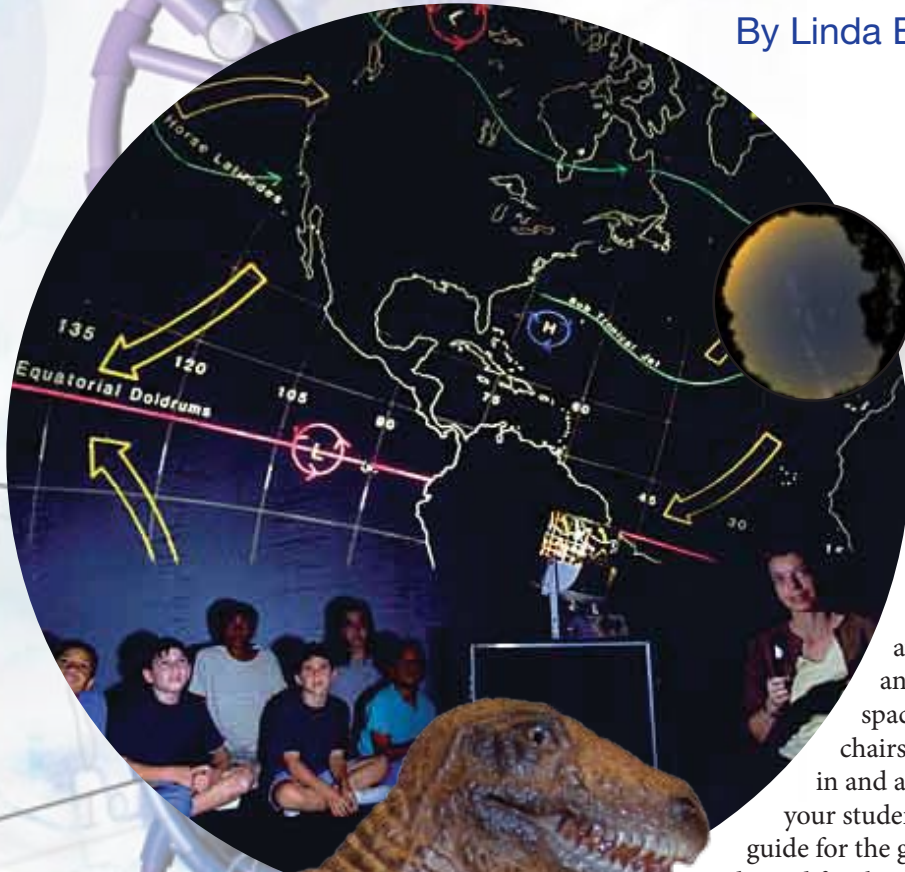
Picture this: You enter the school gym, and in front of you is an inflated dome, about 10 feet high. On the side facing you is the first door to an inflated airlock. You and your students push through this opening, one at a time, pass through a short tunnel and another inflated door into the interior of the space. Seating yourselves on comfy beanbag chairs with your back to this opening, you settle in and allow your eyes to adjust to the darkness, your students whispering, fooling around. Your tour guide for the galaxy invites you to sit back and enjoy the ride, and for the next half hour you journey through space, moving out from Earth, looking back at the surface as you explore the space station, moving continuously out to the moon, cruising over the surface as it revolves. By now, your sense of disbelief has been suspended, the kids are quiet and focused, and you are all caught up in the magic of being in space.

Now the questions start: Can we visit Mars? What does the surface look like? Where is the Milky Way? Your tour guide navigates you over the surface of the red planet, you hop around the solar system for a while and then she offers a sightseeing trip through the known parts of the universe. You sit back, and your mouth drops open as your mind absorbs the magnitude of what she has just said. Your eyes feast on the majesty of scale that is presented as, for the first time, you begin to grasp just how vast space is and how infinitely tiny we are.

