PROCEEDINGS OF THE 55TH ANNUAL

G.L.P.A. CONFERENCE

TOLEDO, OHIO
OCTOBER 23-26, 2019

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Invited Papers

Contributed Papers

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Editor's Notes:
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TOMORROW'S ASTRONOMY FOR EVERYONE: FROM DEEP SPACE TO THE MOUNTAINTOPS TO YOUR BACKYARD

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Abstract: Astronomy has changed in many ways over the past 50 years. With regular availability of space-based telescopes and instruments, from the large and powerful to the small and clever, astronomers have never had such an amazing suite of tools with which to explore the universe. From the ground, new telescopes and techniques are opening new areas of research. The development of high-quality off-the-shelf equipment has allowed more amateur astronomers to make significant contributions to the field. Citizen Science projects are bringing everyone into astronomy and encouraging them to join in the grand endeavor to understand the universe.

Introduction

On behalf of our University President, Dr. Sharon Gaber, and myself, I would like to welcome all of you to the University of Toledo (UToledo – www.utoledo.edu) and our Ritter Planetarium. We are delighted that the Great Lakes Planetarium Association (GLPA) has chosen our city and our campus for your annual conference in 2019.

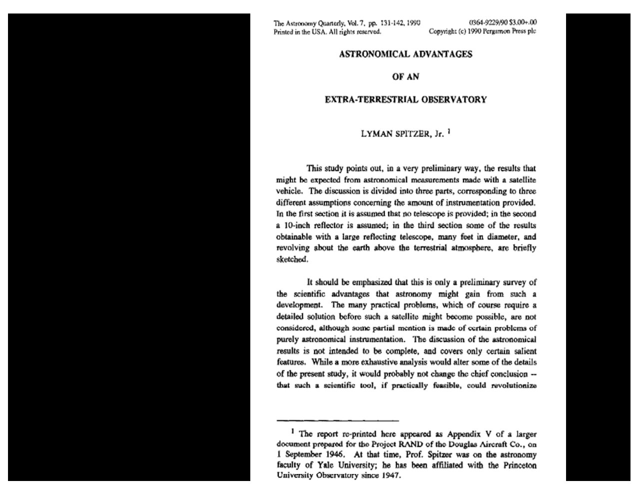
Let me start by giving a little background about astronomy at UToledo. Our astronomy & astrophysics group, which is housed within the Department of Physics and Astronomy in the College of Natural Sciences and Mathematics, currently consists of 9 active faculty (+4 emeritus faculty), between 2-5 postdocs, and typically 15-20 graduate students. Our areas of expertise include massive stars, brown dwarfs and exoplanets, circumstellar disks, star and planet formation, cosmo-chemistry, interstellar gas and dust, stellar clusters, galaxy formation and evolution, active galactic nuclei, x-ray binaries, and cosmology.

UToledo is a science partner with the Lowell Observatory in Flagstaff, Arizona, and through this partnership we have dedicated access to the state-of-the-art 4.3-meter *Discovery Channel Telescope* *(DCT)* located in the Coconino National Forest at Happy Jack, Arizona. We are members of the Association of Universities for Research in Astronomy (AURA), and we were recently named as one of three Research Areas of Excellence at UToledo. Our research utilizes both space-based and ground-based observatories, along with theoretical and computational astrophysics. Our students (both undergraduate and graduate) are deeply involved in our research programs. Besides our research and education missions, we are also engaged in public outreach and informal science education, especially through the on-campus Ritter Planetarium and Brooks Observatory.

Space-based Astronomy (now)

Note: most of the Hubble Space Telescope slides used in this presentation are courtesy of NASA and are freely available online at https://hubble25th. org/resources/7#categories_bar). All NASA images are available online in a searchable database at https://images.nasa.gov.

The concept of carrying out astronomical observations from a large space-based telescope was first advanced in a publication in 1946 by Lyman Spitzer, Jr. , a native son of Toledo, who went on to a faculty position at Princeton University; he was one of the leading astrophysicists of his time. It was almost 45 years later before his concept would become a reality, with the launch of the Hubble Space Telescope (HST) in 1990. UToledo has an endowed fellowship (the Doreen Canaday Spitzer and Lyman Spitzer Fellowship) which honors the connection between UToledo and the legacy of Lyman Spitzer.


The Astronomy Quarterly, Vol. 7, pp. 131-142, 1990 0364-9229/90 $3.00+.00
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ASTRONOMICAL ADVANTAGES
OF AN
EXTRA-TERRESTRIAL OBSERVATORY

LYMAN SPITZER, Jr. [1]

This study points out, in a very preliminary way, the results that might be expected from astronomical measurements made with a satellite vehicle. The discussion is divided into three parts, corresponding to three different assumptions concerning the amount of instrumentation provided. In the first section it is assumed that no telescope is provided; in the second a 10-inch reflector is assumed; in the third section some of the results obtainable with a large reflecting telescope, many feet in diameter, and revolving about the earth above the terrestrial atmosphere, are briefly sketched.

It should be emphasized that this is only a preliminary survey of the scientific advantages that astronomy might gain from such a development. The many practical problems, which of course require a detailed solution before such a satellite might become possible, are not considered, although some partial mention is made of certain problems of purely astronomical instrumentation. The discussion of the astronomical results is not intended to be complete, and covers only certain salient features. While a more exhaustive analysis would alter some of the details of the present study, it would probably not change the chief conclusion -- that such a scientific tool, if practically feasible, could revolutionize

[1] The report re-printed here appeared as Appendix V of a larger document prepared for the Project RAND of the Douglas Aircraft Co., on 1 September 1946. At that time, Prof. Spitzer was on the astronomy faculty of Yale University; he has been affiliated with the Princeton University Observatory since 1947.

HST has been a major workhorse and invaluable tool for space-based astronomy since its launch. From relatively nearby objects (at least in astronomical terms) like planets and comets, to more distant nebulae and galaxies, to the most distant reaches of the early universe, HST has fueled significant advances in astronomy for nearly the past 30 years. Because it was designed and planned from the start to be serviced while in orbit, HST has been refurbished with new and better instruments throughout its lifetime. This ability has kept HST at the forefront of astronomical research. The images obtained with HST have become some of the most recognizable and awe-inspiring to both scientists and laypersons alike. In this talk, I describe a selected number of these images in terms of their scientific significance—the basics of these results are found in many places on the HubbleSite web pages. HST's impact has been multiplied through collaboration with other NASA missions and space-based instruments, as well as with ground-based observatories.

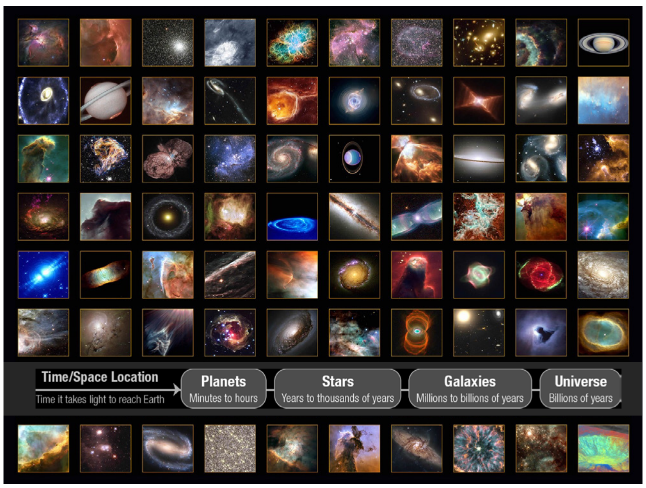
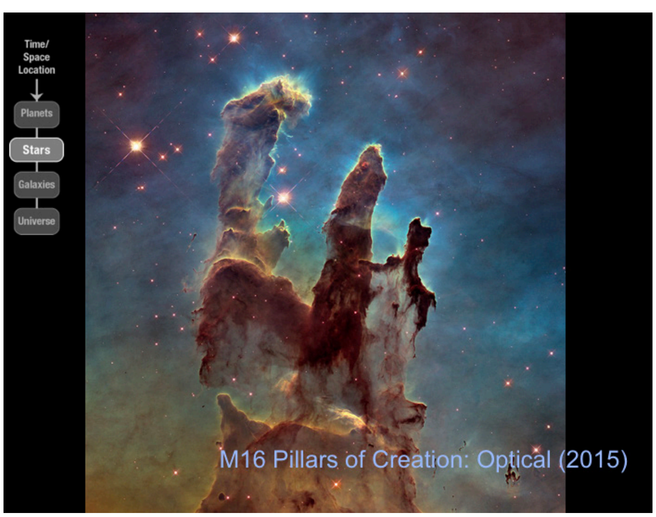
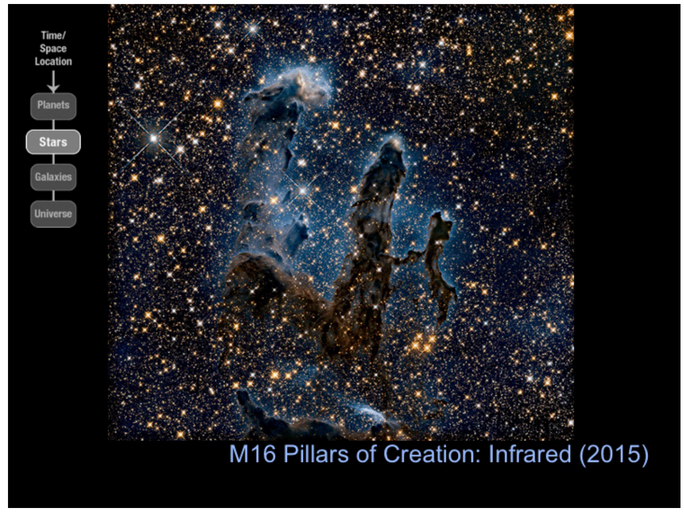


Image Credit: NASA/ESA/HST

Other NASA missions have contributed greatly to space-based astronomy as well. I can only touch on a few of those missions in this talk. By observing from space, many different wavelengths of light are accessible that would not be observable from the ground. For example, the Spitzer Space Telescope provided unprecedented views of the universe in infrared light, which has enabled many new discoveries about the process of star and planet formation, and about the role of dust in the interstellar medium.





The European Space Agency (ESA), in collaboration with NASA, led the development of the Herschel Space Telescope, which provided data in the far-infrared region. NASA's Fermi Gamma Ray Observatory opened a window into the high energy gamma-ray universe, which led to the discovery of so-called "Fermi bubbles" of expanding hot gas being emitted from our Milky Way Galaxy, traveling at speeds of over 2 million miles per hour.

In addition, NASA's program of robotic explorers to other planets, including both orbiters and landers, has fostered a much better understanding of the objects in our own solar system. The recent New Horizons mission explored distant Pluto, and continues to study Kuiper Belt objects in the outer reaches of the solar system. Specialized missions to study the Sun have provided insight into the in-depth workings of our home star. Many missions have explored the planet Mars in great detail. And missions are now being carried out to explore the nature of asteroids and comets, and even bring back samples of these smaller solar system bodies.

NASA missions such as Kepler and the Transiting Exoplanet Survey Satellite (TESS) have enabled the discovery of thousands of planets orbiting around other stars, known as exoplanets. With HST and ground-based telescopes, follow-up observations are now even working toward taking spectra of the atmospheres of some known exoplanets.

Space-based Astronomy (future)

The next generation of major space-based observatories will include the James Webb Space Telescope (JWST), currently estimated for launch in 2021. JWST will have a deployable primary mirror that is 6.5 meters in diameter, as compared to HST with its 2.5-meter monolithic mirror. This will provide JWST with much greater sensitivity than HST, operating at both optical and infrared wavelengths. This will enable JWST to probe more deeply into the early universe and will make possible much more detailed studies of exoplanets.

Another major new space-based observatory will be the Wide Field Infrared Survey Telescope (WFIRST), which is under development and is tentatively planned for launch in the mid-2020's. WFIRST's primary mirror will be the same size as in HST, but its 300 Megapixel cameras, which will operate at infrared wavelengths, will provide a much wider field of view (100 times as much sky imaged per observation) compared with HST. Thus a single image from WFIRST will have 100x the information in a single HST image. WFIRST will probe the first billion years of the universe, allow for more detailed studies of dark energy and dark matter, and carry out a broader census of exoplanets within the Galaxy.

The data from all of these instruments (current and past) is being archived by NASA for use by future astronomers. Large data sets such as these provide important resources to tackle questions that haven't even been thought of yet. Making the archival data freely available and accessible to all astronomers, current and future, as well as to the general public, means that new discoveries will continue to be made long after the instruments and observatories themselves have ended their useful lifetimes.

Ground-based Astronomy (now)

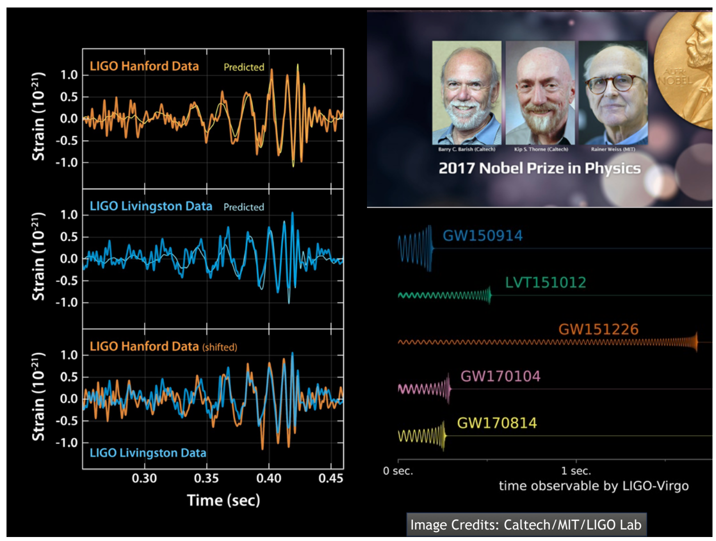
Ground-based telescopes and observatories also continue to be important tools for astronomy. The U. S. National observatory facilities are funded by the National Science Foundation (NSF) under the auspices of the NSF Optical-Infrared Laboratories (NSF OIR Lab). The NSF OIR Lab is managed for the NSF by the Associated Universities for Research in Astronomy (AURA), of which UToledo is one of 47 member institutions. At present, these facilities include the Kitt Peak National Observatory (KPNO), outside of Tucson, Arizona; the Cerro Tololo Inter-American Observatory (CTIO) located in Chile; the Gemini North and Gemini South telescopes, located on Maunakea on the island of Hawaii and on Cerro Pachon in central Chile, respectively; and the Large Synoptic Survey Telescope (LSST), which is under construction on Cerro Pachon in central Chile.

Other key ground-based facilities around the world include those supported by the European Southern Observatory (ESO), such as the Very Large Telescope (VLT) located on Cerro Paranal in Chile; the La Silla Observatory, located near the Atacama Desert in Chile; and the Extremely Large Telescope (ELT), currently under construction on Cerro Amazones in Chile. This is by no means a complete list, as many other nations have national astronomy facilities, and many universities and private consortia have observatories as well.

As telescopes and facilities have grown ever larger and more expensive, many newer facilities have been developed as partnerships between multiple nations, such as the U.S., the European Union, Canada, Japan, Chile, Brazil, and others. A primary example of this is the Atacama Large Millimeter/submillimeter Array (ALMA), located on the high Chajnantor Plateau in the Andes of Chile. ALMA is an array of telescopes designed to work together as the equivalent of a much larger telescope using a technique known as interferometry. ALMA collects data in the millimeter range of light, which is the reason for its location in the very dry high Andes of Chile.

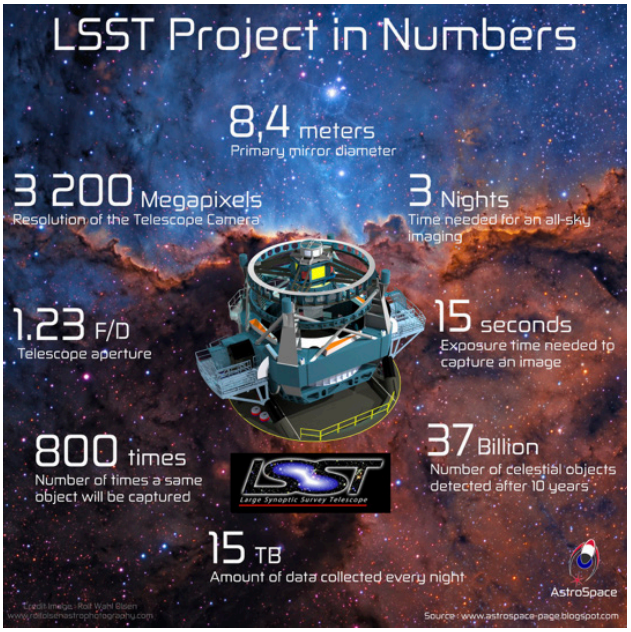
The technique of interferometry has been used for many years for radio astronomy, such as at the Very Large Array (VLA) located in Socorro, NM. In recent years it has been expanded into millimeter (ALMA) and even optical wavelengths of light, via facilities such as the Center for High Angular Resolution Astronomy (CHARA) at Mt. Wilson Observatory in California, and the Naval Precision Optical Interferometer (NPOI) near Flagstaff, Arizona.

Other ground-based techniques also are contributing to the advancement of astronomy. In the past few years, gravitational wave astronomy has come to the forefront and opened up a new way to look at the universe. By using special facilities such as the Laser Interferometer Gravitational-Wave Observatory (LIGO), which is an NSF collaboration with the California Institute of Technology (Caltech) and the Massachusetts Institute of Technology (MIT), the detection of the gravitational waves produced by merging black holes and other gravitational events is now possible. This major breakthrough led to the awarding of the Nobel Prize in Physics in 2017.



Ground-based Astronomy (future)

The future of ground-based astronomy looks bright, and several planned facilities will play key roles. The Large Synoptic Survey Telescope (LSST), which is expected to be operational by 2023, will conduct a large-scale time-series survey of the sky, providing a rich dataset for learning about variable sources of many types. Its 3.2 gigapixel camera will generate approximately 15 terabytes (!!) of data each night. The primary science goals for LSST include understanding dark energy and the nature of dark matter; cataloging the Solar System; exploring the transient and variable sky; and exploring the Milky Way structure and formation. This will produce one of the largest available datasets for looking at variable astronomical objects in the time domain.



To probe even deeper into the early universe, and provide better resolution for observations, a new generation of much larger (30-meter class) telescopes are in the design and construction phase. The Giant Magellan Telescope (GMT) will have an effective 24.5-meter primary mirror, made up of seven 8.4-meter mirrors working together. It is already under construction at Las Campanas Observatory in Chile. It is expected to be commissioned for science operations in 2029. Many resources and information about the GMT, its instruments, and science goals can be found on the GMT web site.

Another example is the Thirty Meter Telescope (TMT), which will have a 30-meter primary mirror (single mirror design). The preferred site for locating TMT would be on Maunakea, Island of Hawaii. However, the likelihood of this has become uncertain due to controversies and concerns from some native Hawaiian groups (see background information here and here). An alternate site (La Palma, in the Canary Islands) is being considered as a "Plan B".

Even larger telescopes are also under development. For example, the European (ESO) Extremely Large Telescope (ELT) will have a 39-meter primary mirror made up of 798 hexagonal 1.4-meter mirror segments. It is under construction in Chile, with expected operations starting in 2025. ESO had done a design study for an even larger (100-meter primary mirror) telescope, known as the Overwhelmingly Large Telescope (OWL). However, the projected cost was determined to be too high, and the project was scaled back to become the ELT.

One recent concern on the horizon for ground-based astronomy that should be noted is the stated plans of some private companies (SpaceX, as one example) to launch large numbers of small satellites into earth orbit. As has been pointed out in a number of places, and emphasized by the American Astronomical Society (AAS), this may pose a serious threat to our ability to continue to do astronomy research from the ground, and may jeopardize projects in the initial stages such as LSST and Pan-STARRS. Attempts to find a solution to mitigate these problems are being proposed, but are as yet uncertain. Also relevant, there has been concern expressed by the meteorological community regarding how such a planned rollout of large numbers of satellites to provide global 5G coverage could severely undermine our capability to do accurate weather forecasting, including storm warnings.

Citizen Science

With the rise of large archival datasets, many opportunities have developed for the general public to contribute to the analysis of these data through "Citizen Science" projects. There are many of these opportunities (and not just in astronomy, but many branches of science) for interested citizens to participate. Some representative web links with information about citizen science projects related to astronomy (and other sciences) include:

Planet Hunters TESS – for those interested in analyzing TESS data to help in the search for exoplanets;

Einstein@Home – for those interested in searching for signals of neutron stars using data from LIGO as well as from the Arecibo radio telescope and the Fermi gamma-ray satellite;

Zooniverse - People-Powered Research – for a wide-range of citizen science projects in astronomy, with additional projects in many other science fields; and

Spacehack – for a wide-range of citizen science projects in astronomy and other aspects of space-exploration.

There are also many places where amateur astronomers, using their ever-more sophisticated equipment (or even using just their eyes!) can contribute meaningful data to scientific projects. Some examples and links include the following:

American Association of Variable Star Observers (AAVSO)

AAVSO Spectroscopy Observing Section

Sky & Telescope List of Pro-Am Collaborations

Astronomical Ring for Access to Spectroscopy

Conclusion

The science of astronomy lends itself to inspiring generations of future scientists, and its visuals are engaging to many non-scientists as well. For those working in education and public outreach, and notably for planetariums, there are a wealth of online resources that have been developed for use in these efforts. Some recommended resource sites include HST learning resources, which also includes some dome videos, as well as NASA resources for educators and the general NASA site. Ground-based observatories also provide many educational materials and resources; for example, the National Radio Astronomy Observatory (NRAO), National Optical Astronomy Observatories (NOAO), Yerkes Observatory, High Altitude Observatory (HAO), Australian Astronomical Observatory (AAO), and Laser Interferometer Gravitational-Wave Observatory (LIGO), which provides an Educators Guide to gravitational waves.

Other resource sites include the National Science Foundation, Solar Data Analysis Center (SDAC), and science teaching venues provided by CSUN, PhysLink, Sky & Telescope, Astronomical Society of the Pacific (ASP), Amazing Space, Astronomy Picture of the Day (APoD), Andrew Fraknoi, Space Science Institute, and many more!

In closing, I want to thank you again for visiting our campus and community, and our Ritter Planetarium and Brooks Observatory, and I hope that you have found the meeting to be both informative and worthwhile. Planetariums such as those represented at the GLPA meetings provide wonderful settings for engaging students and the general public in the findings and techniques of astronomy, and of science in general. In that role, each of you serves as an important ambassador and advocate for humanity's exploration of the universe. The work you do in this arena is important and valued, and I want to personally thank you all for your efforts. It has been an honor to be able to speak with you today—thank you for the opportunity, and for your attention.

THE MAKING OF A MISSION

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Abstract: Picture NASA's famed Mission Control Center and you think of men and women quietly sitting around computer consoles. Calmly sitting there whether vehicles are hurtling towards each other at thousands of miles per hour for a docking of two vehicles in orbit, perhaps not even from the same country. Tranquilly monitoring their data as a spacewalk is conducted to keep the International Space Station operating. Quietly controlling the vehicle as emergency alarms on the spacecraft are annunciating in red and yellow on the computers of the control room. But what is not seen is the years these women and men prepared for that mission. Designing the spacecraft. Developing the plans and procedures to operate it. Training. From the Earth to low Earth orbit. This talk will present some of the stories of these tough and competent people as they prepare for these different operations.

The 130th shuttle mission/32nd ISS assembly mission—Space Transportation System (STS)-130/ISS-20A—took place over a 13-day timespan in February 2010. The core objective of the mission was to attach the new Node 3 and Cupola modules. The success of this and many other tasks rested on the shoulders of a highly competent and passionate team that spent years working to make it all happen. Most of the challenges encountered along the way actually occurred on the surface of the Earth. Each challenge was resolved, often in parallel, as the team prepared for the actual mission. With the impending retirement of the Space Shuttle, it was a mission that might never have happened.

The STS-130/ISS-20A mission was tasked to accomplish four primary objectives during an estimated 11-day mission, as defined by the Space Shuttle Program and ISS Program. These objectives included:

Launch the orbiter with Node 3 module and Cupola
Install Node 3 module on the ISS (but do not activate or connect anything)
Transfer critical items
Land the orbiter

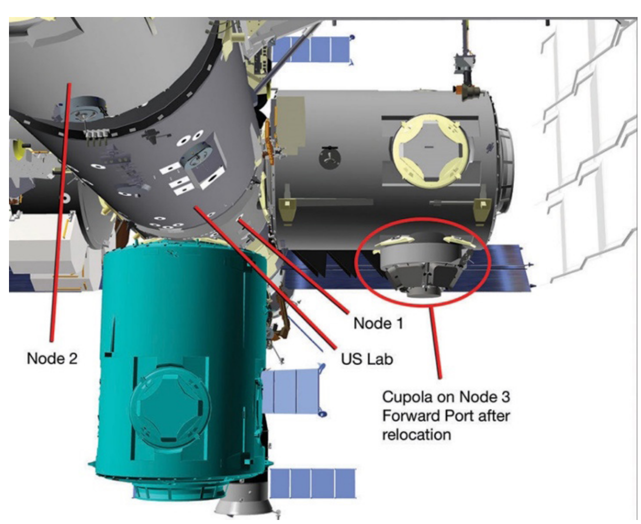
During one or more space station increments after the mission, the following would be accomplished:

Attach the power and cooling lines from Node 1 to the main systems of the ISS

De-mate the Cupola from its launch configuration, at the end of Node 3 module (required for it to fit into the orbiter's cargo bay), and attach it the nadir side of the module
Relocate all the regenerative life support systems and exercise equipment to Node 3, which was located throughout the US On-orbit Segment

Originally, the module was to hang down in the nadir direction, pointing toward the Earth with the Cupola facing forward (the direction the ISS flies around the Earth), as shown in Figure 1. In this configuration, NASA's crewed vehicle, Orion, and the Japan Aerospace Exploration Agency's uncrewed cargo ship, H-II Transfer Vehicle (HTV), were to be attached to the space station at the nadir side of Node 3. But it was realized that interference could occur with the Russian Mini-Research Module projecting nadir from the Functional Cargo Block module.

To solve the clearance issue, ISS Program officials asked whether Node 3 module could be installed on the port (left) direction off of Node 1, as shown in Figure 2. Although the berthing mechanisms were designed to allow a module to be mounted in any orientation, the plumbing to that module was not as accommodating. All of the ventilation lines, computer circuits, water tubes, nitrogen lines, and communication cables had been installed years earlier in Node 1 under the assumption that Node 3 would be on the nadir. To place Node 3 on the port side meant all these had to be rerouted—in space. Furthermore, the electrical power cables and the external ammonia lines used for cooling the Node electronics would have to be rerouted. Figures 2 and 3 show the final proposed configuration.



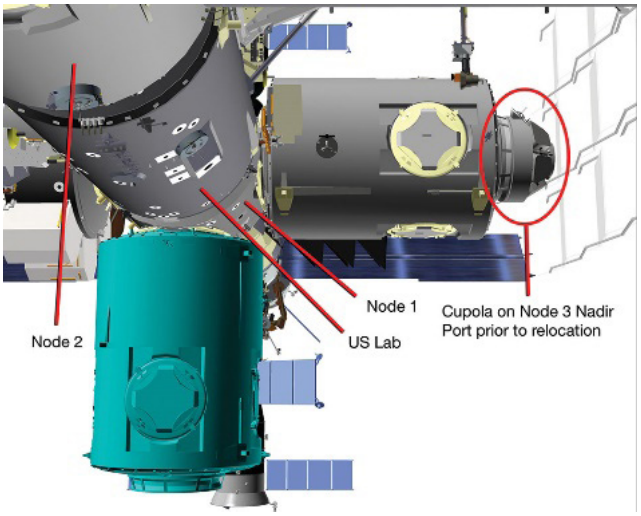


Figure 1. Initially, the Node module was supposed to project nadir (light blue silhouette); however, it was changed to the port side. The Cupola would be launched on the end of Node 3 to fit in the cargo bay of the orbiter, and then relocated to its permanent position through use of the robotic arm. Images courtesy of MAGIK Robotic Analysis Team.

The task was analogous to modifying a bedroom by moving the bathroom to the other side of the room. The changes also would have to be somehow verified in advance to ensure that everything aligned just right when Node 3 was installed during the mission. Node 1 was already in orbit, so no direct fit checks could be performed. The mission would be a complete disaster if the shuttle was launched and then Node 3 could not be physically mated to Node 1.

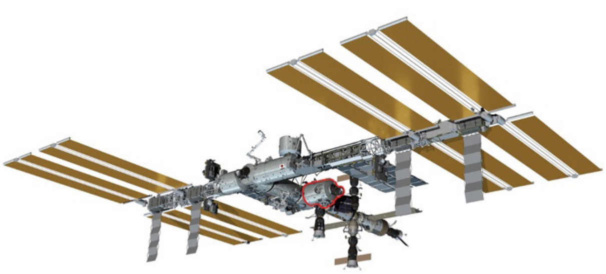


Figure 2. Drawing of the ISS now showing Node 3 berthed on the port side (red outline).

Making the modifications to Node 1 would require extensive work. The lines are actually located within the aluminum structure of Nodes 1 and 3, passing through what is called the bulkhead. The required modifications to Node 3 were made prior to launch. However, for Node 1, this meant the crew had to make new holes in the port side, reroute the lines, reseal the bulkhead, and carefully check for leaks to ensure the integrity of the new seals. At that time, the other side of the wall of Node 1 was a vacuum. Per the initial mission plan, Node 3 would be installed and the crew would perform the modifications after the shuttle left. This meant, however, that the many hours needed to activate and outfit the module would have to be performed by three people—without the benefit of the seven extra astronauts who were available during a shuttle mission.

The flight control team came up with an interesting proposal. A small connector module called the Pressurized Mating Adapter (PMA)3 resided on the ISS. Atlantis docked with PMA3 during the STS-98/ISS-5A mission, but the module was not currently being used. This module could be moved by the robotic arm and installed on Node 1, thus providing a pressurized area in which to make the changes. The module would be moved back to its original location upon completion of the modifications. This meant Node 3 could be connected and activated during the flight (i.e., "plug-and-play," as the team called it) when those extra sets of hands are available.

With the many available hands of the shuttle and increment astronauts, significant progress could be made in relocating the regenerative life support and exercise racks that were destined to be installed. This promised to be a complicated task. Much of the US Segment life support system would have to be shut down, transferred, installed, and reactivated. This large amount of work had to be accomplished in as short a window as possible because of the critical need for life support.

A new problem surfaced in the fall of 2009. With the decision to install the new Permanent Multipurpose Module (PMM) on the nadir side of Node 1, concern arose that the billowy insulation over the ammonia lines that ran right beside the Node 1 nadir berthing port might interfere with the module during installation. Analysis showed that the lines would pass *through* the PMM (Figure 3). This is what happens when late changes are made to a program that has been working on these issues for years. The team had to adapt and came up with a new routing as shown in Figure 4.

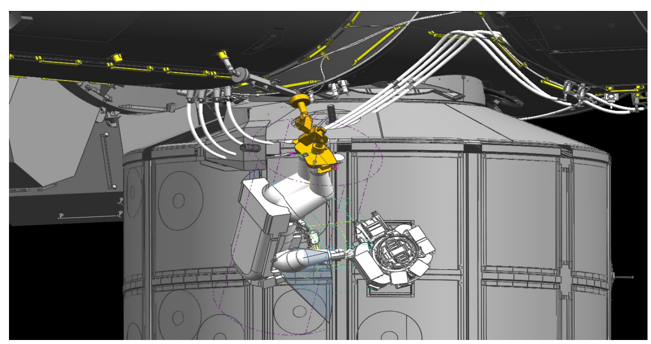


Figure 3. A computer-generated analysis showed the ammonia hoses (four white lines) would pass through the PMM near the astronaut's feet.

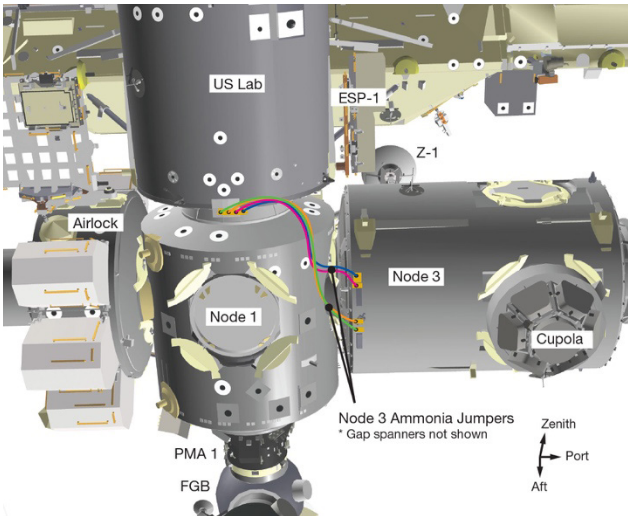


Figure 4. A schematic showing the routing of the ammonia lines (colored). There are four ammonia lines. Images courtesy of MAGIK Robotic Analysis Team.

The four lines needed to be about 8 m (~25 ft) long—the longest lines on the ISS. In addition, the ammonia could be at a fairly high pressure (3,400 kPa or 500 psi—more than 10 times the pressure in a typical car tire) to ensure enough fluid was passing fast enough to provide an adequate amount of heat-removal capability. Once in place and pressurized, a rigid line was not an issue; however, the crew members needed to be able to route and install the lines while wearing their bulky space suits. Therefore, NASA chose a flexible design. A line of flexible hose was to be attached to longer hoses using a braided sleeve welded to the joint.

At this point, the mission had changed a great deal. The plan now included the following:

- Launch the orbiter with Node 3 and Cupola
- Install Node 3 on the ISS during the first spacewalk
- Outfit the vestibule of Node 3 in preparation for activation and ingress
- During the second spacewalk, install two pairs of the ammonia lines and open one pair to begin cooling and allowing for activating half of the module. As soon as the systems were working, relocate the Cupola from the port end of Node 3 to its nadir side.
- The next day, move the PMA3 from its temporary location on top (zenith) of Node 2 to the port end of Node 3
- During the third spacewalk, integrate the second ammonia loop, open the shutters on the Cupola
- Transfer critical items including life support systems
- Land the orbiter

A significant setback occurred in July 2009 (about 7 months prior to flight) when an ammonia hose exploded at 973 psi during pressure testing on the ground, causing significant damage to a second line nearby. A safety valve should open at 450 psi completely venting the lines in the event of a problem, such as a pump running at too high a speed. The hoses were tested up to 52,000 mm Hg (1000 psi) to ensure that the lines would not rupture if the valve itself failed. Analysis of the exploded hose seemed to indicate that the explosion was the result of a manufacturing issue and not a design problem, thus new lines were produced. The number of braids in the welding was doubled to improve margin.

The new hoses began testing in November 2009. One of the hoses showed a leak. Metallurgical analysis revealed that liquid-metal-induced embrittlement during the welding process led to the failure. At this point, the team was less than 3 months to launch. To add insult to injury, a third hose that had passed testing was damaged during shipping from the manufacturer. Of great concern was that the damage seemed greater than one might expect from simply dropping the container. This led some to think a critical design flaw would prevent the lines from meeting their stringent requirements.

At this point, a “tiger team” was formed. A tiger team is a panel of experts given the authority to focus on a particular issue until a resolution is found. At an already busy time, numerous reviews and meetings were occurring at all hours of the day and night, all over the country. When the great sleeping beast that is NASA awoke, all resources turned to this problem. Many members of the 20A flight control and engineering teams were busy supporting the tiger team. In addition to understanding the issues, the team had to identify impacts that any proposed solution would present to the mission, and then figure out how to modify procedures or training. Several parallel paths were chosen. First, more of the original hoses were being produced. With the revelation that the embrittlement was caused by welding, a new welding process was adopted to hopefully prevent this from happening. In addition, hoses using a new design were being built. Instead of the flexible line and sleeve, the middle would be a solid tube and a basic metal-to-metal, or butt-weld type would be used. Multiple versions of each type were manufactured to allow for further problems.

The new design really was simply an application of previous techniques. The method was previously used on the ISS, yet the length had never before been used either in space or on the ground. In fact, since time was short, leftover hoses from previous evaluations were to be used, thereby reducing the amount of testing. These hoses were dubbed “frankenhoses” because they were put together from several pieces. The welding process was tried and true. In January, the new lines were tested to their bursting point of 5204 psi. Although the updated braided hoses were also ready, ISS Program personnel decided to go with the frankenhoses.

The frankenhoses were being completed literally as the crew went into quarantine. Spacewalkers Bob Behnken and Nick Patrick left quarantine and flew to Huntsville, Alabama, where the testing equipment and hoses were located, and where the two astronauts would be able to handle the items in advance. In fact, engineers at Marshall Space Flight Center quickly built a test stand that roughly represented the attachment points (Figure 5). Engineers were concerned that the equipment would be too stiff, but the astronauts felt they could work with the lines. After familiarizing themselves with the lines, the crew packed the hoses into a special EVA bag for shipping to Kennedy Space Center where the items would be loaded onto Space Shuttle Atlantis.

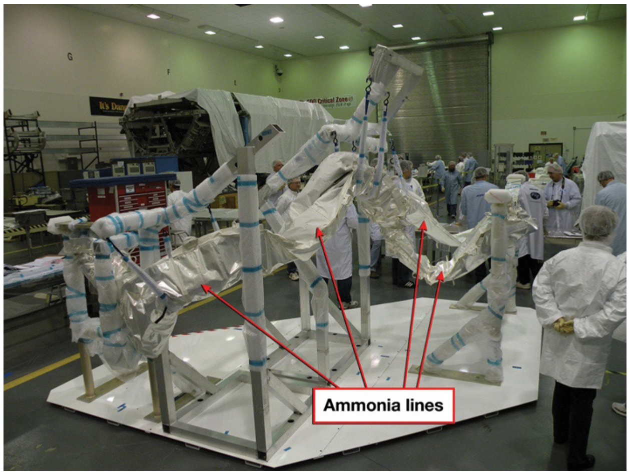


Figure 5. Engineers at Marshall Space Flight Center built a test rig that allowed the astronauts to roughly lay out the final ammonia lines (wrapped in white insulation, as seen in the photograph) with realistic attachment points days before the mission was scheduled to launch. Image courtesy of Art Thomason.

In 2009, NASA initiated a novel public outreach project: have the public name Node. NASA set up a website and asked the public to submit names for Node 3. The most popular name would be selected. Comedian Stephen Colbert of the Comedy Central show *The Colbert Report* tried to get his audience to name Node 3 after him. This campaign proved hugely successful and his entry (the "Colbert module") was at the top. By law, NASA could not name a module after a private citizen or commercial entity, which put the agency in a difficult situation. Colbert did a great job of raising awareness of the mission. To show appreciation for his efforts, NASA sidestepped the issue directly by naming the module *Tranquility* and coming up with a consolation prize: naming the new treadmill in Node 3 after Colbert. Initially called by the accurate-but-unexciting name of T2, the treadmill was rechristened the Combined Operational Load Bearing External Resistance Treadmill, or COLBERT (Figure 6). It even had an official logo.

Figure 6. The side of the treadmill showing the COLBERT patch from 2009 (top). Tom Marshburn of Expedition 34 exercising on the COLBERT in 2012 (bottom). NASA images ISS929E037641, ISS034e009719.

Training began in earnest approximately six months prior to the planned mission launch. Several types of training were involved. On the Space Shuttle side, the team—i.e., the flight control team and the astronauts—performed a number of simulations, primarily practicing launching, landing, and aborts. The ISS teams also trained. Flight controllers on the ISS side of the house simulated the spacewalks, as well as the berthing, moving, and activation of modules during approximately a dozen simulations (sims). A key series of sims for the ISS team was the powering down of half the systems, integrating the ammonia lines, and activating Node 3 and Cupola modules. The trainers would throw numerous malfunctions at the flight control team. This helped that team gain the confidence needed to deal with real problems in space while remaining composed. Although the specific simulated failures may not occur during the mission, the team knew how to work the problems in a cool and integrated fashion.

A key part of the training was having the crew practice the spacewalks. The crew and EVA team, as well as the lead station flight director, conducted many dives in the NBL to practice the timelines. Although EVAs are always tricky, the ammonia lines were, once again, the biggest challenge (Figure 7). The crew needed to extensively practice the installation in the NBL because the ammonia lines were long, stiff, and covered by bulky insulation (Figure 8).

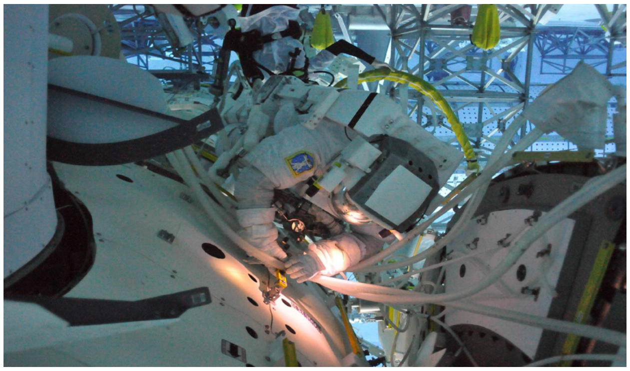


Figure 7 - Astronaut Robert (Bob) Behnken installs a clamp to hold down the ammonia lines during a training run in the NBL. NASA internal images.

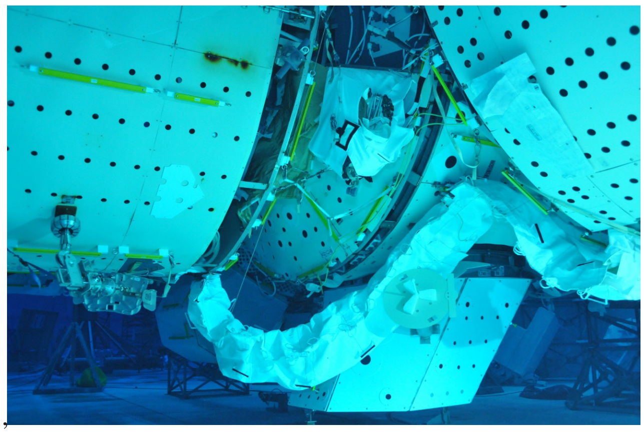


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Figure 8. The billowy white insulation surrounding the ammonia lines at the NBL mock-up. NASA internal images.

On February 8, Space Shuttle Endeavour launched perfectly (Figure 9).

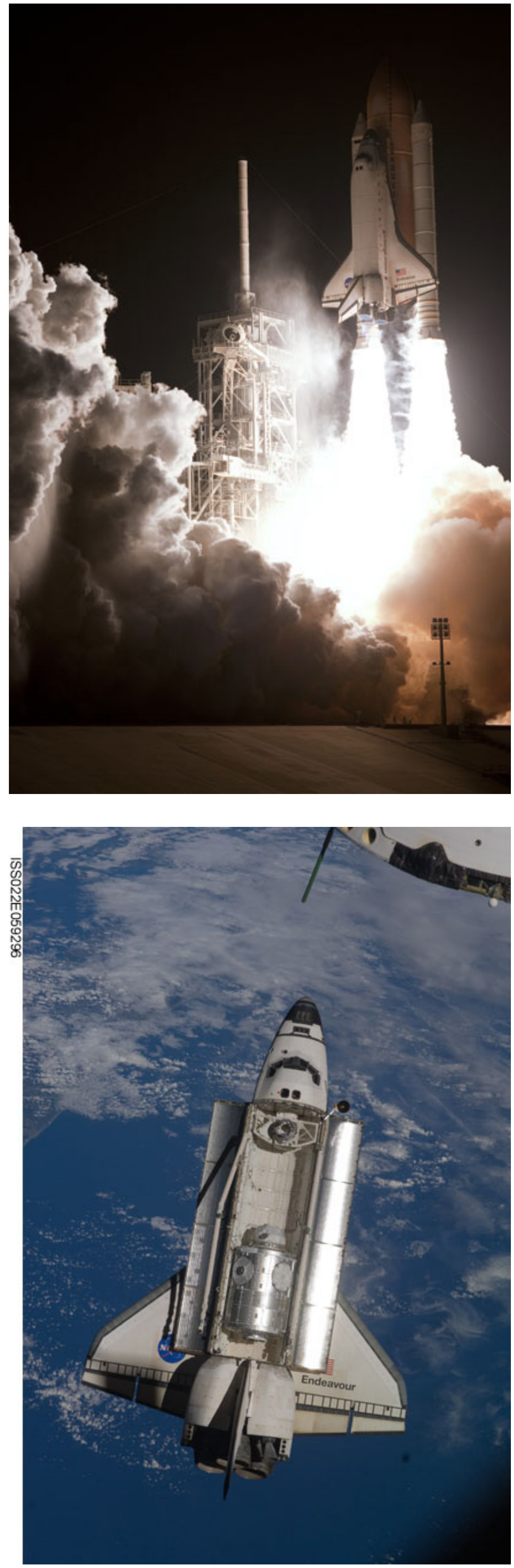

Figure 9. Launch of Space Shuttle Endeavour on February 8, 2010 (top). View of Endeavour's cargo bay from the ISS showing Node 3 with Cupola attached to the end. NASA images sts130-s-078, iss022e059296.