What I just described is one experience made possible by a new technology, fulldome video, which has been adopted fairly extensively by the larger, well-funded planetariums. However, the rapidly advancing progress of projection technology has given us high-resolution projectors at increasingly lower prices, resulting in entry-level systems within the reach of schools. Dome projection systems appropriate for schools, complete with inflatable dome, projector, software, laptop, and some basic show content are available for prices from $20,000–$40,000. However, you do get what you pay for, and purchasing a higher resolution projector and a better operating system will greatly enhance the capability of the system. Schools should also budget each year as their finances allow for adding content and for training of staff.

Affordable Technology

The earlier, larger fulldome systems seen in places such as the Rose Space Center at the American Museum of Natural History in New York use multiple, high-powered projectors and many computers with custom software to drive them. These huge systems create convincing images on the dome by stitching them seamlessly together with a computing technique known as edge blending. Needless to say, this is a very costly process both in computational time and the maintenance required to keep many projectors aligned and with their brightness balanced. The sensory experience in this environment is further enhanced by the addition of 5.1 surround sound systems that give a spatial experience of the sound, linking movement of images with the placement of specific sounds in space.

The breakthrough for schools has been twofold: higher-powered projectors combined with a special lens that allows coverage of the dome with a single projector. Another optical approach, developed in Australia, uses a spherical mirror and a projector with a non-fisheye lens, resulting in even lower prices, although with lower projection quality. Add to this an inflatable dome, a laptop running specialized software, and a small 5.1 surround sound system and there you have it—a portable system that can be set up in less than an hour and easily moved from school to school in the trunk of a car.

Beyond the Stars

Now we have hardware and software to drive the system, and content becomes the big question. Planetariums were originally built to teach about the stars. Optical systems simulated the placement of stars in our skies by projecting points of light, and later systems used arrays of projectors with slides to create wrap-around scenes on the planetarium domes. But all of this was largely used to teach about astronomy. With fulldome video, the door is wide open to all subjects; the dome is a blank canvas waiting to be explored.

Two approaches are emerging in how content is handled in this format. The first is the pre-recorded show played back as a fixed performance. These shows are licensed and available for purchase from a number of sources (including the larger planetariums such as the Rose Space Center and the Houston Museum of Natural Science), and we are beginning to see an array of content appearing. Much of this content is being developed for larger planetariums or manufacturers of the hardware, where they have a production staff creating content through 3D animation. This is high-level animation and the end product reflects the skill level of the team that created it. These shows are re-rendered in formats appropriate for the various inflatable domes that currently exist.

There has also been much discussion, championed by Ed Lantz of Visual Bandwidth Inc. through the International Planetarium Society's Fulldome Standards committee, regarding the development of format standards to make it easier to share content among different domes.

Although there is still a preponderance of astronomical content, innovative new shows on other topics are being developed. In my opinion, the most exciting educational show to date is the Molecularium: Riding Snowflakes. Produced by the Rensselaer Nanotechnology Center in Troy, New York, in cooperation with Nanotoon and funded with a grant from the National Science Foundation, this is a 3D animation of molecules. In their own words, "Molecularium is a science lesson, a thrilling ride, a musical cartoon, and a magical journey into the world of atoms and molecules." Targeted to elementary and middle school students, the atoms and molecules are animated characters that tell the story of how our world is composed of them. It succeeds so well because the 3D animation is visually stunning, the storytelling is engaging, and the

Basic fulldome video equipment includes an inflatable dome and a laptop running a fisheye projector and sound system. The entire setup fits into the trunk of a car.

content is very tied into the curriculum needs of schools. (*Editor's note:* See Resources on page 15 for a list of fulldome video hardware and software providers.)

The second approach is the interactive exploration of 3D content databases in real time. At the beginning of this article I described a navigated journey through space. This journey can be experienced by exploring the Digital Universe Atlas created by the American Museum of Natural History and the Hayden Planetarium. This 3D map of the universe can be navigated with two packages of software, Uniview from Sciss AB, a Swedish company, and on Digital Sky 2 by SkySkan, New Hampshire, USA, through a custom plug-in. A third product, Starry Night by Imaginova, is a widely accepted product that runs on classroom computers and has a sophisticated set of packages targeted at different grade levels for the study of outer space. This product offers another possibility—that students can design their own presentation about aspects of their study of space and present it within a fulldome setting with another product, Starry Night Dome. Although all of the above examples are navigating datasets of the stars, Digital Sky 2 is capable of navigating other information libraries, such as ones about DNA. Uniview is also working on this, and both packages offer a doorway into future real-time journeys through data from almost any source.

Immersive Technology

How students learn in this environment and how well they retain information is a tantalizing question. Dr. Ka Chun Yu, curator of space science at the Denver Museum of Nature and Science, is working on a research project to evaluate how well students retain information learned through the immersive environment of fulldome video versus more traditional settings. Similar research is being

planned at the Chabot Space and Science Center in Oakland, California. If you look at the multi-sensory input that fulldome video offers in the context of the groundbreaking work on multiple intelligences of Dr. Howard Gardner, a professor at the Harvard Graduate School of Education and author of *Frames of Mind: The Theory of Multiple Intelligences*, it is easy to see how this provides a highly engaging teaching environment targeted at those students who learn through other modalities than the customary linear-sequential approaches of schools. It is my calculated guess that their research will find that this way of learning will benefit all students, but we will see a significant improvement

and engagement in learning from students classified as "at risk."

There are issues to be addressed in the future evolution of this exciting new technology. First, more content packages tied to curriculum with strong supporting teacher materials, staff development programs, and summer teaching institutes to train teachers must be developed. It is not hard to imagine packages dedicated to world history with data sets of navigable 3D reconstructions of historic sites where you experience the art, science, and literature of a place through successive periods of time. Imagine journeying through a 3D version of the brain with animations that show how different nerve pathways and parts of the brain are activated when we use our eyes or hear or smell something. This program has already been proposed by a German company, Livinglobe, and titled the Brainarium.

Second, educators should encourage the evolution of new tools that allow students to easily create their own content. Susan Reynolds Button, president elect of the International Planetarium Society, and herself a teacher and an early user of the Starlab analog projector that was the precursor of these latest digital systems, strongly advocates this approach.

I think that the trend towards cheaper and more powerful projectors will continue to make these environments more financially feasible for all schools. In addition, the innovative teachers who take on the ground-

Virtual Reality, Then and Now

In the early 90s we were introduced to the concept of virtual reality (VR), and suddenly we saw a range of interactive experiences in virtual worlds. This was made possible by 3D modeling on computers accompanied by helmets with imaging systems and sensing devices in the form of data gloves or joysticks that placed us in those worlds. At that time I was hired to look at the educational possibilities of the technology by a company that made VR helmets. Although the interactive experiences were quite compelling and the promise was that this was an approach that could offer new modalities of learning, I finally came to the conclusion that VR was still a future technology waiting to happen.

For me, there were too many strikes against this approach. The helmets were isolating; interaction between students, although possible, was very complex to implement and unsatisfying—this was not a group experience. The cost of the technology was very high, prohibitively so for schools, and the computers of that time (more than 10 years ago) were not fast enough to give really convincing reconstructions of reality. The final nail in the coffin for this idea for me was the big question regarding just how safe it was to allow students to wear these helmets for extended periods of time. They were quite heavy and the optical systems forced their developing vision to focus in an unnaturally close position.

Since then, I have been looking out for the next technology that would open up the possibility of VR within an interactive group experience and one that would be cost effective for schools. I think that I can safely say that it is here.