By all standards, the mission was going smoothly. The training and hard work of numerous people over the years was paying off. On the second spacewalk the ammonia lines were installed (Figure 10). The first significant issues with the intricate ballet of module movements came when the crew ingressed the Cupola on Day 6 of the mission to ready it for the relocation. Next, the crew went in and installed a protective cover over the Cupola to thermally shield it during the relocation. When crew members installed the cover, they noted that the clearance between the cover and some brackets was too small—a thin metal ruler barely fit between the bracket and the insulation. If the clearances were even tighter on the nadir port, the Cupola could not be mated. The root of the problem quickly became apparent: to save file size, the computer models did not include bolts since thousands of bolts added megabytes to each drawing. What seemed like a small issue became a significant wrinkle.

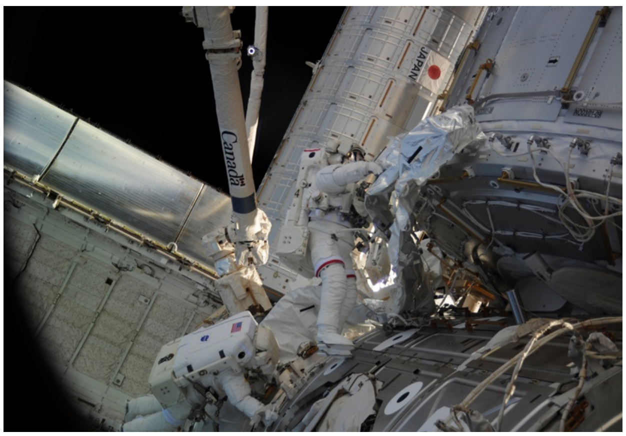

Figure 10. Bob Behnken and Nick Patrick installing ammonia lines and associated insulating blanket during the second STS-130 spacewalk. NASA image iss022e065714.

After a number of meetings around the clock, the teams determined that there would be barely enough clearance for the Cupola to fit on Node 3 nadir. If enough clearance did not exist, it was likely some of the brackets would bend but nothing would break. This, however, was considered unlikely. The teams pressed ahead toward the relocation. After the second spacewalk, Node 3 module was activated for the first time using half of the power and cooling systems.

On the 8th day of the mission, the crew was like an army of ants, removing bolts that would hold things in place during the tremendous vibrations during launch, removing items stowed in Node 3, moving the life support racks and exercise equipment into place, and trying to secure all the elements. It was slow work. Each rack was shut down and carefully moved to the new location (Figure 11). The flight control team then powered the system back up.

Figure 11. Astronauts maneuver one of the many racks relocated to Node 3 module during the mission. NASA image s130e00930.

The ground followed along in all the activities working all the small problems that cropped up (Figure 12). The Cupola was installed with no issues (Figure 13). On the 8th day, as soon as the crew members awoke, they had a linkup with the president (Figure 14).

Figure 12. Flight Director Robert Dempsey and Capsule Communicator (i.e., CAPCOM) Hal Getzelman in Mission Control focus on activating Node 3 module during the STS-130/ISS-20A mission. NASA image jsc2010e021633.

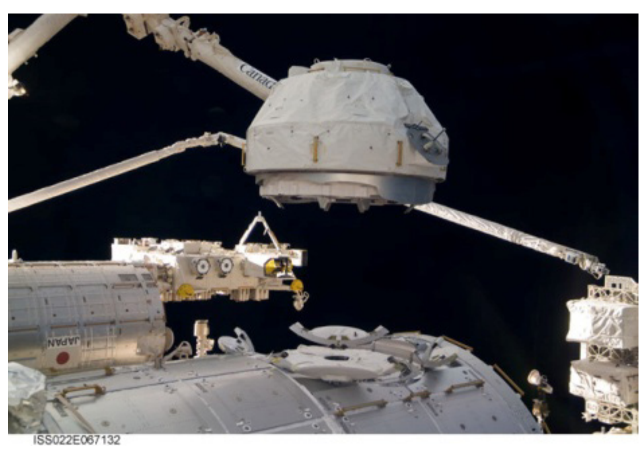

Figure 13. Cupola being maneuvered into position on the nadir side of Node 3 (top), and astronaut Patrick, during the third spacewalk, after removing the insulation that protected the module from launch until its heating system was operational (bottom). NASA images iss022e067132, iss022e066880.

Figure 14. President Barack Obama talks to the astronauts (seen in a video linkup in the top right of the picture) while students look on. NASA image ID 201002170002hq.

As quickly as the storm began, the mission started to wind down. Although not every task was complete, it was time for the crew of Endeavour to undock and return home. Far more had been accomplished than had been planned for even a year prior to the mission. Endeavour undocked on February 20 and flew around the station. Photos were taken of the new installed module (Figure 16). The ISS crew took a much-needed break and then completed the outfitting of Node 3 and the Cupola over the next few weeks. On February 21, 2010, Endeavour made a flawless nighttime landing at Kennedy Space Center.

Figure 15. View of Earth from the newly installed Cupola. NASA image s130e09953.

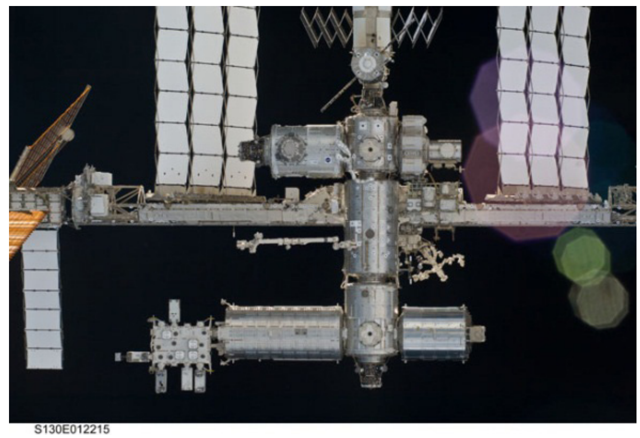

Figure 16. The underside of the ISS, as photographed by astronauts aboard the undocking shuttle, showing the newly installed Node 3 and the Cupola. NASA image STSe012215.

The operations team conducts a major ceremony after each mission: the hanging of the plaque. Since the days of project Mercury, the flight director would pick the person, persons, or team that did the most outstanding job during the mission and let the honoree(s) hang the mission plaque (Figure 17) that had been displayed at the flight director's console during the flight. Actually, two plaques—crew mission patch and ISS mission patch—were awarded for a given Space Shuttle assembly mission.

Figure 17. Hanging the 20A mission and module patches in the control room following the successful mission in 2010. NASA images JSC2010e032877, jsc2010e32869.

Later that year, when NASA was trying to figure out what to do after President Obama redirected the Constellation Program, some officials at the space agency wrote a press release stating that Node 3 could be detached from the space station and incorporated as part of a new vehicle that would go to an asteroid. Flight Director Robert Dempsey shook his head, laughed, and uttered the words that the whole team was thinking: "If they only knew how hard that would be."

INCLUSION AND DIVERSITY IN EDUCATION

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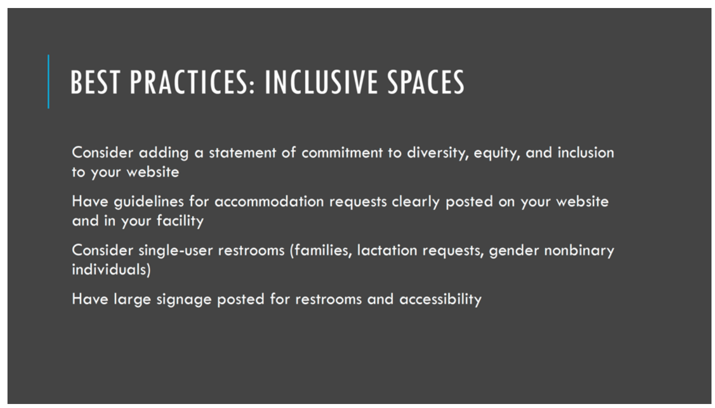
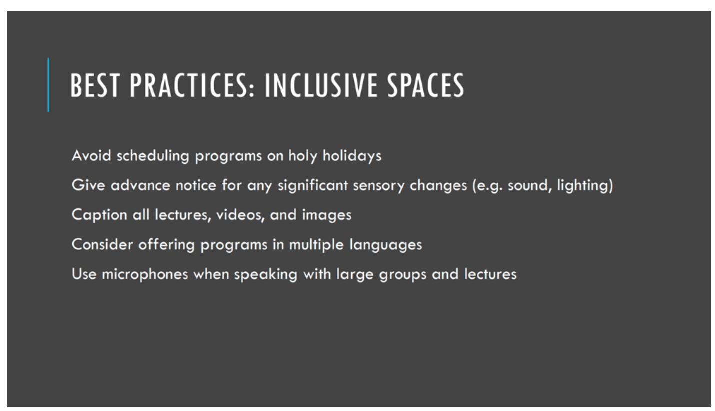
<u>Abstract:</u> In this interactive session, participants had the opportunity to reflect on challenges they have faced during instruction and identify potential solutions for creating more inclusive, engaging learning environments rooted in best practices. Issues of identity and bias were also addressed.

<u>Editor's note:</u> The author did not respond to requests for a Proceedings text. In order to share some content of the session, we have included selected images from her presentation.





BEST PRACTICES: GROWTH MINDSET

Believe that your attendants can thrive

Understand that innate talent is less important than hard work

Encourage collaboration

Make it safe for attendants to make mistakes and learn from them

Have high expectations and provide scaffolded learning opportunities

Carol Dweck, *The New Psychology of Success*, NY, Ballantine Books, 2016

BEST PRACTICES: INCLUSIVE INSTRUCTION

Give attendants your full attention; be present

Avoid jargon; be succinct

Invite students to participate; offer multiple means of engagement

Wait

Call on a range of students with questions of varying difficulty

Avoid putting students on the spot to "represent" their "group"

BEST PRACTICES: BEFORE YOU BEGIN

Know your audience and adjust accordingly

Establish and share participation guidelines; be aware of inconsistent discipline

Announce availability of gender-neutral restrooms and emergency evacuation routes with egresses

Backward Design: Start with the learning objectives and fill in lessons from there

Incorporate curriculum that represents diverse, relevant identities and perspectives (narrations, examples, stories, scholars); acknowledge cultural differences where applicable

Be mindful of Eurocentric content and culturally-specific references

BEST PRACTICES: INCLUSIVE INSTRUCTION

Create opportunities for students to interact with one another; avoid isolating marginalized students in group work when possible

Check in with attendants

Show respect and empathy

Collect feedback; comment boxes and online forms

Consider peer evaluations or reviewing recordings

SELF-WORK

Learn to recognize your own biases: https://implicit.harvard.edu/implicit/takeatest.html

Know yourself and your own triggers

Stay curious: Learn about other cultures and communities; seek out training opportunities

Become an outsider (empathy building)

Be open to feedback

Practice intentionally, especially on your worst days

Encourage others to do the same work

ASTRONOMY UPDATE 2019

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Abstract: There is constantly news coming out of the astronomy world to pique people's interest in what is happening in our vast universe. It is our job as planetarians to help tell those stories and offer context to our general public. This talk will help offer that context for some stories that we may be asked about, have been in the news quite a bit, or haven't been in the news as much as they should have been. I also offer a broader context for why these are important stories and how they fit into the larger picture of astronomy research and education. Included this year is a discussion of the first all-female space-walk at the International Space Station, Jupiter's shrinking red spot, the citizen funded LightSail 2 mission, the first astrophysical detection of the first molecule, an impossible white dwarf, Saturn's new moons, a really puffy hot Jupiter exoplanet, the first image of a black hole's shadow, and some broader context of where observatories sit in light of the controversy over the Thirty Meter Telescope on Mauna Kea.

Introduction

Astronomy Update is a long-standing tradition for the Great Lakes Planetarium Association and this is my first year taking the reins. The format is slightly different than it has been with fewer stories but with more contextualization. Like my predecessor, I saved stories from the astronomy world over the year in order to keep track of the discoveries and my list, at the end of this past summer, was enormous. I had to make decisions and build a rough set of rules for what I was going to talk about.

I chose some stories that were quite big and all over the news and that had some substantial peer reviewed papers that offered a deeper insight than what you would find over most of the web. I also tried to choose stories that had those peer reviewed papers in the past year (October 2018-October 2019). I also wanted to make sure that there was some breadth to the topics covered and reflect questions we may get asked a lot by the public. The list that I have is not comprehensive by any means, but hopefully offers some useful knowledge to take along through the next year and beyond.

First All-Female Spacewalk

Figure 1: Image of Anne McClain and Christian Koch on the International Space Station. (NASA)

In early 2019, NASA scheduled a spacewalk with astronauts Christina Koch and Anne McClain. They did not immediately realize that this was a historic event as the first all-female spacewalk ever to be conducted. However, once that was realized, it was heavily promoted to much fanfare online. However in March 2019, the spacewalk was cancelled due to not having sufficient medium sized spacesuits ready for the space walk. Anne McClain herself chose not to conduct the spacewalk (New York Times, 2019). She had trained in both a large and a medium suit. Before this spacewalk, McClain did another spacewalk in a medium suit and realized it was much better suited to her and therefore safer. It was more efficient to switch out an astronaut who could fit into a large suit that was prepped than spend time on prepping a second suit.

While the spacewalk was not cancelled due to overt sexism, it was due to a sexist legacy at NASA. NASA banned women from serving as astronauts until the 1970s. As a result, all suits were designed specifically for men. This episode has exposed some issues in the design of suits in general and work is being done to rectify this. Specifically, the newly unveiled suit planned for the Artemis mission coming up in the next decade will scan astronauts in several positions to make custom suits for their bodies. (NASA, 2019)

The all-female spacewalk did happen in October of 2019 with astronauts Christina Koch and Jessica Meir. It was live-streamed and history was finally made.

Figure 2: (top) Image of Jessica Weir and Christian Koch on the International Space Station. (bottom) New spacesuit design for the Artemis missions to the Moon (NASA)

LightSail2

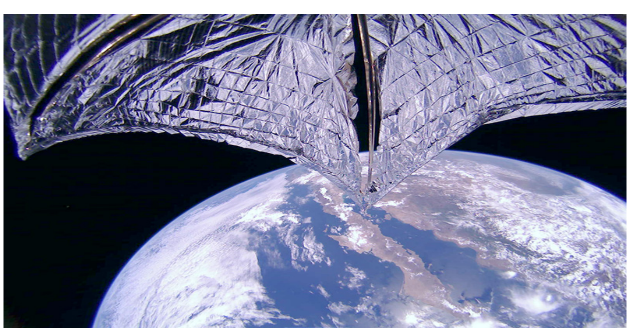

Figure 3: Image of LighSail2 sails deployed above Earth (The Planetary Society)

Most of what we hear about in the news related to great breakthroughs in science and technology are projects funded by major agencies such as NASA or the National Science Foundation. More and more projects are now also coming out of private companies like Elon Musk's SpaceX or Jeff Bezos' Blue Origin. It seems as if only places with deep pockets can contribute to science. However, there are some examples of citizens working together to make inspiring projects happen. LightSail, a project led by the Planetary Society, is a great example that was funded by much smaller entities. This project cost about $7 million dollars. Nearly $1.5 million of that was raised through Kickstarter and Omaze campaigns. The remainder came from Planetary Society members, private foundations, and corporate partners.

LightSail is a project that started about 10 years ago in order to test the feasibility of propulsion through space using only light. Light is considered both a wave and a particle. The particle nature of the light means that when it hits an object and reflects off, it transfers some momentum to the object, causing it to move. Though the effect is initially imperceptibly small, over time an object can gain significant speed, saving on fuel costs. This project in particular wanted to not only show propulsion with light, but also steering and controlled movement.

LightSail has had two missions so far with its spacecraft. The main piece of the spacecraft is made of three cubesats, very small cube-shaped spacecraft meant for university scale projects. The first cubesat carries cameras, sensors, and control systems. The other two hold a folded up light sail that is deployed once in orbit. The sail is made up of 4 triangular sheets of highly reflective mylar and polyester for a total area of 32 square meters. This entire craft is very small to reduce weight and more effectively move via light.

LightSail1 was launched in May 2015 and its main objective was to show that the light sails could deploy when in orbit. It then deorbited and fell back to Earth. In June of this year, LightSail2 launched and has successfully completed its objective of showing a clear change in the satellite's orbit only through sunlight. Twenty days after launch, LightSail2 successfully deployed its sails. As it moved in its orbit away from the Sun, it would face perpendicular to the sunlight to help move it to a higher orbit. When it moved toward the Sun, it would rotate 90 degrees to be parallel to the sunlight so as not to slow itself down (see Figure 5, source Betts et al, 2017). It behaves similar to a ship at sea using sails to steer. The spacecraft was successful in changing its apogee by 450 miles (or over 700 kilometers). It is now slowly returning to is original orbit and is expected to re-enter Earth's atmosphere next year.

If you wish to learn more about LightSail, check its progress, or learn how to catch a glimpse in your night sky visit the Planetary Society's website at http://www.planetary.org/explore/projects/lightsail-solar-sailing/.

Jupiter's Shrinking Red Spot

Jupiter's Great Red Spot is shrinking. New observations have been made in the past year that show hooks or blades coming off the GRS and appears to show the storm disintegrating. It's unclear exactly what is happening, but this speculation has made Jupiter become big in the news again of late.

A paper by Simon (2018) discusses a more comprehensive historical trend on how exactly the Great Red Spot (GRS) is changing. Longitudinally the size is decreasing by 0.194 degrees a year and latitudinally it is decreasing by 0.048 degrees per year. While it's shrinking along both axes, it is shrinking in width faster making the GRS rounder over time. Its drift rate is also increasing at 0.1 degree per year as well and seems to be strongly correlated with the size of the spot. The why is still a mystery.

Not only is the GRS changing in size and speed, but also in color. There has been yearly imaging since 1995 from Voyager, WFPC 2 (Hubble), and Cassini. What this has shown is that the spot is getting oranger. What exactly is going on is unclear, but the changes will offer more insight into Jupiter's atmosphere and gas giant atmospheres in general and will be a fun topic to talk about for a while to come.

Saturn is the New Moon King

A huge story in October 2019 was that there were 20 newly found moons around Saturn. This makes Saturn the planet with the most known moons, beating Jupiter. There isn't a lot of peer reviewed information out yet, but what is interesting about these moons is that they are mostly retrograde around Saturn. This means that they had to have been captured or created after the planet had finished forming. In the early days of Saturn, there would have been a large debris field. Retrograde objects would have been smashed up as they would have been more likely to crash into prograde debris. So their existence means they came along much later (Carnegie Science, 2019).

First Astrophysical Detection of the First Molecule

The first molecule has been found! What does that mean? According to astronomers' understanding of the early universe, there was a period of time known as recombination. The universe cooled enough for nuclei and electrons to bond together to form atoms. As the particles continue to cool, compounds could form as well. The first compound that would have formed was Helium Hydride (HeH+). This molecule was a stepping stone to creating molecular Hydrogen. However, it has eluded detection in astrophysical conditions, worrying astronomers into thinking their understanding of the early universe was severely flawed. It had been created in laboratory settings, but never seen in space.

This year, it was finally detected in the planetary nebula NGC 7027 (Gusten et al., 2019). This was a good candidate to find this molecule because it is a young nebula that hasn't expanded significantly and therefore is still very hot. Around very hot stars (>90,000 K) there is a radius defined as the Strömgren sphere. This is the radius in which it is still hot enough to ionize hydrogen. Recombination outside this sphere re-releases photons. However, those photons have less energy that cannot ionize hydrogen. This Strömgren sphere for hydrogen overlaps the helium Strömgren sphere to create a narrow band around the nebula where the temperature and composition are just right to create Helium Hydride.

This great candidate combined with better instruments to resolve the emission lines from HeH+ allowed astronomers to finally find an astrophysical detection of this molecule and assure them that their understanding of the early chemical nature of the universe is sound.

Impossible White Dwarf

There is an impossible white dwarf! Of course it is not actually impossible as it exists and has been found. However, it is a very curious object. Astronomers have a pretty good handle on stellar life cycles with smaller stars living for significantly longer periods of time than larger stars. The larger a star, the more hydrogen it must burn in order to hold itself in hydrostatic equilibrium and vice versa. The smallest objects that can burn hydrogen into helium in their cores and be called stars can live to be about 20 billion years old. When these stars eventually die, they will leave behind some very small white dwarfs. With the universe being only 13.8 billion years old, those smallest white dwarfs should not exist yet.

Extremely low mass white dwarfs are found with some frequency. They have always been found within binary star systems with a very close orbit. This means a companion star has been close enough to siphon off material from the star that leaves a white dwarf. So the star has already evolved more quickly, becomes a smaller star, and then leaves a smaller white dwarf.

This "impossible" extremely low mass white dwarf does have a companion, but its orbital period suggests it is 1.28 AU from the white dwarf (Masuda, 2019). This is much too far to have a stable mass transfer between the two stars. So, how did this extremely low mass white dwarf come to be? There are some possible explanations offered by the authors of the paper. There could have been a third star in orbit that has since been ejected that could have contributed to mass transfer earlier. There could be an unseen large exoplanet or brown dwarf that could have contributed to mass transfer. Based on the inclination of the system, there was a 1 in 200 chance of finding this white dwarf. As the Gaia dataset comes in, it is expected to lead to more observations of systems like this and help further our understanding of star evolution.

Puffy Jupiter

The earliest detected exoplanets were considered "hot Jupiters." These were large, massive, gas giants in close orbit to their host star. This proximity and size made them easy to detect and confirm because short orbits gave several data points over a short period of time, the planets cause their stars to wobble, and they were large enough to cause significant dips in the star's brightness during occultation. This data can also give the radius of the planet and these very close gas giants seem to be very low density meaning they are puffed up. It is unclear why.

The puffiest Jupiter was discovered and written about this year (Mancini, 2019). There is a planet found that has a 4.2-day orbital period, and is so large it covers up 76% of the star's disk during occultation! These factors make it the least dense planet ever found. Also, with its size and proximity to the star, it makes a great candidate to get an absorption spectrum of its atmosphere to further our understanding of gas giants and exoplanets.

Black Hole Image

Figure 4: First image of the shadow of a black hole (Event Horizon Telescope)

One of the biggest stories out of astronomy this year, to much fanfare, was the first image of a black hole's shadow ever made. This was such a large undertaking, there were five separate papers released to announce the results. There were 326 authors on each paper with 143 institutions represented.

The image was of the supermassive black hole in the center of the galaxy M87 and was taken with the Event Horizon Telescope. This telescope uses radio interferometry to link up simultaneous data from several radio telescopes across the world to make an effective telescope with an Earth-sized diameter. This is key because the resolution of a telescope is proportional to the ratio of the wavelength over the diameter of the telescope. The larger the wavelength the bigger your telescope needs to be to get the same resolution. For the longest radio wavelengths, then you need an Earth sized telescope to resolve the innermost regions of galaxies.

There is a lot of theory around what the shadow of a black hole should look like and how light will behave around a telescope. We have had simulations of these types of images for a long while. Also, in taking all the data to make the images, there have to be assumptions made in order to process and image. The image that was released was so close to expectation, astronomers also needed to go through several tests to make sure there was no bias in the results and be assured the image they were processing was what was collected.

Though one image was released, there were 4 days of data processed to make 4 final images (EHT, 2019). Each of those initially went to four different teams who made their own assumptions in order to process the data. The teams were not allowed to talk to one another whatsoever about their process. The images that resulted were all a bit different but resulted in an image with the same shadow radius and a bright wing on the lower half of the image, as expected from simulations. After this all the data was then processes through three different automated algorithms for processing the data, resulting in similar results as well.

Where Observatories Sit

Another major news story this year surrounding astronomy is the placement of the Thirty Meter Telescope (TMT) on the summit of Mauna Kea. This matter is extremely complicated. There are many different opinions, ideas, and desires from everyone surrounding the TMT. Each community at the center of the controversy has differing opinions as well. Not being involved, I don't feel like I can properly discuss the matter. However, I feel this is an opportunity to discuss where observatories sit. Other observatories also sit on land leased from other organizations, groups, sovereign nations, and private landowners. It is a chance to be reminded that astronomy is not done in a vacuum and where the instruments we use are placed will have an effect on those around them. Offered here are just a few examples.

One example is the Kitt Peak National Observatory. The land used is leased by the National Science Foundation from the federally recognized Tohono O'odham people. The NSF and the Association of Universities for Research in Astronomy (AURA) met with indigenous community members to draft an agreement of how that land could be used and staffed in the late 1950s. Today that agreement means there is preferential hiring for Tohono O'odham people and artisan crafts are sold in the gift shop. That doesn't mean the relationship is always a good one. The nation has also sued the NSF for projects like VERITAS without proper consultation of the sovereign nation. As a result, VERITAS is at the site of Mt. Hopkins (de los Reyes, 2019).

The Atacama Large Millimeter-submillimeter Array (ALMA) is leased from the country of Chile but sits on land that traditionally belonged to the Atacameno or the Likan Antai people. When this observatory was built, ALMA officers started working directly with the indigenous communities to build their ways of knowing into the programming of ALMA. They recognized the Likan Antai scientific knowledge and worked to help preserve culture and language. Roads were constructed to avoid a sensitive archaeological site, ALMA helped build a museum around that site, and the Likan Antai people were involved in the dedication of the observatory. They have also started programs with nearby cities that have large populations of Likan Antai students to get them involved in radio astronomy. Other observatories in Chile have not had this extensive communication with indigenous people. (Storey-Fisher, 2019)

Another example it the Very Large Array (VLA) in New Mexico in the United states. The VLA has 27 radio dishes along tracks that can extend into three 11-mile arms. The VLA only owns the inner square mile of this land. The tracks for the telescope as well as the posts and placement sites lie on private land, often owned by local ranchers. This requires that the VLA maintain strong and good relationships with the ranchers to maintain use of the land needed. These conversations are going to have to be expanded with the next generation VLA (ngVLA) in the coming years, which will take up much more room and locations in the southwestern United States.

Bibliography

Betts, B., Spencer, D. A., Nye, B., Munakata, R., Bellardo, J. M., Wong, S. D., ... & Vaughn, J. (2017, January). Lightsail 2: Controlled solar sailing using a CubeSat. In *The 4th International Symposium on Solar Sailing. Kyoto Research Park, Kyoto, Japan (17–20 Jan 2017b)*.

E. H. T. (2019). First M87 Event Horizon Telescope results. IV. Imaging the central supermassive black hole. *Astrophysical Journal Letters*, *875*(1), L4.

Güsten, R., Wiesemeyer, H., Neufeld, D., Menten, K. M., Graf, U. U., Jacobs, K., ... & Stutzki, J. (2019). Astrophysical detection of the helium hydride ion HeH+. *Nature*, *568*(7752), 357.

Mancini, L., Sarkis, P., Henning, T., Bakos, G. A., Bayliss, D., Bento, J., ... & Hartman, J. (2019). The highly inflated giant planet WASP-174b. *arXiv preprint arXiv:1909.08674*.

Masuda, K., Kawahara, H., Latham, D. W., Bieryla, A., Kunitomo, M., MacLeod, M., & Aoki, W. (2019). Self-lensing Discovery of a 0.2 M☐ White Dwarf in an Unusually Wide Orbit around a Sun-like Star. *The Astrophysical Journal Letters*, *881*(1), L3.

NASA (2019). https://www.nasa.gov/feature/a-next-generation-spacesuit-for-the-artemis-generation-of-astronauts/)

New York Times (2019). https://www.nytimes.com/2019/03/25/science/female-spacewalk-canceled.html

Simon, A. A., Tabataba-Vakili, F., Cosentino, R., Beebe, R. F., Wong, M. H., & Orton, G. S. (2018). Historical and Contemporary Trends in the Size, Drift, and Color of Jupiter's Great Red Spot. *The Astronomical Journal*, *155*(4), 151.

Storey-Fisher, K. (2019) Astronomical Observatories and Indigenous Communities in Chile. https://astrobites.org/2019/09/10/astronomical-observatories-and-indigenous-communities-in-chile/

De los Reyes, M. (2019) A Tale of Two Observatories: Astronomy and Indigenous Communities in the Southwest US https://astrobites.org/2019/08/16/a-tale-of-two-observatories/

I BELIEVE—IN STUPIDITY
(And I'm Here to Prove It)
2019 Armand Spitz Lecture

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__Abstract:__ **In this talk, you'll learn Gary's opinion on what makes a good planetarium show, the difference between a movie and a planetarium show, the need for questioning and observation, myths and beliefs, and some of his favorite things.**

I had a different title when I started writing this talk—"I believe: How to Lose Friends and Un-influence People". But after writing this talk, I counted the number of times each and every word appeared. And "Believe" was number one. "Stupidity" was number two. And since I would never ask any of you to accept anything on faith…. "I believe in stupidly and I'm here to prove it" is my new title. This is scary, humbling, and exciting all at the same time but I am truly excited to be here.

Of course at my age I'm excited to be anywhere. You know what they say, the first thing I do when I wake up in the morning is go to the bathroom, then I get out of bed.

This all started at 3:42 a.m.—in the morning! That's when my phone rang

I answered it. It was the technologically *sophisticated* GLPA Conference Planning Chair. We talked for a little bit, then he asked if I wanted to deliver the Spitz Lecture at this conference. I was totally surprised! Completely taken back. I never dreamed that was coming. He said, "Well do you want to or not?" I said, "This is such a surprise, I need time to think about it." To which he replied, "Thank you for agreeing to give the Spitz Lecture," and then he hung up.

So here I am. Now you're probably expecting this talk to be funny, but, the trouble with humor is 3-fold:

Problem #1

Professional comedians practice their routines and material on audiences—at comedy clubs etc. I couldn't do that. Imagine doing planetarium jokes at a comedy club. How many planetarians does it take to screw in a light bulb?

What's a planetarian?

They find out what works and what doesn't. Here's a case in point—a funny little bit I learned from Ron Kaitchuck that I thought was the most stupidest, unfunny thing I've ever heard---but what would you expect from Ron? *But*, it never failed to get a laugh.

Back in the 1970s, General Motors made a compact car called "Vega." This was also before I met Bob Victor and I didn't know how to correctly pronounce the star Vega. So I would point out Lyra and the bright star, Vega, and state that it has a car named after it. Here is a head light, here's the other head light. Here's a taillight. Here's the other taillight. He's got his left turn signal on—zoom, there he went!

Stupid, stupid, stupid but it always got a laugh. And I bet or I believe that if nothing else, a lot more people left remembering the name of that star—even if they couldn't pronounce it correctly.

Problem #2

You can say a lot of serious things with humor! The problem is that you're often not taken seriously—that's problem # 2. And I will say some serious things with humor in this talk.

Problem #3

And problem number three, it is hard work to be funny. It's much easier to be serious. And you're not paying me that much to do this talk so don't expect a lot of humor. You get what you pay for!

I've been asked before to deliver this talk and I've always declined—guess that's why the stupid Conference Planning Chair didn't give me any choice this time.

The reason I hesitated dates back to 1993 when Jon Marshall gave an excellent Spitz Lecture and I didn't want to give one too close to his as I would be, most likely, unfavorably compared to Jon—so I waited so you would forget how good a talk Jon gave.

And then along came people like:

- *Bob Elliott*
- *John Hare*
- *James Kaler*
- *John Stoke*
- *Rob Landis*
- *April Whitt*
- *Dave DeBruyn*
- *Gene Zajac*
- *Dan Francetic*
- *Ken Miller*
- *Chuck Bueter*
- *Dan Goins*
- *Art Klinger*
- *Sheldon Schafer*
- *Susan Button*
- *Gary Sampson*
- *David Hurd*
- *Dave Batch*

-just to mention a few. I just couldn't win, so I finally decided that I'm getting old waiting for a bad Spitz Lecture—I'd just have to give it myself. As I said, I'm old. I mean I not only know what LPD4, 3PD, BFJ stand for, I've *actually* used them—I'm old!

And I decided it would be a lot easier to give this lecture while I'm still alive rather than the other way around, so I finally gave up and accepted the invitation of the Executive Committee—they're responsible for me being here tonight. And for that, you should probably impeach them all!

"I believe."

This is supposed to be everything I know of value in 45 minutes. Everything of value. And it's supposed to take 45 minutes. Things of value---and inspiring no less.

Past Spitz Lecturers have talked about many things but also a lot about themselves and I'm just vain enough to do the very same thing, but this talk will not be a coherent flow of ideas or a chronological order of my life. Instead it will be disjointed thoughts spaced around a common theme—I believe. And in no particular order—that takes more work too. But it will be mainly about *me*!

I wanna talk about me
Wanna talk about I
Wanna talk about number one
Oh my me my
What I think, what I like, what I know, what I want, what I see
I like talking about you, you, you, usually, but occasionally
I wanna talk about me[1]

Why is it about me? Well, the answer's simple!

Oh Lord, it's hard to be humble
When you're perfect in every way
I can't wait to look in the mirror
'Cause I get better lookin' each day
To know me is to love me[2]

1 *I want to talk about Me* by Toby Keith
2 *It hard to be Humble* by Mac Davis

There I am. I was born at a very young age. Notice I was wearing suspenders then too—must have been fat then as well.

You'll hear about my favorite:
Saying
Joke
Song
Poem
Journal Article
Book
Movie
TV show

And to make this talk relevant to this audience, my favorite:
Planetarium show

Raindrops on roses and whiskers on kittens
Bright copper kettles and warm woolen mittens
Brown paper packages tied up with strings
These are a few of my favorite things[3]

Humor and thanks

I believe in humor. I believe it is almost always appropriate. Who do you think it was, while riding in the limousine behind my grandfather's hearse on the way to the cemetery, rolled down his window and yelled at an ambulance running code in the opposite

3 *My Favorite Things* by Julie Andrews

direction, "you're too late!?"

Humor is universal, it is participatory.

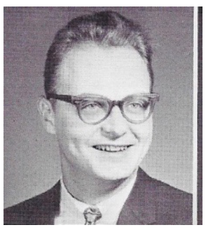
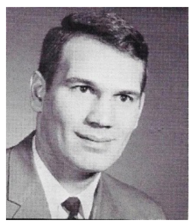
I'll say that again. It is participatory—and people like it.

I guess that's the inspiring part of this talk—using humor.

But I could never give a talk like this without thanking the people who helped me achieve whatever success I have today: an unemployed has been. I just realized all my specialized training, my unique knowledge of building special effects, all that photographic magic I worked on the dome is all obsolete.

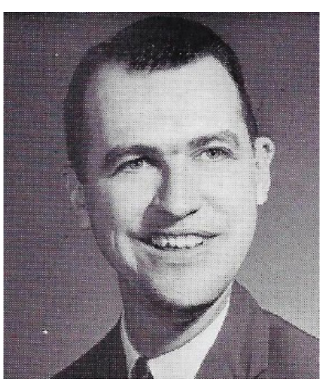
I thank people like:

Paul McDaniels (left)
Stewart Brown (center)
Joe Seip (right)

Never heard of them? My high school band teacher, algebra teacher, planetarium teacher.

And Richard Pugelsy (photo below). My 8th grade math teacher, who advised me to only take 9th grade arithmetic—*not* algebra or college prep algebra. I ignored his advice, I took algebra, the only course I ever got an A+ in. But he was a good guy. And he told jokes like why can't an elephant smoke? Because he can't get his butt in the ash tray. See I remember humor. He was the first teacher I had that I considered human. And that was quite a revelation for me—that teachers are human.



And you've heard the old algebra joke about the country boy who goes to college and takes algebra? He comes home at Christmas and his folks throw a party for him. They ask him what algebra is and he tells them it uses letters and numbers to communicate. They said it sounds almost like a foreign language to which he replies it is in a way. So they ask him to say something in algebra. Taken aback, he blurts out, πr^2. His parents hang their heads in despair and apologize for their son, stating everyone knows pie are round.

Well, I too, am just a country boy.

And I'm just a country boy
Money have I none
But I've got silver in the stars
Gold in the mornin' sun
Gold in the mornin' sun[4]

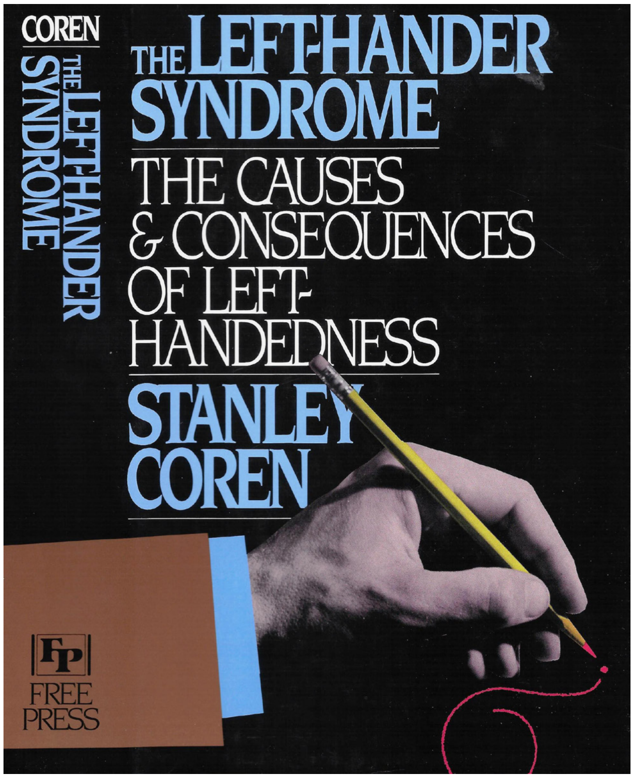
OK math quiz. Take out a pencil and paper if you have to:

1. Think of an integer between 1 and 10 inclusive. Do not tell anyone what the number is.
2. Multiply that number by 9. Take off your shoes if you have to
3. Add the two digits together (e.g. if number was 62, add 6+2=8)
4. Subtract 5 from that number.
5. Assign a letter in a one to one correspondence such that 1 = A, 2 = B, 3 = C, etc.
6. Take that letter and think of a European country that starts with that letter.
7. Take the <u>last</u> letter of that country and think of a mammal that starts with that last letter.
8. Take that mammal and think of a color that starts with the <u>last</u> letter of that mammal.
9. What's wrong with you people?? There are no orange kangaroos in Denmark.

4 *I'm Just a Country Boy* by Don Williams

It's easy to be set up. We have to teach people when to question things that don't make sense, things not supported by observation and data.

Not only am I a country boy but I'm left handed too.



In 1992, Canadian psychologist Stanley Coren wrote, "The Left-Hander Syndrome: The Causes & Consequences of Left-Handedness." In his research he found:

There is no left-handed gene

It's just as natural to be right handed as it is to be born with 2 eyes, 2 nostrils, 2 ears.

About 10% of the population is left-handed to varying degrees

Being left-handed seems to be a birth defect

The average IQ of a left-handed person is 3 percentage points below that of a right-handed person

3 percentage points stupider.

But wait, there's more.

How many people in here are left handed or at least will admit to it now?

Did you know that kids with bigger feet are better spellers? It quite a statistically significant correlation. Now the conclusions you may draw from that can be quite incorrect. Do you go home and start stretching your kid's feet?

You have to be very careful how you interpret things like statistics. You know what they say, 7 out of 5 statistics are made up.

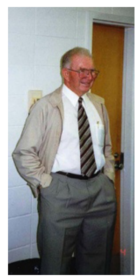
Kids with bigger feet are generally older and therefore better spellers. So back to being left-handed. There is one more statistic you need to know.

50% of the profoundly mentally impaired are left-handed

Conclusion: To make up for the highly skewed number of left-handed profoundly mentally impaired people, left-handed people who have any smarts, have to have a lot of "smarts" just to get the average to be only 3 percentage points below that of right-handed people.

Be careful about jumping to conclusions. Analyze, think, question.

And then there's my college profs I need to thank (Ball State University): Leon Reynolds (left), Malcom Hults (center, he was left handed), and Newton G. Sprague (right). There's a name you might recognize.



And Gerald Thomas (photo below)—a terrible teacher. I had him for quantum mechanics. I learned more quantum mechanics in freshman chemistry than in quantum mechanics.

After quantum mechanics, I signed up for celestial mechanics. Guess who taught that? You got it, Dr. Thomas, who on the first day of class, brought his big 3-ring binder of teaching notes from quantum mechanics as he thought they would be relevant—after all they both are mechanics. In the very next sentence he talked about comets being very hot.

It's going to be a long, long semester!

You don't have to have a PhD to be stupid, but it helps! Just kidding—anyone can be stupid—we *all* are at one time or another—some of us just less than others. So maybe the best we can hope for is to be less stupid than most?

But Dr. Thomas had to learn with the students and he did, what for him, was a good job of teaching celestial mechanics. He also taught me my favorite joke that I use to explain what I do as a profession. I'm not an astronomer. I don't have a Ph.D.—not a professional astronomer. But I'm more than an amateur astronomer. Kind of half way in-between—a half assss—trophysicist.

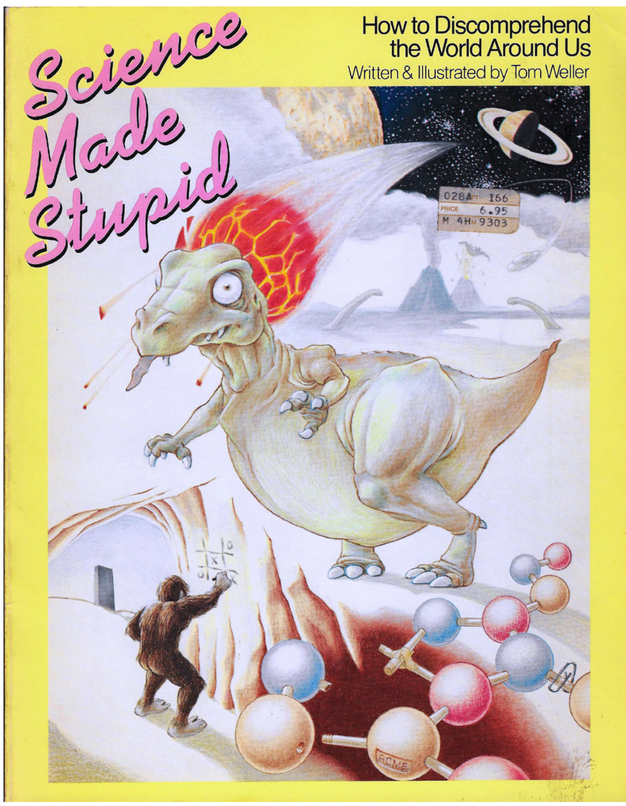
My favorite book: Science Made Stupid.