—Linda E. Law
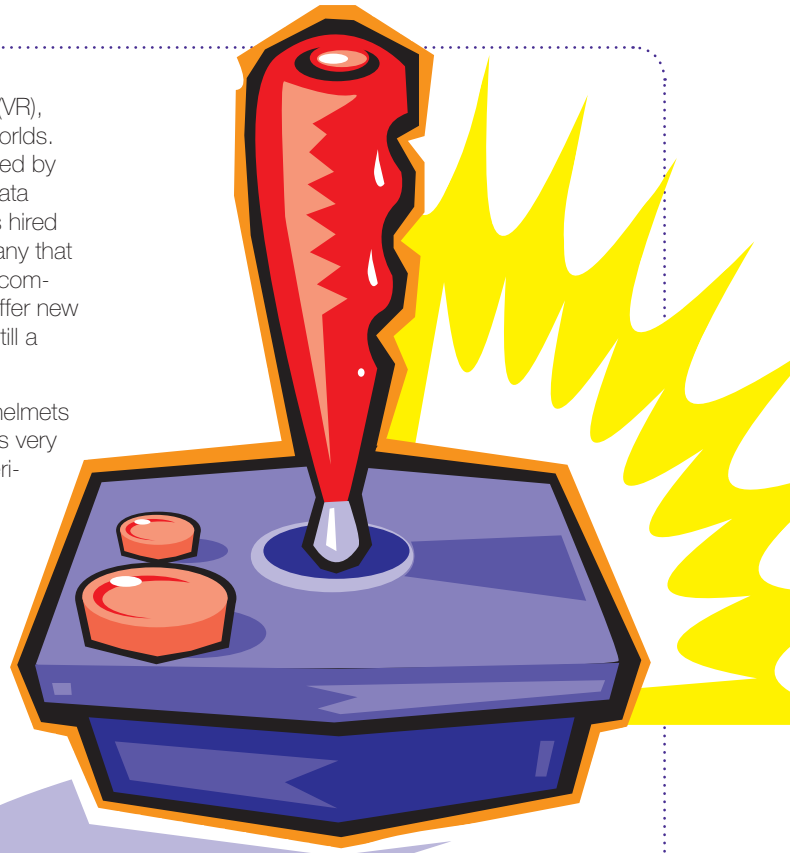
breaking work of introducing this technology to their classrooms will be rewarded by classes of students who are eager to come to school to learn. Students today come from a generation that has grown up with technology. It is our responsibility to provide them with tools that match the capabilities of their multitasking minds. Given an environment that allows them to stretch their imaginations in the years when they are the most flexible, we will be giving them a jump start into the understanding of the rich complexities of the art, science, and technology of the 21st century.

Editor's note: A follow-up article by Linda E. Law in the December/January issue of *L&L* will take a look at some of the schools who have already bought portable fulldome video systems and who are breaking new ground with this technology.

Resources
Manufacturers:
Digitalis Education Solutions: http://www.digitaliseducation.com
Elumenati: http://www.elumenati.com/
e-Planetarium: http://www.e-planetarium.com
Evans & Sutherland: http://www.es.com/products/digital_theater/d3-family.asp
Konica Minolta: http://konicaminolta.com/kmpl/
Learning Technologies: http://www.starlab.com
Sky-Skan: http://www.skyskan.com

Sources for content:
Hayden Planetarium: http://haydenplanetarium.org/universe/
The Houston Museum of Natural Science: http://www.hmns.org/see_do/planetarium.asp?r=1
LivinGlobe: http://www.livinglobe.com
Loch Ness Productions: http://www.lochness.com/lfco/lfco.html

The Molecularium Project: http://www.molecularium.com
Sky-Skan, Inc.: http://www.skyskan.com/Products/
Starry Night: http://store.starrynightstore.com/newversion6.html
UniView: http://www.scalingtheuniverse.com/uniview.php

Other useful links:
Fulldome.org, a community site for immersive dome theatre users: http://www.fulldome.org
International Planetarium Society: http://www.ips-planetarium.org
Loch Ness Productions Fulldome Resource page: http://www.lochness.com/fulldome/fulldome_resources.html

Linda E. Law is a digital artist/teaching artist/consultant who specializes in new educational technology. On the cutting edge in both her personal work and in her work in schools, she rides the wave that is sweeping through our educational systems, helping teachers and schools to navigate the flow of information.