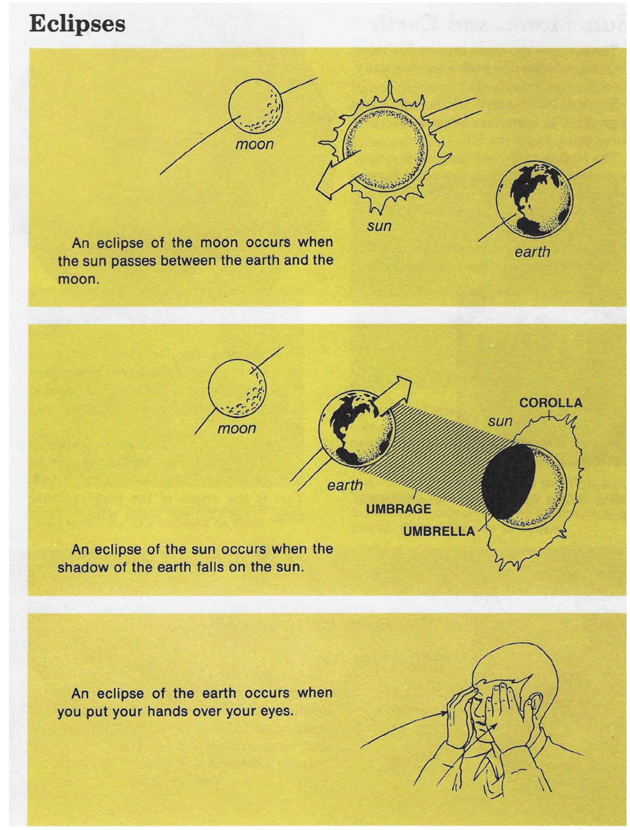
I'll let you read the reason for eclipses[5]

An eclipse of the moon occurs when the sun passes between the earth and the moon

An eclipse of the sun occurs when the shadow of the earth falls on the sun

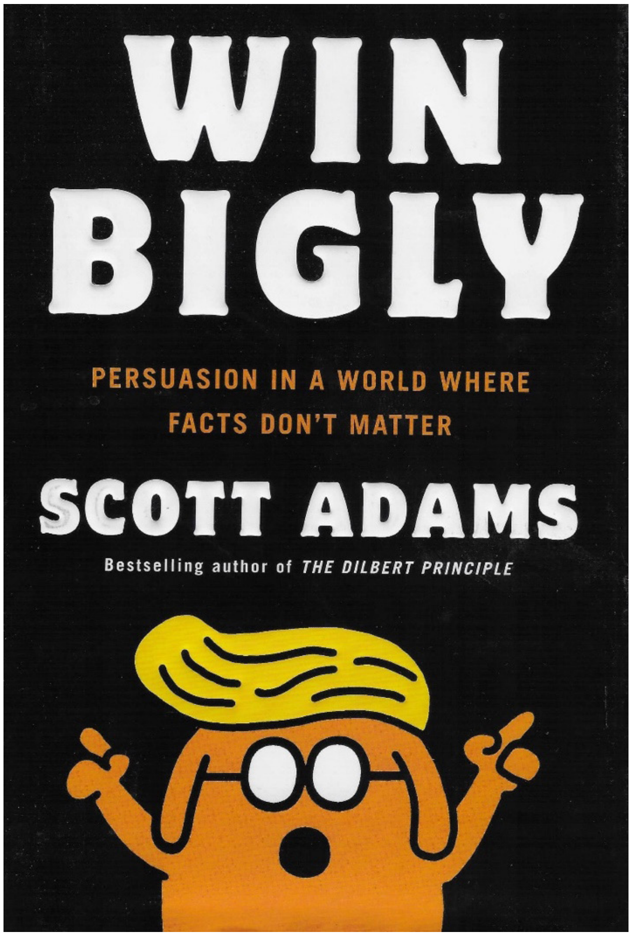
An eclipse of the earth occurs when you put your hands over your eyes.





This is the scariest book I've ever read: "Win Bigly" by Scott Adams, creator of the Dilbert cartoon. Subtitled, "Persuasion in a World Where Facts Don't Matter." Statements like, "Facts don't matter," and "Facts are weaker than fiction" are scary to a person who believes in logic.

5 *Science Made Stupid* by Tom Weller, Houghton Mifflin company 1985



Adams states we are not rational beings. In fact he states, "Humans think they are rational and that they understand their reality. But they are wrong on both counts." Can he be right? If so, that would explain a lot of human behavior I've observed. That means no matter how many facts we can present, no matter how elegant the argument, no matter how good our intentions are, we cannot sway anybody's position. Scary! More on that later.

To an Amateur Astronomer's Wife by Mrs. Mary H Ganser

Come on now, old dear, let's cheer up and smile!
You've married a man who is well worth the while.
His eyes may be glued to a beautiful star—
But it's nicer than sitting blear-eyed at a bar.

In front yard, or back yard, on mountain or knoll,
An astronomer's quite an inquiring soul.
He's happy at his telescope wherever he sees
The dazzling diamonds of the bright Pleiades,

Or a galaxy millions of light-years away,
Or a star that exploded one prehistoric day,
Or Jupiter's moons, or Saturn's broad rings—
To astronomers, these are all challenging things

No wife will be lonely, unhappy, forlorn,
If she'll join her spouse in the wee hours of the morn
In this science that calls to the greatest of men,
And how proud she will be
---out there freezing with him!

And in grad school (Michigan State University, Abrams Planetarium) there were

Von Del Chamberlain
Dave Batch
Bob Victor
John Hare
Eric Melenbrink
Lee Shapiro
Zen Billeadeaux
Ron Cobia
Steve Hill: An astrophysics professor and the only person to ever get me drunk. Now as many of you know, I do not really drink—maybe once/year if that. I don't like the taste. I like being in control and drinking can make you stupid. And I don't need any help with that, I can do that all by myself.

And of course my esteemed colleagues at the Chaffee Planetarium:

Dave DeBruyn & Mark Perkins

And being an only child the closest thing I had to a brother, my cousin, James Buchanan, an amateur astronomer.

Well, oh yes even what's his name: Ron Kaitchuck

As I was preparing this talk and looking through my high school yearbook, I realized someone who was probably more responsible for me being here today than anyone else—and I *never* realized it until I was preparing this talk. This is a true story I've never told anyone—until now.

Vivian Harnish was my 8th grade general science teacher. Now I was, at best a "C" student. I did *not* like school. Again, being an only child, I interacted better with adults than with kids my own age. One day, at lunch, I found in the waste basket, near the candy machines, a discarded, graded standardized science test. The same one used in my science class—for the same chapter we were just about to complete. It was Steve Gernand's –a smart kid---he got an "A."   I took it out of the trash.

I bet you think you figured out where I am going with this and you are probably right.

I wrote down the question numbers and the corresponding correct answers on an index card. During the test I discretely took out the index card and circled all the correct answers on my test paper. I put the index card back inside my notebook, started to get up to hand in my test when my lab partner grabbed my arm (he was even a worse student than I was) and whispered, "What is the correct answer to 15? I set back down, took out the index card and said "D," stood back up and handed in my paper. I got an "A"—perfect score!

I cheated! (the only time I ever cheated). But wait, there's more.

Afterwards, I started to think. I was at best a "C" student and I got a perfect score on that test. If I get anything other than an "A" on the next test, Mrs. Harnish is going to get suspicious. What was I going to do? –get a new lab partner?   No, I had to study and so I did.

Mrs. Harnish never said anything. I got away with it—or so I thought—even to this day. A few days after the test, Mrs. Harnish walked up to the lab table where my lab partner and I were seated and told us that the classroom was going to get some white rats. Would we like to build some cages? I was actually touched that she thought of me to help out. She didn't ask anyone else—just us

As I said, I never realized it until now, but she *knew*. The cages were penance. But I had to study so as not to tip her off. I found science interesting and I started to get interested in astronomy. My grades improved and I graduated in the top 10% of my class.

I believe I have her to thank, *but* I never got a chance to tell her because I didn't realize it until just recently. She's probably dead now. I mean she was *really, really* old way back then—probably in her 30s!

Turned out she was a very smart person, so to any classroom teachers out there, there are a lot of ways to handle things. What would have happened if she had handled that situation differently? So try to be like Mrs. Harnish. I believe I not only owe her thanks but that she is the reason I had the career I had and was not a factory worker like my dad—which up to that time was my life's goal.

My family

Speaking of my dad,

He's the one in uniform. He was in WW II in the south Pacific on a little island called Tinian. He actually helped load the atomic bomb onto the plane. He didn't know exactly what it was—only if something went wrong there would be no island left.

But he once told me that boiling water freezes faster than room temperature water. Now I was taking high school physics by that time and I knew that could not be true---didn't make sense. I asked him how he knew that and he said he heard it on the radio. Now for the young people in here, a radio is a method of communication that predates the Internet, Cell Phones & Streaming. You could get news and information from it. Next thing you know I'll have to explain what a phonograph record or an 8-track is.

I finally realized what he heard was that water that has *been* boiled will freeze faster than water that hasn't. We all have misconceptions. That is one of my biggest fears, to think I know something and I really don't. We have to be on guard in ourselves, in our students, in our programs. I believe we need to confront those misconceptions head-on and guide people to correct explanations

This is my grandmother. She died during the 1999 Kalamazoo GLPA conference. I had to leave part way through the conference to attend her funeral. Now my grandmother purchased some property when I was a child and she wanted to have a well drilled, so she took me with her to figure out where to drill. When we got there, she told me she was going to witch for water. She took out two L-shaped partial coat hangers, one in each hand, and walked. She explained that when she crossed water the coat hangers would cross. When they crossed, she took out a peach tree branch and held it out. Soon it started bobbing up and down and she counted the bobs. She explained the number of bobs correspond to how many feet down the water is. I didn't ask her about a peach tree branch cut form an English tree—would that count in meters as opposed to feet? Do you know how that experience can influence a young person?

I got some coat hangers and made the L-shaped rods. They crossed exactly as I walked over a mud puddle. It worked! I could have been scarred for life. We need to confront things like this or people will believe we accept it. In spite of all of that, I made the decision, *all by myself,* to go into science.

Educating and teaching

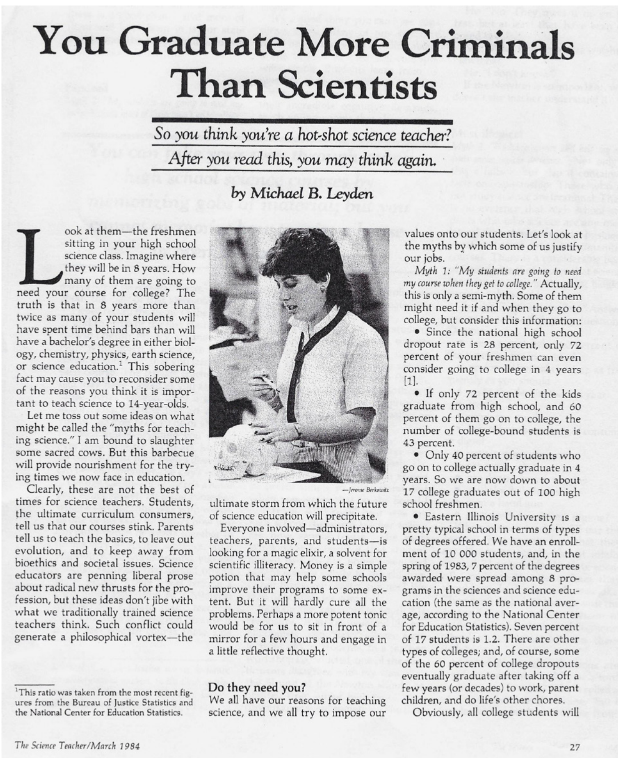
When I lost my job, I went on to teach at local colleges and universities—about one course per year and here is what I discovered:

College students of today behave like the 9th graders I student taught in 1974.

I was not very good at teaching in a formal educational setting.

I was very good at informal science education. I tried but… Guess Dr. Thomas thought me everything he knew about teaching! (my last class was different. It was a graduate level class and one student stated that this was the best class she'd ever had—a good way to go out)

Early on in my career, I read an article that changed my entire outlook on teaching.



You Graduate More Criminals Than Scientists

So you think you're a hot-shot science teacher?

After you read this, you may think again.

by Michael B. Leyden

Look at them—the freshmen sitting in your high school science class. Imagine where they will be in 8 years. How many of them are going to need your course for college? The truth is that in 8 years more than twice as many of your students will have spent time behind bars than will have a bachelor's degree in either biology, chemistry, physics, earth science, or science education.[1] This sobering fact may cause you to reconsider some of the reasons you think it is important to teach science to 14-year-olds.

Let me toss out some ideas on what might be called the "myths for teaching science." I am bound to slaughter some sacred cows. But this barbecue will provide nourishment for the trying times we now face in education.

Clearly, these are not the best of times for science teachers. Students, the ultimate curriculum consumers, tell us that our courses stink. Parents tell us to teach the basics, to leave out evolution, and to keep away from bioethics and societal issues. Science educators are penning liberal prose about radical new thrusts for the profession, but these ideas don't jibe with what we traditionally trained science teachers think. Such conflict could generate a philosophical vortex—the ultimate storm from which the future of science education will precipitate.

—Jerome Berkowitz

Everyone involved—administrators, teachers, parents, and students—is looking for a magic elixir, a solvent for scientific illiteracy. Money is a simple potion that may help some schools improve their programs to some extent. But it will hardly cure all the problems. Perhaps a more potent tonic would be for us to sit in front of a mirror for a few hours and engage in a little reflective thought.

Do they need you?

We all have our reasons for teaching science, and we all try to impose our values onto our students. Let's look at the myths by which some of us justify our jobs.

Myth 1: "My students are going to need my course when they get to college." Actually, this is only a semi-myth. Some of them might need it if and when they go to college, but consider this information:

- Since the national high school dropout rate is 28 percent, only 72 percent of your freshmen can even consider going to college in 4 years [1].
- If only 72 percent of the kids graduate from high school, and 60 percent of them go on to college, the number of college-bound students is 43 percent.
- Only 40 percent of students who go on to college actually graduate in 4 years. So we are now down to about 17 college graduates out of 100 high school freshmen.
- Eastern Illinois University is a pretty typical school in terms of types of degrees offered. We have an enrollment of 10 000 students, and, in the spring of 1983, 7 percent of the degrees awarded were spread among 8 programs in the sciences and science education (the same as the national average, according to the National Center for Education Statistics). Seven percent of 17 students is 1.2. There are other types of colleges; and, of course, some of the 60 percent of college dropouts eventually graduate after taking off a few years (or decades) to work, parent children, and do life's other chores.

Obviously, all college students will

[1]This ratio was taken from the most recent figures from the Bureau of Justice Statistics and the National Center for Education Statistics.

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"You Graduate More Criminals than Scientists[6]" by Michael B. Leyden (Eastern Illinois University) that basically said that if you plan on your course preparing your students for life, you'd service a higher percentage teaching them how to survive in jail than teaching science.

As my Trueisms said, "Those who can, do. Those who understand, teach." But there's more to it than just that. *My* students did not care for my teaching nor could they or would they offer any suggestions for improvement. Which implies teaching is a talent. You have to find something you have a talent for and nurture that talent. Find something you like and go for it.

6 The Science Teacher, Vol. 51 March 1984 pp. 26-30

Very few of us have talents in all or even many fields. Guess that means you should be proud to be introduced as a Man or a Woman with few talents. So to you good teachers out there, I salute you!

Be proud of what you can do and don't concentrate on the things you aren't so good at—try to improve them—sure but if you can't—move on. There is hope. If you are bullied, aren't good looking, you can accomplish lots of things in your life.

Now I've never done drugs—I've thought about it. I've even been to parties where they were provided. In fact by a person in attendance at this conference. But I didn't partake. When I was President of GLPA, we joined forces with the White House in Nancy Reagan's Just say NO campaign, which as it turned out, really wasn't an effective campaign. But as I said back then, we need to get these kids off drugs—so there'll be more for the rest of us! As I get older I starting to believe that drugs should be legalized—at least for old people so we can move without pain.

You know what it means to be an adult? It means knowing when to ask for and/or accept help, emotional, physical, psychological, relationship, whatever. We'll all human. Let's not fault people for that and we all need help. Things don't always go our way.

We need to be independent, think for ourselves, but know your limitations, like you're good at informal science education and not so good at formal science education. Some of you have done both and done them well. Some of you are even good researchers on top of that—God I hate Kaitchuck! To help us achieve success is why we have doctors, universities, family, friends.

My favorite movie[7] is about an old cowboy in search for his kidnapped grandson (who in real life is the old cowboy's real-life son) who, in this clip, is talking to his on-screen son (who is also in real life, another one of his real-life sons) about his new fancy gun. The son keeps practicing and practicing using this new technology, drawing faster and faster. Finally the father (John Wayne) says, "hey I bet you could almost get that fancy gun out of the fancy holster before someone with an old fashioned six shooter blew a hole in ya."

Just because technology exists does not mean it's good or that we have to use it. Sometimes the old-fashioned way is better. Use what works for you. It's a tool. Use it if it helps you achieve your goals. I've seen you people do some amazing things with stuff like artificial insemination tubes.

You know the difference between a planetarium and a movie? The answer is simple. It took me a long time to figure it out but the answer's simple:

The planetarian.

If you just push a button, then you're not a planetarium—you are a movie. So make sure if you do just push a button—that is what you really want to do. But it is the live planetarian who gives a planetarium its heart and soul.

I've tried to figure out what makes a good planetarium show. Story telling makes a good planetarium show.

For the past several years, I have not seen a show that I've considered good except for one. I don't know if that's because I'm jaded, if I'm just no longer able to tell, because of all my experience, a good one from a bad one or if I just can no longer put myself in the general public's shoes.

My favorite TV show: Star Trek. In Star Trek: The Voyage Home[8], which I still consider a TV show even though this episode is a movie, takes place after Mr. Spock dies in a previous episode and is brought back to life—a topic Dr. McCoy wants to discuss with Mr. Spock. Dr. McCoy asks Mr. Spock to share his insights on death. Mr. Spock replies it would be impossible to discuss it without a common frame of reference. To which McCoy replies, "You mean I have to die before we can discuss death?"

We need to put ourselves in other people's shoes hopefully not by dying, but sometimes we forget what we went through to learn. Learning is easier the second time around. It's hard the first time. We tend to forget that.

I tell time by bst and ast (before Star Trek and after Star Trek). That may have had some influence on me as well. And no, I did not name my only child, James, because of Star Trek. It's just a coincidence.

But let's not penalize people for being human. Let's use that to our advantage. Let's try to understand where they are coming from and yes while it is often impossible to completely understand unless you've been in their shoes we can get close. When I was asked to develop policies and procedures at work, I went to the people who had to utilize those policies and procedures and asked what they wanted. And it appeared like I was the only one who ever did that. They gave me valuable insight. Made my bosses think I knew what I was doing and gave the people "in the trenches" a workable policy they not only could follow but also felt ownership in.

When I first started out in this profession, I read a very short, to the point book on management. This is what I remember from that book:

Hire good people
Find out what they need to do their job
Get it for them
Get out of their way

And that's what I tried to do, but let's get back to what makes a good planetarium show?

My favorite:

"The Last Question" by Isaac Asimov, educationally it is great. It talks about one topic, keeps going back to that one topic, and emphasizes that one topic.

"One World, One Sky" is kind of the same way.

My favorite saying: Idiosyncratically euphuistic eccentricities are the promulgators of triturable obfuscation. Got it memorized yet?

What exactly does that mean?

Idiosyncratically	peculiar
Euphuistic	style of writing or speaking

7 Big Jake, Paramount 1971
8 Star Trek: The Voyage Home, Paramount 1986

Eccentricities	odd
Promulgators	announcement
Triturable	pulverize
Obfuscation	obscure

Using big and uncommon words doesn't add anything and only distracts from the message you are trying to deliver. It means KISS: keep it simple stupid.

I Believe "Cosmos" was a good show and so was "Star of Wonder" by Dave DeBruyn.

Now it's been said that having an SOB show is akin to supporting astrology. I disagree. It's presenting historical facts that people may have construed as a "sign." After all, we present constellations that astrologers consider a "sign."

And I tried to figure out what made those two shows memorable and I've come to the conclusion it was the music. It was an emotional response. They weren't participatory. They were push button shows. If you elicit an emotional response—humor—music—audiences remember.

My favorite song is one that never made the top forty. Sung by Karen Taylor Good. Listen to the words.

Come in Planet Earth, Are You Listening?
By Karen Taylor Good

Looking down I can almost see dad's farm house
And I can feel his proud eyes looking up at me
I'm 200 miles in space. Between the Moon and my birthplace
Amazed at where a country girl can be

Carolina's slipping past my window
And the swirling clouds are forming out at sea
I'm beyond the atmosphere. A modern pioneer
Humbled by the heavens around me

Come in planet Earth, are you listening?
The world is just an island in the sky
If we can fly among the stars,
We can find the truth within our hearts
Love's the only way we can survive

There's snow upon the peaks of southern Russia
And over there beyond the skies are clear
The whole world looks so clean. No borders can be seen
It all seems so peaceful from out here

Oh, we just passed the coast of California
There's a storm brewing off of Mexico
I'm 200 miles in space. Circling the human race
Wondering will we win or lose it all

Come in planet Earth, are you listening?
The world is just an island in the sky
If we can fly among the stars,
We can find the truth within our hearts
Love's the only way we can survive

Come in planet Earth, are you listening?

No borders can be seen. Borders are manmade just like many misconceptions and beliefs. No borders. We all know about rival gangs—protecting their borders—their turf. That gangs are bad, but you know, I think we should all join a gang but it should be the *same* gang called the Human Race. Try to put ourselves into other people's shoes but don't allow their beliefs to override observation and good common sense. To do so would be a great disservice.

On September 11, 2001, a group of eleven terrorists killed more than three thousand people over "Beliefs." They were called cowards. When a group of passengers on flight 93 decided they would bring down the plane killing all on board rather than let it crash into Washington DC, they were called heroes.

Those eleven terrorists were not cowards. They died for something they *believed* in. We ought not teach stupid beliefs. We have to be *very* careful about what we teach people (by words and deeds) to believe in.

I would prefer to teach people to think for themselves so they could analyze what to hold as truth—and note truth is different than belief. Beliefs are not always true—that's where we need to guide them away from misconceptions. It appears to me that many people, groups, and organizations spend a great deal of time and effort to essentially brainwash people into believing what they believe.

This is a good country.
With good people in it.
Good people don't always agree with one another
Maybe the best thing we do in this country is agree to disagree once in a while
But with a certain amount of civility
And that's what seems to be missing these days…a certain amount of civility.
We're shouting when we should be talking.
We're arguing when we should be conversing.

We're angry when we should be reasoning.
I think the best single thing all of us can do is calm down.
And maybe think a little bit more and talk a little bit less

December 4, 1974
John Wayne

So how do we un-brainwash people back to reality? Well for one we shouldn't try to brainwash people into anything that is not supported by observations and data. When we know our observations support the concept, what do we use to have an impact? The music of Cosmos? The single concept of The Last Question?

Technology?

Full dome video is amazing but is just a tool. And I'm sorry but optical mechanical skies like Zeiss, Goto, and Minolta elicit an emotional response to a dark sky. We've lost a little magic.

But what about those terrorists?

Wouldn't it have been great if someone had challenged their beliefs—being silent implies acceptance and affirmation. If they had been encouraged to think for themselves, to observe, and question things that do not fit the observations, might we all have been better off? Confront incorrect beliefs just as you would anybody who believes the Earth is flat or believes in astrology or physic surgery.

It's not evolution vs. creationism—it's rationalism vs. superstition.

I get upset when I hear about parents who home school their kids just because they don't want their kids exposed to outside influences—brainwashing.

Minds are like parachutes—they work better when open.

They are human but let's not let them be stupid. It's hard to fix stupid.

At a GLPA conference a few years back, I misunderstood something and remarked about how stupid I was. April Whitt graciously pointed out that I was *not* stupid—just ignorant. So I want to thank April for pointing out that I was just too stupid to know I was just ignorant.

So maybe our job is to help people be less ignorant and if that means confronting "beliefs" then we should *not* stand idly by and imply acceptance by our silence.

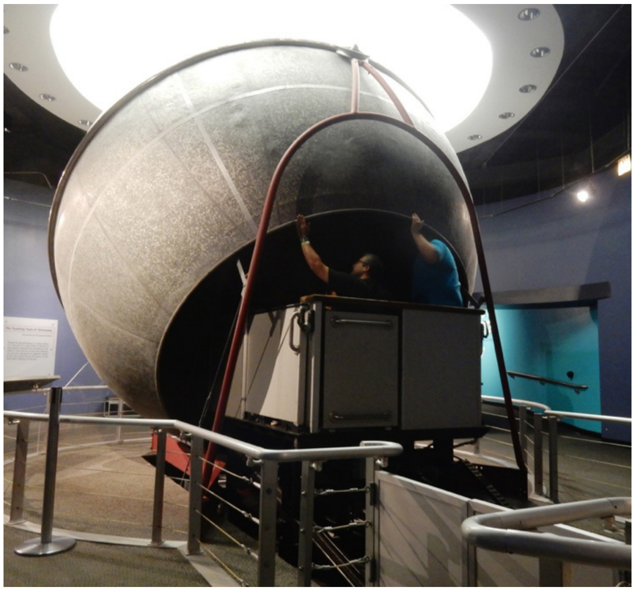
But how do we effectively persuade those people? This is where "Win Bigly" comes in. This is the 2nd publication that profoundly changed my prospective about the human race. Adams has convinced me that we need to become a master persuader. In his book Adams gives 30 persuasion tips. He made me realize that we (i.e. educators) need course work in sales, persuasion, marketing, and hypnosis for only with those talents can we even begin to influence others. Even then it is a tall order. But even Adams agrees a sense of humor is a powerful tool of persuasion.

"Faith is believing in things when common sense tells you not to."
Maureen O'Hara, Miracle on 34th Street

As much as we'd all like to believe in Santa Claus, that is a very dangerous statement. Let's help them see.

The time: 2009

The place: Adler Planetarium's Atwood Sphere.



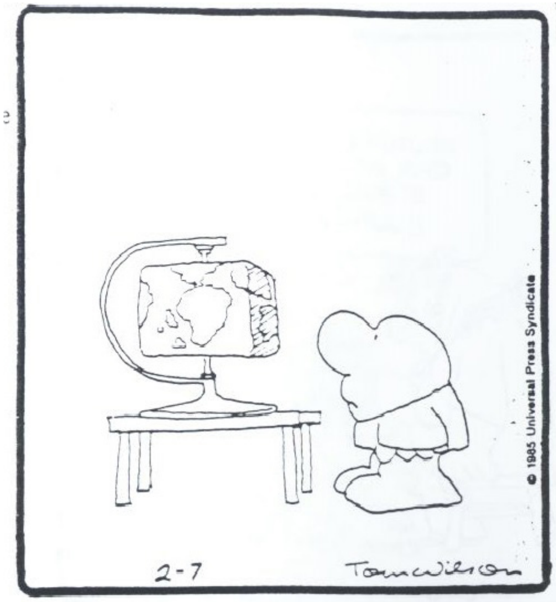
I attended their show and the lecturer pointed out a constellation incorrectly (Little Dipper as I recall). I waited until everybody left and told her I thought she got the constellations confused. She replied she did not and that she knew what she was talking about because she was an astrophysics major. And then I did something really, really stupid. I shut up and left. I should have persisted. I did a great disservice to the profession, to Adler, and to the public by not helping her see.

Everything is beautiful
In it's own way
Like a starry summer night
On a snow covered winter's day

And everybody's beautiful
In their own way
Under God's heaven
The world's gonna find a way

There is none so blind
As he who will not see
We must not close our minds
We must let our thoughts be free

For every hour that passes by
You know the world gets a little bit older
It's time to realize that people lies
In the eyes of the beholder[9]



Let's see if you've been listening and more importantly understanding.

Let's review

Use emotion to capture the mind. Humor and music are two ways to that goal.
Keep It Simple Stupid.
Technology is a tool.
Know your talents and weaknesses. Accept help.
Accept that you and everybody else is human.
Bet tolerant of non-manmade conditions, Put yourself into other people's shoes.
Beliefs can kill so confront misconceptions and beliefs.
A great many people and organizations spend a great deal of effort to brainwash people to believe as they do.

Those are the charges I leave you with. I'd like to believe they are worthy of your consideration.

It is our job, nay our duty, our obligation to confront misconceptions and beliefs by *not* standing by in silence, for if we do, we imply acceptance. It's like believing in square planets. You know you can't have square planets---any more than you can blow square bubbles. They're always round. You know how to make super bubbles? Add glycerin.

I had a dream---to be a planetarium director---one I *never* achieved. My dream now is to be remembered as having an impact on this glorious profession. More importantly, I have a dream just as Armand Spitz had a dream—that one day, people will no longer be taught beliefs that lead to non-tolerance and misconceptions—that they accept the Universe as it is ---not how they wish it to be.

Tie your dreams to mine
See how high we can climb
Together, we can rise above it all
One step at a time
Leave the world behind
If you'll tie your dreams to mine[10]

Or at least that's what I'd like to believe.

You need to confront things that don't make sense. And if you do, you will find what we do in this profession is truly magic.

Thanks to:

Garry Beckstrom
Dan Goins
Bart Benjamin
for their help with photographs

And especially John Foerch.
for his help with the audio and visual portions of this talk

And a very special thank you to Dave Leake for being there when I needed him. He offered to read this talk if I was physically unable to do.

9 *Everything is Beautiful* by Ray Stevens

10 "*Tie Your Dreams to Mine*" by Marty Robbins

VISUALIZATION DESIGN IN THE PLANETARIUM: MOVING AWAY FROM THE BINARY NOTION OF STANDARDS

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Abstract: It is not uncommon in the effort to present data that the notion of absolute standards is brought up. When art and science are coming together in the task of visualizing space and time it is a good idea to use precise words that avoid obstacles between disciplines. Standards do not exist in design but there are guidelines for when there is nobody to articulate visual perception and prevent contradictions. While safe, guidelines produce less memorable planetarium experiences, excessively toning down the saliency of the data. This presentation will cite examples that promote better collaborations among seasoned professionals.

What is it with standards?

Standard as a quality may have the following meanings: normal or average/ordinary/of permanent value/accepted as usual. Does this point to creativity, exploratory endeavors, exciting realizations or discoveries? "The only thing that does not change is change itself" is a common saying. I would like to advocate today for the planetarium community to pursue a culture of non-standards and reinforce the role of professionals who have dedicated years of education and practice to understand perception, action, and the internal simulations that are our thoughts. At a time that astronomy is using scientific visualization as a branch of research in its own right (McCormick et al., 1987), perhaps it is also time to understand scientific visualization as a matter of process and change and not a binary notion of rules that are followed or broken.

Working in the planetarium setting over the years I came across many meetings where someone would bring up "standards", and I have to confess: I had no clue where this was coming from. I can still only guess. As a designer I was surprised to hear about "standards" such as "letters should always be white or black depending on the background", and "photos should be black and white", or "3D should be avoided". As time passed I have come to guess that some people assume that there is an absolute solution for visualizations that apply for every medium, situation, or concept. As cited from the dictionary, that is not necessarily the meaning of the word "standards" though. Perhaps there is a conflation of guidelines with the notion of standards as a safety measure. In the realm of scientific visualization I think these guidelines are there to prevent misunderstandings in the worst case scenario where there is nobody available who is perceptually trained, so the guidelines are recommendations to avoid making the visualizations confusing or unreadable. But in neutralizing the risks of confusion and unintelligibility, the visuals are often toned down to be merely formatted and average, as perhaps unconsciously desired. In such a scenario, the unintended result is the recognition of something that looks safe and unremarkable. This presents a conflict with data being presented to be experienced and explored, especially in the setting of a planetarium dome, as a place one has never been before, which is also true of the actual data itself, if it is a new dataset or a new theory. In that regard, planetarium professionals are confronted with two disciplines, astronomy and art/design, that should perhaps strive to move forward in conjunction in their theoretical and perceptual research of space and time.

Perception and the outer world

When considering the umwelt of the human species, that is, the world that the human body can perceive through its sensory motor capabilities (Von Uexküll, 1934/1957), it is obvious that there are aspects of the world that exist beyond our perceived world because there are animals that see, hear, smell, and overall sense the world with different capabilities. Societies in specific locations across the world further interpret what is perceived and acted upon differently influenced by their specific contexts and cultural constructs like spoken language, imagery, dance, and other vehicles of expression and collective reflection, more so when people move around the planet and combine those interpretations.

Uniqueness of experience

Experience, on the other hand, is a cumulative endeavor. This is particularly important for the emergence of astronomy as a cultural discipline that assisted various human communities early on with the understanding of cycles that helped coordinate food cultivation and hunting based migrations. Such an understanding arose from paying attention to the imperceptibly slow changes that would happen over days, weeks, and even months. In that regard, the detection of patterns of change would have arguably allowed for a cultural experience connecting the life activities of communities to planetary cycles. Such connections would have encapsulated the experience of the community as a whole in time and space (Aguilera, 2019).

Understanding slow patterns and experience over long spans of time is one aspect of the temporality of experiencing. Another aspect of temporality are the assumptions made of what does not seem to change at all, for example, the land on which we stand. What is the perception of the planet as static and stable in relation to human experience? Weather and geologic events such as hurricanes, earthquakes, and volcanic eruptions have altered the landscape throughout recorded history, to a degree that questions the likely unconscious assumption derived from direct experience of the ground being static forever.

Both these examples address perception of change. The first one when change is slow enough to escape immediate direct experience, and the second one when there is direct experience of change in something that was assumed to never change. Whereas in the first example, change is not necessarily detected as a pattern when experienced in the moment, the second example can be directly experienced as a weather or geologic pattern but from an unexpected source, like that from wind streams or tectonic activity. How humans relate directly or historically to the changes in the environment tells us something about what informs the human umwelt, our perception of the world as is at large.

A common context

Looking at changes over time or unexpected changes on what was perceived as timeless also uncovers an aspect of the scalability of experience according to greater contexts. On one hand, each person has a unique daily life experience per the unique point of view that the human body occupies in its own surrounding context. On the other hand, when that physical context is scaled and cohabited, it may become a common physical context. The greater the context, the less unique it is.

Something else that happens when context is scaled, is that the experience of that context changes because some aspects of the context become irrelevant while others become noticeable that were not noticeable at human scale.

Planetarians introducing astronomical data regularly present the experience of shared context at different scales, from 360-degree photographs in different places on the planetary surface, of the moon, of Mars or even asteroids, to simulations that allow viewers to go on a journey at solar, galactic, or cosmic web scales. Scaling at those magnitudes is done with so much ease these days that the customization of space and time that takes place for cosmic journeys to happen may go unnoticed or given for granted.

The constructed Universe

The same way humans create internal simulations that help integrate daily to yearly spatio-temporal events into day-to-day experience, planetarium experiences present external simulations of these and other greater scale events, making adjustments for the planetarium experience to be possible. Planets are scaled up when looking at the whole solar system, celestial bodies move along their corresponding paths, and galaxies attract each other when at a suitable distance for their gravitational forces to eventually lead to a merger. And all these simulations derive from actual, estimated, or theorized data that are then scaled for planetarium viewers to see change happen, ultimately showing that even what is perceived as static is not really so.

Data beyond direct experience

In 2007 I applied to a visualization developer position at the Adler Planetarium because, having worked in architecture and Virtual Reality projects, I was curious about what kinds of impossible spaces from data needed to be represented and what were the variables one should consider when mapping that data into a simulation to create a direct human experience. During my work at the Adler I was fortunate to collaborate and support various kinds of projects including particle animations and interactives of instruments in the Webster Collection that allowed me to learn how phenomena are both captured, abstracted, and mapped to the human body. I also saw online projects like Galaxy Zoo grow up close, which crowdsourced data that are then used for research.

Galaxy Zoo is a citizen science that emerged from a specific need. Astronomers wanted to classify galaxies into different shapes. This was not something computer vision could do but something that human vision excelled at. To a single human the task would have taken months if not years, but upon posting the data online, all galaxies were classified in a couple days. Eventually astrophysicists were able to see how galaxy shapes were distributed in the filaments and clusters of the cosmic web. This experience would come handy later on.

I spent 13 months on the Big Island of Hawai'i in 2016 and even though I was familiar with Algalita Research showing the problem of plastic pollution and the floating islands of garbage in the planet's oceans, and I had also been picking up said garbage in front of my house in the Chicago suburbs, I got to see plastic cutlery and Solo cups washing into remote beaches, piling up just after a week or so of the regular beach cleanups that now are commonplace. It is during this time that I leaned about the Litterati app and noticed that classifying litter data may not be that different from classifying galaxies. Once back in Chicago after my Hawaiian appointment was completed, I worked in my own neighborhood spreading the word about the importance of seeing the single piece of litter in the street in the context of larger temporal and spatial scales. About 60 people in my village participated collecting and classifying the street garbage as part of the Science, Art, and Trash project, a mosaic image (a nod to Chris Jordan's work "Running the Numbers") of about 6K individual pictures taken with the app, which toured the main street of our small suburban town over this past summer.

Understanding the mapping process is not trivial. The human experience of litter is something we try to put away as soon as possible. Over 60% of the litter picked up has been consistently plastic. Of course this result is not necessarily geared to a great discovery per se, but to behavior change that is not aligned with the insignificant number of pieces of litter each of us may see in our regularly supervised and swept streets, but to demonstrate that the volume of unsustainable waste is pretty significant and putting it away is not the answer. As the saying goes "there is no away in throw away". In a way, we are as much inside the garbage data as we are in our Universe data, and thinking how we map it for research into scientific visualizations and simulations or to the behaviors directed by our internal simulations, both intellectual activities that require an understanding of data mapping and scientific visualization.

Resizing the Cosmos

Understanding the scaling and mapping of space and time seems to be of greater value in the planetarium setting because it is necessary to understand the scientific visualizations that are used to experience the Universe, but inverting the process to reflect on the direct experience of planet Earth can further enhance the way simulations are developed to correspond to human perception and action, and at the same time focus on what the simulations represent as to be further explored.

As previously indicated, scaling data changes context, and this is made obvious if redshift was applied at the human scale because then we would see people turning blue if they were walking towards us, and red if they were walking away. But redshift (and blueshift) require large distances and speeds to appear as phenomena in visible light.

Besides the resizing of data, there is also the issue of resolution, where aspects of a certain structure will become more apparent as resolution increases or as a certain segment of the electromagnetic spectrum is focused on and expanded such as is the case of the cosmic microwave background radiation where a couple degrees of temperature have been expanded and mapped to the whole visible spectrum in order to make structural patterns apparent.

In other words, educating planetarium show viewers about their own perceptuo-motor experience of the world is reciprocally beneficial to the understanding of cosmic data in the mapping process and the development of scientific visualizations. The mapping process for change detection is what is taught in foundation courses in art school, which takes years of education and practice to master, and ideally attains what could be described as aesthetic method. It only makes sense that formulating simulations that encode data into planetarium experiences takes this kind of expertise into account instead of misplaced notions of standards that see everything as the same contextual experience.

Change in the Universe

Inhabiting the moment as in understanding the present could be explored as a scientific-aesthetic endeavor because in a way, it is. Assessing data in the form of an experience should require an understanding of how capturing, encoding, and decoding the data works and how it relates to human perception. A common question astronomy and visualization staff were asked at the Space Visualization Laboratory (SVL) while I was there was whether what was being shown was real. An interesting realization derived from the question is what can be directly experienced and what cannot. Everything that is not directly experienced is mediated in some way, whether it is the framing of an image, motion edited over time as in video production, the transfer and focus of colors that escape visible light, and position data that may be algorithmically adjusted to present relationships that would otherwise escape the scope of patterns that human attention can grasp and follow.

In the development of content, I think it is a good idea to let the human perception of non-experts respond to scientific visualizations, backing down from the assumption that memorized absolute standards would apply to every project because reality changes across scales and perhaps often in unexpected ways. If one were to assume that bigger bodies move slower for example, some data would make no sense. For example, considering how the solid ground we stand on relates to geologic motion and in turn how the planet we are riding across the Universe relates to the motion of our Solar System or the motion of our galaxy depends on the scale being considered and the temporal and spatial scale and placement of the viewer in relation to the context: the Milky Way moves very fast at 1.3 million miles per hour yet our human scale is too small and dependent on the Earth's gravitational force to notice. Continental plates on the other hand are also moving but too slowly, significantly slower than the galaxy and the solar system where Earth is.

Conclusion

I wrote this paper because I think it is important to educate the public on how data are being converted to a planetarium experience and why. Creating data visualizations for the dome should include integrating the continuum of our direct and extended experience of the Universe. This continuum encompasses considering Earth's planetary data (i.e. planetary cycles, weather forecast and disaster alerts) even though such data may not be directly experienced because of location or spatiotemporal planetary scales. Acknowledging how the data about the many planetary events that are needed to make daily and yearly or decadal collective decisions reaches world inhabitants today can empower a range of important changes to be made. Understanding the boundaries of direct experience can help formulate data in a way that extends said direct experience consistently with the salient aspects of reality that arise in the act of extending that reality. The data presented in the dome should avoid being forced into a known average place but instead strive to be precise and formulated to connect with direct experience.

In order to connect data with the world as experienced by humans (human umwelt), a better understanding needs to be established on what it means to master perception and action in the process of extending reality in media and devices such as the planetarium dome. The dome can be understood as a spatiotemporal theater that immerses the human umwelt in multiple scales of space and timespans of time. In doing so, the notion that context changes when scale and span change needs to be emphasized and paid attention to so assumptions can be revised accordingly. Cosmic data cannot just be transferred across scales in many cases, so the process with which data are adjusted to human perception needs to be presented with the data, not only to educate viewers, but also for viewers to learn how to explore the data and be able to apply the process to their own reality, for example, regarding planetary existence.

One way to connect data to experience is through the data collection actions realized by people around the world. The Litterati app was presented as an example, because people can gather data from street trash that is quickly and regularly put away, which removes awareness and responsibility from the people that enjoy it as a mere convenience. By keeping a persistent record of this aspect of pollution to which companies without a long- term vision and most humans individually contribute, an opportunity is given to regain consciousness of the issue so we can reflect on how spatial and temporal scales relate to human scale and the impact collective and personal human actions have in the planetary environment.

Another well tried and effective way to lift the curtain under which the spatiotemporal mapping process in scientific visualizations operate is to adapt large scale phenomena to human scale, showing how reality would be if large scale phenomena, for example redshift, would change direct human scale experience. Understanding the limits of human perception has reciprocal benefits to data visualization when the mapping process is made transparent. This understanding includes notions of continuous motion that contradict immediate direct experience as much as the damage to the environment that we humans are causing which is not necessarily apparent at human scale but it is highly noticeable at the planetary level. Educating the public on scientific visualization can therefore not merely be a matter of art and science but of public planetary awareness.

References

Aguilera, J. (2019). Mindfulness and Embodiment in the Design of a Synthetic Experience (Doctoral dissertation, University of Plymouth).

Von Uexküll, J. A stroll through the worlds of animals and men, in Schiller, C. (Ed.) (1957). Instinctive behavior: The development of a modern concept. International Universities Press, Inc.

McCormick, B. H., Defanti, T. A., & Brown, M. D. (1987). Visualization in scientific computing: Report of the NSF Advisory Panel on Graphics. Image Processing and Workstations.

Fraknoi,A.,Greenstein,G.,Partridge,B.,Percy,J. (2001). An Ancient Universe: How Astronomers Know the Vast Scale of Cosmic Time. Retrieved from https://astrosociety.org/file_download/inline/948789fe-6198-4ce6-a0e0-44f85f8c2eac

The Science, Art, and Trash project (March, 2019). Retrieved from https://www.facebook.com/sciartrash

DEALING WITH DARK DOME DISCIPLINE

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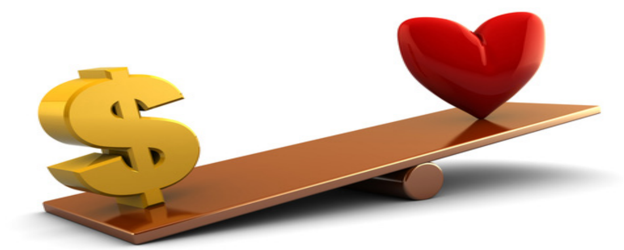
Abstract: As we observe in our domes, many adult visitors want the Planetarium experience to go further. To meet this demand, we recently offered a 5-week course called *Deep Space*. The class met for 2 hours one night a week. It sold out in a few weeks and was a nice revenue generator.

Why?

Two forces led to this creation of this adult class—love and money.



Love & Money

Love

The cosmic love story starts, surprisingly, with a surplus of kid content for our planetarium shows. Four years ago our planetarium became *free*—with purchase of museum admission. And, they made the planetarium free for anyone four and under. This programming is great in one sense—it drove attendance way up! But it led to many more families with young kids visiting the planetarium. Since museum leadership did not want limits on families visiting the Museum and Planetarium, we had to adapt our planetarium shows.

Quiet Down Planets

*Side note: This "FREE" planetarium policy also led to more people visiting the Planetarium who did NOT necessarily want to be there. This led to more phone watching and talking. This led to our **Quiet Down Planets** Public Service Announcement (PSA), the paper I presented last year at GLPA.*

Family Shows: To serve this new kid demand, our original show productions became more family oriented. We needed more content and characters to engage children ages 6-12, and be playful enough to hold the attention of kids ages 3-5.

It's About Time--MPM

Example: Our latest production ***It's About Time: Cosmic Cycles We Live By*** has two robots—Tortoise and Hare—who take the audience around the Earth and to the stars exploring time. We included a segment on Einstein's time dilation to throw an education bone to adults, but the show was mainly geared toward families with younger children.

Kid Burnout? Please know I love kids. They are amazing astro sponges. They energize you; wonderfully challenge you with their questions. Their curiosity leads to great learning and great teaching. But besides the few precocious kids, the science education is pretty basic. Most of the science ed stuff we planetarium people have taught a zillion times.

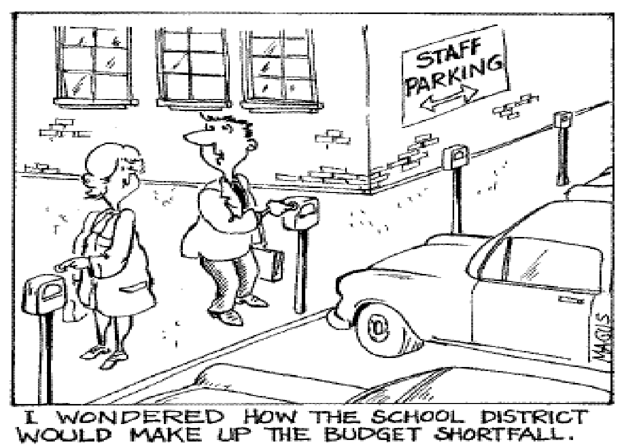
Missing Brain Matter: This "younger universe" made me miss my true astro love—***Deep Space***. Specifically, I missed researching and teaching about the bigger questions and mysteries in astronomy. The Big Bang. Black Holes. Dark Matter, Dark Energy. Plus…there are all the intricacies of the night sky that you normally don't get to teach. Things like the analemma, parallax, precession, and so on.

Digistar Planetarium

Remedy: So I started to muse about how I could incorporate some heavier astro into my day. I taught college astronomy many moons ago in Minnesota. I did a community education for adults back then too—in the old Minneapolis Planetarium. Hmmm… I kept thinking. We have a great new Digistar 6 system from Evans & Sutherland. Lots of amazing adventures are already programmed. I can explore Digistar's Cloud Library more. Plus, we have a great library for all the shows we produced here at the Soref Planetarium in Milwaukee.

A starry jigsaw puzzle was coming together. But one piece was missing---money!

Money



Budget Cartoon

We all have budgets, pretty sure on that. Ok, some of our money numbers are low. Still, we are all accountable to them. And bosses anywhere like it if your planetarium can bring in extra cash.

Price: For our Deep Space adult class, we decided to charge $135 for 5 nights on consecutive Tuesdays. (This fall we are doing it on Wednesdays.) The cost was reduced to $110 for Museum members. Class limit was set at 25 people to encourage questions and an interactive format.

Revenue: We sold out the class spring. This fall we came close. We have taken in over $5,000 for the 2 classes so far.

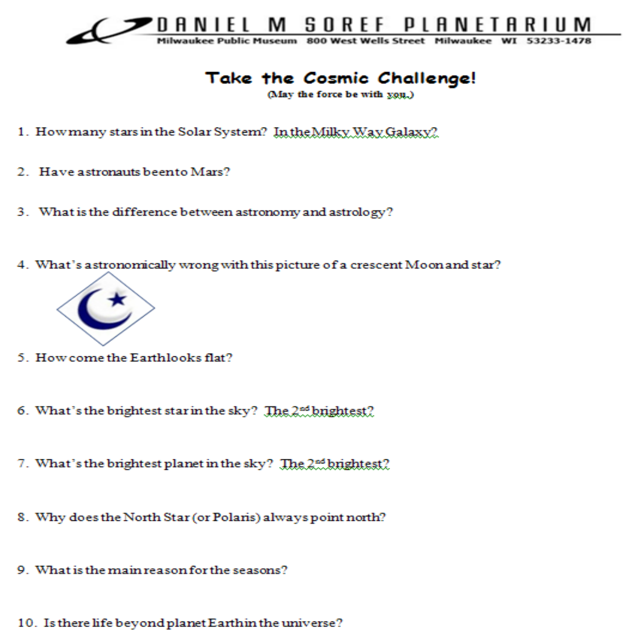
Expenses: None really, except for the lamps on the projectors. I am on salary so I get paid the same no matter what. All adults pay in full before class—so they just show up—no usher needed. My sanity took a hit—for what that's worth. I had to work a bit more, but is planetarium work really work?

Class Format

The format of the class was fairly simple. The adult students call admission and pre-pay. No refunds if they miss any class.

When: We did five consecutive Tuesdays in the spring and then five consecutive Wednesdays this fall.

Time: We went from 6:30pm to 8:15pm—with no breaks—but they could step out if they needed too. They were allowed to eat during class in case anyone was coming straight from work.


DANIEL M SOREF PLANETARIUM
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Take the Cosmic Challenge!
(May the force be with you.)

1. How many stars in the Solar System? In the Milky Way Galaxy?
2. Have astronauts been to Mars?
3. What is the difference between astronomy and astrology?
4. What's astronomically wrong with this picture of a crescent Moon and star?
5. How come the Earth looks flat?
6. What's the brightest star in the sky? The 2nd brightest?
7. What's the brightest planet in the sky? The 2nd brightest?
8. Why does the North Star (or Polaris) always point north?
9. What is the main reason for the seasons?
10. Is there life beyond planet Earth in the universe?

Cosmic Challenge Quiz

Where: We had all 5 classes in the planetarium—with the goal to use the cool full dome as much as possible. The only exception was a short quiz we did before each class.

Basic Outline: Below is the basic outline with details and suggested readings for one of the weeks.

March 5: The Changing Sky
March 12: Solar System Exploration *
March 19: Eclipses*
March 26: Stars & Galaxies
April 2: Black Holes & Cosmology
* *Optional Telescope Observing after class--if clear. Mainly just the Moon.*

March 5
Week 1: The Changing Sky
Tuesday Topic Outline
Our Place in Space http://www.eamesoffice.com/the-work/powers-of-ten/
Constellation Flight
Celestial Sphere http://stars.astro.illinois.edu/celsph.html
Southern Sky
Time & the Analemma (see enclosed pdf)
Seasons on Earth
Retrograde Motion https://earthsky.org/space/what-is-retrograde-motion
Stellar Parallax & Aberration (see enclosed pdf)
Moon Phases
Week 2 Preview: The Solar System

Summary

A little more work—but for love. And a little more money always helps!

RISK IT!

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Abstract: What is holding you back from the adventure of a lifetime? You simply can't be a shy homebody and also be a planetarian can you? Too busy? Just can't get organized? Come listen to my offers and be motivated to get it together and take the risk!

Are you insatiably curious about the world and its inhabitants and interested in developing professionally? Are you looking for a way to enhance your programs, for an easy and fun way to learn some new techniques, make new friends, and become a true citizen of the world? Please do not let your busy schedule, fears, and shyness deprive you of these opportunities!

Let's start small. Do you know how to make a short mp3 audio file? No? Well then, knowing how to do this can open some interesting doors for you. So you can just Google how to do it:

Find the built-in microphone, if your system has one, or attach a microphone to your computer.

Open the Sound Recorder

Record your message.

Save the file as a WAV file.

Convert the file to MP3. If you don't have a converter program on your PC, look for a program of this type on: https://download.cnet.com.

Now, why would you want to make an mp3 file? So that you can be a part of an international project called **"Voices From the Dome"** which is promoted by Serafino Zani Astronomical Observatory, and is on line on the IPS website (www.ips-planetarium.org/?voices).

This project is designed to create a database of planetarians' voices. Every planetarian can contribute to this copyright-free digital archive. Currently the audio database includes recordings in several languages: German, Greek, English, French, Italian, Polish, Spanish and Russian. Planetarians from different countries are invited to collaborate in the project in English and also in other languages.

These audio files can be used in a live planetarium show in the dome or during a lesson with students that learn English or other languages. It is very easy to send a new audio file (mp3 format) about any subject that could be useful under the star sky of the planetarium, even memories about how you became interested astronomy or in becoming a planetarian.

Another reason to learn to make mp3 files is to participate in IPS Contests:

"Pages of Stars" is a competition, organized by IPS in collaboration with Serafino Zani Astronomical Observatory, that was designed to build another collection of short audio clips that can easily be shared among planetarians. Each March, on the weekend of the International Day of Planetariums, the winner(s) are published in the IPS journal and receive an award certificate. The winners' audio and texts are published and made available on the IPS site under Resources and Free Media. Web page: https://www.ips-planetarium.org/page/audio

The 2019 winner is *Mark Percy* (Clarence, New York, USA) for 18 audio recordings from "Skylore from Planet Earth: stories from around the world…ORION. The written text is by Dayle L. Brown and the narration by Paula McGirr. Marco Avalos Dittel (Planetario Aventura, San José, Costa Rica) received an honorable mention for a "Script for an astronomy program ending." The script conveys a sense of awe and wonder while giving the audience a challenge to make consequential decisions as citizens of Universe.

“American in Italy” Are you brave enough to travel to a foreign land and work with students and colleagues doing what you love—sharing science and astronomy? Well *Chrysta Ghent* from the Jennifer Chalsty Planetarium, Jersey City, New Jersey was! Chrysta was the 2019 winner of a “Two weeks in Italy” contest which is organized by IPS in collaboration with the astronomical facilities of Brescia and Lumezzane (Serafino Zani Astronomical Observatory), “StarLight… a handy planetarium” association (Perugia) and the Astronomical Center of Farra d’Isonzo (Gorizia)! Students and the public from the cities of Perugia, Spoleto, Assisi, Brescia, Lumezzane and Gorizia participated in conferences and lessons that involved Chrysta as lecturer. Chrysta taught about the Solar system, the Moon, Native American star stories and Italian astronomers, and in Assisi she held a workshop for teachers about “New ideas to teach the Moon”. The two weeks traveling and teaching in Italy will inspire Chrysta to share all that she has learned with her audience at the Liberty Science Center.

In her final report Chrysta wrote, “Over 10 days, I taught around 830 high school students in addition to K-12 teachers and members of the public. I also met over 10 new astronomer contacts and friends.”

Each winner of this competition returns home with new and unique perspectives. Chrysta told us her ‘take-homes’, “One key theme I noticed all through my trip to Italy was how present history and culture is. Walking through each city was like a trip back in time, going through Roman ruins and amazingly well-preserved castles and churches. Astronomy was also present everywhere. In Gorizia, we toured a small town called Aiello Del Friuli that has sundials on every wall and open ground available. One of the members of the astronomy group started a trend in his town in the 1970s by building different kinds of sundials and placing them in public venues. His work has been enhanced by visitors from all over the world who have contributed their sundials.” (Chrysta Ghent email: cghent@lsc.org)

Here is the list of all 21 winners; I am sure you will recognize some of your colleagues: Susan Reynolds Button (OCM BOCES Planetarium, Syracuse, New York); Jeanne E. Bishop (Westlake School Planetarium, Ohio); Jerry Vinski (Planetarium of the Raritan Valley Community College, New Jersey); Dee Wanger (Discovery Center Science Museum, Fort Collins, Colorado); April Whitt (Fernbank Science Center, Atlanta, Georgia); Raymond Shubinski (East Kentucky Center for Science, Mathematics & Technology); Andrea Lee Pisacano (Kauai Children’s Discovery Museum, Hawaii); Dayle Brown (Pegasus Production, Indiana, USA); John T. Meader (Northern Stars Planetarium, Fairfield, Maine); Corey Radman (Discovery Center Science Museum, Fort Collins, Colorado), Carolyn R. Kaichi (Bishop Museum, Honolulu, Hawaii); Michele Wistisen (Casper Planetarium, Casper, Wyoming); Joseph E. Ciotti (Hokulani Imaginarium, Kaneohe, Hawaii); Stephen R. McNeil (Brigham Young University, Idaho Planetarium, Rexburg, Idaho); Patricia Toth Seaton (Howard B. Owens Science Center, Lanham-Seabrook, Maryland); Dave Weinrich (Planetarium, Minnesota State University, Moorhead, Minnesota); ShiAnne Kattner (Casper Planetarium, Casper, Wyoming); Stephen Case (Strickler Planetarium, Olivet Nazarene University, Bourbonnais, Illinois); Shawn Laatsch (Emera Astronomy Center, Orono, Maine); Kevin Milani (Hibbing Community College, Hibbing, Minnesota); Chrysta Ghent (Jennifer Chalsty Planetarium, Jersey City, New Jersey, USA). PlanIt invites IPS Affiliates to organize similar initiatives.

Andy Kreyche is this year’s winner of the “American in Italy” competition. Andy is enthusiastic educator with over 20 years of engagement in astronomy outreach as planetarium presenter in California at the Fujitsu Planetarium, DeAnza College in Cupertino and Hartnell College planetarium in Salinas and through his own business, Dome on the Go, which he started in 2015. Currently he produces and presents programs to preschool through college students, scout troops, private parties, adult education students, autistic and developmentally disabled children, deaf students, the mentally ill, gang prevention programs, senior citizens, English learners, and the general public in and around Santa Cruz, CA.

You are also probably familiar with Andy as a two-time winner in the IPS “Pages of Stars” contest. https://www.ips-planetarium.org/page/pagesofstars

Andy is excited to be travelling to Italy in April 2020 where he will share his creative use of interactive techniques while providing planetarium experiences to the students, public and the Italian planetarium community. In exchange he will learn from the excellent work of his three hosts: Loris Ramponi (Brescia and Lumezzane), Simonetta Ercoli (Perugia and Assisi), and Luciano Bittesini (Gorizia).

We are accepting applications for next year’s competition up until 31 December 2020. For application information go to https://www.ips-planetarium.org/page/italy

A Week in the United States
IPS Professional Development initiative

“Week in the US” Are you adventurous enough to invite a colleague from another land to visit your planetarium? The “Week in the United States” competition winners are high caliber planetarians who are anxious to share what they know and to learn from you.

After hosting this year, Michele Wistisen wrote: “If you want to have a great collaborative experience you should apply to host a planetarium colleague from another country. This experience exceeds any planetarium conference I’ve been to. Through hosting you are able to share and glean ideas that you may not have time to at a conference. When you host, it really is a two way sharing opportunity.”

This year the Casper Planetarium had the opportunity to host Dr. Guilhereme Marranghello from Brazil. Michele explained, “We chose to host him because we were interested in his presentation about the indigenous stories of the southern skies. Guilhereme not only brought his stories, he also shared his culture with us. The staff of the Casper Planetarium appreciated hearing how Guilhereme teaches in the dome and in the classroom. Beyond the educational exchange, we will be adopting his ideas about promoting our planetarium.

"I enjoyed sharing American and Wyoming culture with him. He now has experience with Apple pie a la mode, snow in April, buffaloes, and the Tenzi dice game.

"My text does not begin to describe what a wonderful opportunity it is. When you host, you learn and share on multiple levels. But beyond that, my staff, teachers from my district, my family and many others now consider Guilherme as their friend and colleague."

Michele enjoys hosting so much that this is the second time she has hosted and she is open to hosting every year if no one else applies!

Dr. Guilherme Frederico Marranghello, shared, "Although it was a wonderful experience from where I had learnt a lot and that I'll keep in mind, trying to implement some of them, meeting people, sharing cultures, making our world smaller is always the best experience. When I arrived, Michele hosted me at her house, where I met Cordell and their grandchildren, Duncan and Summer. We had some family meetings, dinners and anniversaries. They drove me to Jackson Hole to show me the Tetons, Moose, Elks, Coyotes and Mountain Goats. More than that, they let me get inside their family, learning about their way of life, their culture."

Jordan Turner, co-host, shared "It was great having Guilherme visit us here at the University of Wyoming! It was a very unique opportunity to have someone from another planetarium, let alone someone from another country, see what we do here and learn what they do at their planetarium. We learned a lot from Guilherme—not just little individual things but also big picture ideas to make our planetarium better at educating and entertaining its patrons. I really hope Guilherme learned at least one thing from us because we definitely learned a lot from him! It was also wonderful for us to be able to host Guilherme's Brazilian Indigenous Constellations shows so that the citizens of Laramie could experience it. A number of Jr. High school groups also got to see his show where they definitely learned about a culture they would never hear about otherwise. Guilherme's visit also allowed for me to visit the Gates Planetarium at the Denver Museum of Nature & Science. I think Guilherme and I both gained a lot from that visit! It was great to exchange ideas with others that are so passionate about not just planetariums, but education and promoting science! Thank you to the Casper Planetarium for setting up this visit for us!"

A second winner, Ruth Grützbauch from Austria, was hosted by John Meader in Maine this Fall; their reports will be published in the March issue of the IPS *Planetarian*.

Another past host is Derek Demeter; he hosted a team from Germany. Derek has also said that it is so exciting and worthwhile to host a colleague for the Week in the US that he is very happy to host again if no one else is excited to do it!

For more information about the program and what is involved in hosting, go to https://www.ips-planetarium.org/page/WeekinUS.

"Week With the GDP" Matthias Rode, Derek Demeter, and Tilo Hohenschlaeger at the Emil Buehler Planetarium at Seminole State College. Demeter hosted Matthias and Tilo in 2017 for the first year of the *A Week in the United States* exchange. In turn, Matthias and Tilo hosted Derek in 2019 in Germany, a trial run before officially inaugurating the *Week with the GDP* program. The Society of German-Speaking (GDP) is an IPS affiliate and its members are from Germany, Austria, and Switzerland.

The GDP invites colleagues from around the world to join them for a week of professional development and cultural exchange for *A Week With the GDP*. A planetarium in Germany, Austria, or Switzerland will host a planetarium colleague from another country for the week, which will be arranged to best fit the schedules of the winner and the host facility. Applications for the 2020 competition are being accepted between now and 31 December.

The 2020 host will be Tim Florian Horn, president at Stiftung Planetarium, in Berlin.

https://www.ips-planetarium.org/page/Weekwithgdp

Conclusion

Now, don't you want to get out of your comfort zone and participate in one or more of these initiatives? Come on, RISK IT!

It only takes a few minutes to record and mp3 file for "Voices from the Dome" and you may even want to use some of the files in your programs.

It takes a little more effort to apply to go to Italy or a GDP country but it is SO worth it!

And finally, it just got even easier to host for the Week in the US! MAPS, GLPA, and SEPA have all approved mini grants to provide $500 to a member who wishes to host a "Week in the US" winner. This same idea is also being explored by all of the other regional organizations. So now, if you want to host and you are a member of one of these the regions, you can apply for one of these grants by going to your region's website to find the application requirements!

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APOLLO 50 CELEBRATION: BEYOND NOSTALGIA

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Abstract: The UWM Planetarium collaborated with units across campus to make the historic Apollo landing anniversary relevant today. I will discuss lessons learned from an effort to make the celebration of the 50th anniversary of Apollo 11 engaging and timely for all audiences.

Most university students, indeed even their parents, do not remember the Apollo 11 landing or fully grasp the magnitude of the achievement today. I wanted to plan event(s) that would both reignite the awe for the people who lived that historic moment and give context to those who did not experience it so they could appreciate the accomplishment.

Start early

My student staff and I started thinking about how to celebrate Apollo 11 over a year in advance. Not only did we want a special event on the day, we wanted several smaller events leading up to it.

Become an expert

I was advised to write an article for The Conversation, an online journal with short articles written by experts. The article "Spacecraft technology: The early years" by Mark Williamson helped me bridge the significant gaps in my understanding of rocketry and of how significant the impact of the space race was both in our building more nimble electronics and how it changed the way we see the Earth itself. It was thrilling to see my article (http://theconversation.com/5-moon-landing-innovations-that-changed-life-on-earth-102700) picked up by newspapers and TV stations across the nation and world. The Conversation estimated that over 900,000 people saw the article. Although writing the article involved a lot of editing and fact checking, it was well worth the effort!

Invite others to shine together

We engaged several entities on campus who might have a historical interest or current involvement in space exploration, casting our net widely from the Robotics Club to the College of Freshwater Sciences. Not all of our ideas came to fruition, but we scheduled programs nearly every month leading up to the big day and even extended programs into October. All experts are UWM employees unless otherwise noted.

"*The Moon Rocks*!", a presentation by planetary geoscientist, Dr. Lindsay McHenry, included pictures of different types of lunar rock. Lindsay showed pictures of beautiful volcanic glass in the lunar soil that cooled in spheres since there is no atmosphere to give the aerodynamic shapes that we see in the glass near volcanoes on Earth.

We saw an entirely different moon, Titan, from the viewpoint of a chemist, Dr. Joseph Aldstadt. In "*Exploring other moons: The amazing atmosphere of Titan*", he explained how scientsts designed the Huygens probe for landing on Titan, given what people knew about its complex hydrocarbon chemistry.

"*Imagining the Moon: A History of Lunar Visualizations*" was a discussion of selenography from the 1600s to the 1960s based on the collection of lunar maps, globes, atlases, and photos at the American Geographical Society Library. The curator, Marcy Bidney, highlighted many artifacts, including the first drawing in modern times by Michal Van Langren (1645) and the first photo of the Moon (1863) by Henry Draper.

"*Getting to the Moon: The greatest engineering adventure ever undertaken*" was not an exaggeration. Dr. Nathan Salowitz described the challenges of developing a flight plan given the complications involved in designing spacecraft that could keep people alive getting to and from the Moon. The research done during these missions has advanced many subfields including timekeeping, rocket propulsion, lunar geology, and human physiology. Salowitz connected the past with the future by describing his own research in self-healing metals, alloys that repair themselves when introduced to heat.

Also speaking about her research was Dr. Janis Eells, who works in Health Sciences. In "*Unblinded by the light*" she discussed how the fact that astronauts' wounds healed faster when exposed to infrared light encouraged research on photobiomodulation, or how light changes chemical processes. One of the applications was that red-light therapy can treat eye diseases on Earth such as macular degeneration.

This form of light-therapy is a postcard child for NASA's Office of Small Business Programs, as was discussed by Lynn Garrison, a small business technical advisor at NASA. In "*How space exploration impacts our life on Earth,*" Lynn mentioned how 1,800 products developed for space had other applications since 1976, including flame retardant fiber and devices that mitigate wind vibration in tall buildings.

In "*Challenges for low-cost space exploration*," Dr. Rani El Hajjar described how the ability of humans becoming a multiplanetary species hinges on the ability to reduce the cost of access to space. To that end, El Hajjar's team is developing suitable high-performance metals for 3D printing, which reduces the cost of labor, production time, and footprint by roughly a factor of 10.

For some fun and outreach, I was guest speaker on a "*Full Moon Canoe*" program hosted by the Urban Ecology Center. Participants enjoyed the full Moon while canoeing down the Milwaukee River as I described our nearest celestial neighbor and other exotic moons in the solar system.

As guest speaker at the event "*Under One Moon*," featuring a 23-foot inflatable art installation of the lunar surface, I told stories about how the Moon played a role in my personal and professional life. I sang a Greek song that talked about Selene and talked about the "Transylvania effect" or the notion that the full Moon somehow affects people's behavior.

I was lucky to find Dr. Thomas Haigh, a history expert with scholarship in the history of computers. In "*Moonshots then and now: why Google isn't NASA*," he posited that Google has misappropriated "moonshot" for projects hundreds of times less ambitious than the Apollo program and has been following an entirely different model of innovation from NASA that is profit driven and incremental.

Another lucky find was Dr. Roshanna Sylvester or the University of Colorado Boulder. The UWM History Department co-sponsored her entertaining and enlightening historical tour of Soviet and American childhood from Sputnik to Apollo called "*Space Crazy! Kids' letters to astronauts in the early space age*." Kids' perspectives came to life through their letters to the pioneering spacefarers Yuri Gagarin, John Glenn, and Valentina Tereshkova.

The apotheosis

On the actual anniversary of the Apollo 11 landing, we threw a "Lunar Party" to acknowledge the event and capture a summer vibe. More than 500 space enthusiasts attended and people of all ages enjoyed Purple Moon ice cream, had their faces painted, enjoyed lunar displays and a virtual reality experience, took selfies with a replica astronaut, and attended stargazing shows in the planetarium. We offered three different talks about the past, present, and future of lunar exploration; the difficulties of landing on the Moon; and space-exploration challenges that led to solutions on Earth.

Over 900 people attended one or more of this yearlong series of events that we called Apollo 50 and which we hope (re-)ignited interest in space exploration and built bridges with other units on campus for future collaborations.

Do and don'ts

- Cast your net wide—you never know who will respond.
- Be open-minded: encourage your potential partners to think broadly about what a joint project might look like.
- Be prepared for changes and have backup plans. You have to ask for commitments far in advance but reconfirm closer to the time.
- Offer programs that speak to a variety of audiences by changing times/dates and themes.

READ UNDER THE STARS

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Abstract: The Michigan Science Center teamed up with Detroit Public Television to present a program called "Read Under the Stars" with some help from SuperWhy, of course. This paper outlines the science behind the program and how we can work together to get early learners excited about science and literacy.

Detroit, along with other big cities, struggles with literacy. Only 4% of Detroit Public School Community District (DPSCD) 4th grade students are at or above 4th grade reading level. This makes them ranked lowest in the nation according to the National Assessment of Educational Progress. DPSCD is the largest school district in the state of Michigan with approximately 50,000 students.

The Michigan Science Center works with DPSCD on a number of projects, including a program that we call Sponsors of Science, where title 1 schools can come to the science center for free. This program is sponsored by several of our donors. We also partner with DPSCD with the Cultural Passport Program that allows all DPSCD 1st graders to come to the science center on a field trip and go to the planetarium. We are currently partnering with DPSCD 9th graders for an energy focused program that pairs with their curriculum. Lastly, we partner with DPSCD during their "Back to School" event at the end of August.

One of the biggest issues with partnering with DPSCD to deliver science programming is trying to get kids to read or write during those programs. Because reading proficiency in Detroit is so low, we keep everything to a basic reading level and try not to make students write anything during our programs. This is to ensure that everyone has equal footing learning science because of the statistics. This also limits what we are able to do with the students. It is very important for our students to be able to read and write, especially as they pursue careers in STEM.

The Michigan Science Center has started doing programming in our 5 and under space called Young Explorers. This programming focuses on literacy and science, bringing the two together for our early learners. Every other week, we focus on a letter in the alphabet and talk about a scientific concept that goes along with that letter. For example, one week in October was focused on D for Density. We explored the concept of density as well as focusing on the letter D in all of its glory. We also read a book to go along with the scientific concept.

Detroit Public Television has a very robust literacy program focused on early learners. The Michigan Science Center was approached to help present a program in the Planetarium called "Read Under the Stars." When they approached us to help with the program, we were very eager to participate. In this program, we read a book and then turned out the lights and looked up into the night time sky to talk about some of the things we saw in the story book. The program lasted about 35 minutes. After we concluded the program, Super Why came in to greet all of our early learners. He explored the museum with our guests and everyone had a great time.

We hope to partner with Detroit Public Television again in the future to do more programming along these lines. This was a very successful event that fit right into our current programming that we do here at the Michigan Science Center.

THE FUTURE OF DIVERSITY AND INCLUSION IN THE PLANETARIUM WORLD AND WHY IT IS IMPORTANT

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Abstract: This paper will discuss current demographics of the planetarium community and how we can change the landscape. It will also discuss why diversity and inclusion is important in our community.

As we have been discovering, the planetarium community has been struggling with diversity for a number of years. According to a study done last year by Shannon Schmoll, it was reported that 91% of planetarians identified as White/Non-Hispanic and 60% of our colleagues were male and 40%, female. Lastly, 13% identified as part of the LGBTQIA+ community. Analyzing this, it could mean a number of things. One of the things that we would like to dive deeper into is how implicit bias can affect these numbers that we see.

Implicit Bias is the attitudes or stereotypes that affect our understanding, actions, and decisions in an unconscious manner. Folks might be unintentionally making decisions in hiring based on prior knowledge and experiences. We encounter this often enough in the education community when we encounter prior knowledge that needs to be steered slightly. For example. You may encounter a curious mind in your planetarium that thinks there are only three states of matter. Because of their prior knowledge, you may have to change the lesson to include the fourth state of matter before you talk about how the Sun is actually a miasma of incandescent plasma.

Implicit bias extends beyond race, gender, and sexual orientation. It also extends to age, socio-economic status, religion, political affiliation, educational background, and the list goes on. Implicit bias in the workplace is something people have to work to be aware of. If you notice that all of the people that are hired at your institution look a certain way and have a similar background, there might be systematic implicit bias in your hiring process.

If you look at the pool of candidates applying to your institution, is it a diverse pool of candidates or are all of your candidates very similar? You may think that this is working well for you because similar applicants mean that you have staff that all think alike and, therefore, get along. This might be a wonderful thing, but diverse ideas make for a better workforce and, therefore, a better experience for your guests. For example, someone who grew up in an upper middle-class home might not be able to relate to inner-city kids that come into your institution. A straight, middle aged, white male may not be able to understand why the non-gendered trans child doesn't want to pursue science because they don't want yet another thing to be bullied about. Having a diverse staff allows people to better understand the communities that they reflect.

Where are you posting your jobs? If you are only posting on the Planetarium forums, or in the local newspaper, you will only get applicants that read those. The Michigan Science Center posts our jobs on Indeed, but also at our local universities and through cultural news organizations, such as the Dearborn Press and Guide.

This also goes for a diverse background or education. The planetarium community has gotten much better about not only hiring astronomers, but there is still bias and perception out there that you cannot work in a planetarium unless you are an astronomer. Hiring artists, teachers, and actors can improve the shows that we are showing to our guests, especially the ones that are "science curious".

The Michigan Science Center has worked to remove some of the more biased language from our job descriptions. For example, instead of saying "Knowledgeable in Science, Technology, Engineering, and/or Math" our job description says "Knowledgeable OR Curious about Science, Technology, Engineering, and/or Math." The change to add "curious" has allowed us to hire folks that might not have a background in the information that we are teaching, but they have a curiosity to learn.

Is the pool of candidates fairly diverse, but you are still seeing very similar staff get hired? There is something out there called Name Bias. When you look at someone's name, you might think that they may or may not be a good fit. A good way to work around this is to not look at the name until you have fully reviewed the resume. This practice allows you to make a decision on the candidate by their skills and past alone.

There can also be a bias about someone's education. For example, if you have two different candidates, one has a Masters but not very much experience and the other only has a bachelors but has a ton of experience, most hiring managers would pick the Masters. This is something else to think about when writing a job description. Do they really need the degree, or do they need the experience?

Under federal law, employers cannot discriminate on the basis of race, color, national origin, religion, sex, age, or disability. There is a difference between a legal environment and an environment where people can thrive. Allowing staff to feel ownership and giving them the ability to grow in their environment is incredibly important, and sometimes, opportunities might be given to some, but not others completely unconsciously.

We feel like the Michigan Science Center does a good job of making sure that we have a diverse staff that can thrive in their environment. Below are two case studies from floor education staff.

Case Study 1: Raul Orozco, STE(A)M Activator at the Michigan Science Center—My ties to the Michigan Science Center started when I was a very young patron exploring the halls of our museum. My most vivid and inspirational memory was watching one of the many planetarium shows offered at the time and thinking, "this is exhilarating, I wonder how one gets to work in such an exciting field?". I have worked here for several years now and as a kid growing up in Southwest Detroit, I would not have imagined that someone like me would have had the opportunity to work as both a planetarian and as an educator. People like me, a first generation son of Mexican immigrants who attended Detroit Public Schools for the entirety of their k-12 career are not usually known for wanting to pursue a career as a planetarian; much of it is not because of a lack of willingness to get into the field, but because the opportunity is not known, encouraged, or well-funded.

At the Michigan Science Center, our goals are to spark an interest in STE(A)M, to be a neighbor, and to be a hub where the public can come to get their information. As planetarians looking to hire and inspire in low-income urban communities, these goals set a clear precedent as to who we are, how inclusive we are, and what kind of lasting impact we want to make in our communities. Museum culture and astronomy culture in general are usually aimed at the more affluent, classically educated members of society. When we think about those with lower social-economic backgrounds, we usually encounter social environments where children know their society is investing less in them, ergo, many fall into a self-fulfilling prophecy where they live up only to the bare, so-called realistic standards that they have been taught to embrace because they have learned to settle for less and subsequently trick themselves into believing that they are not good enough. For the vast majority, even attending college is a dream, a privilege- not the societal expectation and a human right. Cognitive and Educational theory have shown us that a child living in an enriching, educational environment is more set to succeed than a child who has the bare minimum and who grows up in an environment where educational themes are not easily expressed or readily available.

How do we in the planetarian community even begin to chip away at such a complicated problem? First and foremost, we must actively seek these communities out. We must make our presence known as not just an entertaining location, but as a neighbor that has their best interests in mind. The Michigan Science Center excels at this with our cultural passport program. We provide all Detroit Public Schools with a free field trip that features a planetarium show. Currently, our program serves inner-city students in grade 1; an age where they are young enough to be inspired by what our message is and old enough for them to start to think about possible career paths.

During my time as a planetarian, I have been able to be a valuable asset to my company because of my diverse background. As an inner-city Detroiter, I grew up and understand the culture of the incoming visitors. This commands attention and helps me come across to them as more genuine because they do not view me as an outsider, but as a person who has been on the same path they currently walk; suddenly, the path toward a career in STE(A)M doesn't seem as unreachable and intimidating.

As a Latino I have been able to increase the inclusivity at the Michigan Science Center not solely because of the color of my skin, but because of my fluency in the Spanish language, both formal and informal. There has been many a time where we get general admission visitors and full schools of students who can only speak Spanish (Detroit, especially Southwest, has a high concentration of people from all over Latin and Central America). I have been able to accommodate them and do full planetarium shows in Spanish—a precious activity that they would have missed out on if the option was not available.

Another effective method of seeking out these communities has been through our outreach program's traveling planetarium. Through this program, we have been able to not just share the mysteries of the cosmos with our students, but we can more deliberately enter their environments and challenge their beliefs as to what a scientist looks like, in both communities of lower socioeconomic statuses and in more affluent communities, which tend to be more Caucasian. I've been able to challenge racial and gender biases sometimes simply through how I look. Many teachers and students don't expect a long-haired Mexican-American man to show up to teach them. It's been really surprising to me that in 2019, a lot of adults and students hold the bias that "long hair is just for girls", "that science is just for boys", or that they are not smart enough to be interested in, invested in, or employed in the STE(A)M field—beliefs that I love to debunk in a compassionate manner. When introducing such themes to students at an early age, we normalize the fact that diversity is good, it's ok to be yourself, and that everyone can be involved in STE(A)M in more than one way. By working together as planetarians to embrace diversity in race, language, religion, gender, class, educational backgrounds, and experience we can have a stronger, more inclusive workplace, a greater impact on our local communities and ultimately society in general.

Case Study 2: Julia Marsh, STE(A)M Activator at the Michigan Science Center—I've had a hard time figuring out what to do with my life. I have produced plays that have had successful runs and won multiple awards. I've worked my way up from a janitor to an HR manager, all without a degree. All while being afraid of simple, unaided arithmetic. I went from living on the streets of Detroit, a homeless nineteen-year-old, to a twenty-two-year-old hiring electrical engineers. Because there was something I could do that those engineers could not; I could take their experience and translate it into something a hiring manager could use. I had a good understanding of people, it's what makes me a good comedian. I've worn so many hats: customer service, comedy, improv, theater, beauty school dropout, amateur astronomer, trainer, volunteer. I have been an amateur astronomer my whole life, teaching myself relativity on coffee breaks while attending cosmetology school. I dropped out of beauty school to learn more about science. I did stand-up comedy while working as an HR manager and taking math classes at a community college, conquering a long-held fear of mathematics. I found I was good at communicating scientific ideas to other people. I discovered that people feel foolish because they don't understand a concept that has taken humanity thousands of years to understand. I was able to get people to look at science through a lens of common sense. Still, I didn't have a degree. I wanted one. My counselors suggested I get a degree in theater since it was a field I was already working in. I wanted to be a science teacher. I wanted to connect with people on stage. I wanted to learn the deeper concepts of physics and astronomy so I could translate those ideas to the public. It never once crossed my mind that I could do all three at once.

At the Michigan Science Center, I have found a talent for getting people to understand complex ideas intuitively. Because I have struggled over a lifetime to understand these ideas, I know what it's like to struggle. I once explained our Foucault pendulum to an electrical engineer's wife. He had tried, multiple times, to explain it to her and she was about ready to throw the pendulum at his head. I came in and worked with her until her eyes lit up with wonder. She understood what she was looking at. Her husband could not believe it. "But I'm an electrical engineer," he protested. "Well," I said, "I'm an actor." It's this background as an actor that has allowed me to make our shows more engaging. I have used my writing and production experience to improve our Sparks Electricity show, as well as our Global Soundscapes show. I also strive to make sure my information is correct because I have that desire to learn myself. I have become more than I ever thought I could be at the Science Center. I am more than the sum of my parts here. I am a gateway for people to understand themselves, each other, and the cosmos.

BEYOND THE MOBILE SCIENCE THEATER WITH INTENSE 2.0: ENGAGING THE STUDENTS OF BERLIN WITH BEGABUNGFÖRDERUNG

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Abstract: Since 14 July 2018 the INTENSE program at the *Stiftung Planetarium Berlin* (*SPB*—the Foundation of Berlin Planetariums) has been funded by the Senate Administration for Education, Youth, and Families in Berlin. The program brings our Mobile Science Theater to schools within Berlin that cannot commute to one of our permanent planetariums. The program, however, is more than a typical mobile planetarium. This paper shares how INTENSE engages students, provides teacher development, and advances students who fall under the category of Begabungförderung (development interested and/or talented in STEM subjects), as well as lessons learned as the program continues to grow.

Introduction

The INTENSE program at the Stiftung Planetarium Berlin (SPB—The Foundation of Berlin Planetariums) is just a little over three years old now and has gone through a few phases, but each iteration has always served the people, and especially the students of Berlin. INTENSE is the SPB's mobile Wissenschaftstheater (Mobile Science Theater), which goes to schools within Berlin that cannot make it out to one of the city's three permanent planetariums. The program, however, is more than a typical mobile planetarium program. This paper will explain what the Stiftung Planetarium Berlin is, why Berlin has so many planetariums, including a mobile science theater, and how students, teachers, and festival goers in Berlin benefit from INTENSE. The paper will also explore how the program has grown from version 1.0 to 2.0 to what the future might hold for INTENSE 3.0 in 2020, and how the lessons learned can be applied to other organizations.

What is the Stiftung Planetarium Berlin?

The Stiftung Planetarium Berlin was founded in 2016 to bring together the three permanent planetariums and two observatories and the mobile planetarium of Berlin so they could share resources instead of competing. Berlin is a unique city with a complicated history. Due to the division of Germany into East and West after World War II, Berlin also became a split city of East and West, with the famed Berlin Wall separating the two halves of the city. Due to the division, the city often has at least two of most major facilities (*e.g.* Opera Houses, American Embassy Buildings, Zoos, and yes, even Planetariums and Observatories).

Before World War II, the city had one planetarium near the zoo, but it was destroyed in the bombing of Berlin. The Berlin observatory, Archenhold Sternwarte (ASTW), opened in 1896, and survived the war unscathed. With the division of the city, neither East nor West had a planetarium, and ASTW was in the Eastern Bloc and not easily accessible to those from the West. In 1957, the ASTW further boasted the very first Zeiss-Kleinplanetarium in East Germany, under an 8-meter dome. Meanwhile, in West Berlin, much of the rubble from the war was used to make an artificial hill, known as the Insulaner (island). It was here that the Wilhelm-Foerster-Sternwarte (WFS), an observatory for the West, was built. Not long after WFS was established, the campus was expanded by building the Planetarium am Insulaner (PAI), which opened in 1965 with a 20-meter dome. Finally, in the 1980s, the head of East Germany, Erich Honecker, decided that the capital of the German Democratic Republic (GDR) needed to be able to boast the largest and most technologically advanced planetarium. The Zeiss-Großplanetarium opened in 1987 with a 23-meter dome, as well as a 160-seat movie theater.

Fig. 1: One of the logos of the Stiftung Planetarium Berlin. ©SPB

After the fall of the wall in 1989 and the reunification of Germany in 1990, Berlin wasn't sure what to do with three planetariums and two observatories. The administrations of the different sites changed hands several times, and there was always a looming concern that one of more of the sites would be permanently closed. After negotiating an agreement with all three sites, as well as the senate, all the sites came together as one combined entity. The SPB now shares all resources, creating a better experience for the citizens and visitors of Berlin.

There is one Berlin planetarium, however, that has been left out of this story so far, and that is because it is the newest, coming into existence only shortly after the founding of SPB: the mobile science theater, or mobile planetarium, INTENSE.

What is INTENSE?

In late 2016, a project by the official name of INTENSE—Immersive Darstellung von Technik und Naturwissenschaft im mobilen Wissenschaftstheater (immersive demonstration of technical and natural science in a mobile science theater)—was created and funded. Although it may seem like an acronym, the name INTENSE comes from a pun that everything with the program would be done "in tents" which sounds like "intense." While the name may have been born out of a play-on-words, the project does serious but fun work. The INTENSE dome goes to schools and fairs to work with students and visitors to open the universe of science, especially space science, to them.

INTENSE 1.0

INTENSE was launched with the financial help of the Industrie- und Handelskammer zu Berlin (IHK Berlin—the Chamber of Commerce and Industry of Berlin). The project ran from October 15, 2016 to July 14, 2018 with the aim of inspiring 7th grade and older students in Berlin in science and technology and giving them a career orientation in these areas. For this purpose, the SPB purchased a 30-person digital mobile planetarium. Two planetarium programs were specially developed for INTENSE, „Forschen im Kosmos" (*Research in the Cosmos*) and „Energie und Umwelt" (*Energy and the Environment*). Through the live presentation of the programs, the students were engaged both linguistically and technically, and the moderators were able to interact and answer their questions—this often led to a longer dialogue between the moderator and school class.

Fig. 2: A class enjoys learning about the universe inside the dome during INTENSE 1.0. © SPB/F.M. Arndt

In „Forschen im Kosmos" the starry sky in the planetarium forms the starting point for current events in space exploration and research. State-of-the-art space probes investigate the celestial bodies of our Solar System and shed light on the cosmic origins, before moving on to newly discovered phenomena and curiosities that shape the image of our own planet. Of course, with the fulldome digital system, we can travel through our Solar System, and journey to the limits of our universe. The program ends with a visit to the International Space Station (ISS). The weightlessness laboratory at 400 km altitude is a prime example of international cooperation and research. By virtually boarding the ISS, students can gain insights into the working world of astronauts and cosmonauts. Due to the modular structure of the programs, both a basic course and a longer, more specialized course can be offered, depending on what experience teachers want for their students.

The starting points for „Energie und Umwelt" are questions of everyday life: Every student knows that electricity comes out of the electrical socket, but how does it get there? It is about the concept of energy, about the different forms of energy and the possible transformations of one form of energy into another. Subsequently, Earth's radiation budget is examined in more detail. Where does Earth's energy come from? How does the Earth manage to create life-friendly temperature conditions? In addition, the natural and anthropogenic greenhouse effect is explained. To really drive home the concept, a comparison between the climates of Mars and Venus of our planet Earth is shown and the consequences of manmade climate change are discussed. The structure of terrestrial planets and the characteristics of plate tectonics are also discussed during this show. At the close of the show, different power plants for renewable energy are examined. Optionally, when time allows, the moderator can also take the students on an immersive flight through the Sun and explain how a solar cell functions.

The first iteration of INTENSE was quite successful. Throughout the project, INTENSE visited 18 schools and was part of 10 educational and vocational orientation events. More than 630 courses were held, attended by over 13,000 participants. In June 2018, INTENSE was honored as „Ausgezeichneter Ort im Land der Ideen“ (Excellent Place in the Land of Ideas) 2018 on „Welten verbinden - Zusammenhalt stärken“ (Connecting Worlds - Strengthening Cohesion). INTENSE 1.0 ended on a high note and was ready for the next step.

What is Begabungförderung?!

Before diving into the current period of INTENSE, it would be good to translate a term that will be used often (in the original German) throughout the rest of this paper: *Begabungförderung*. To do so though, requires a bit more explanation than a word-to-word translation, because English does not have a succinct or one-word way of translating what it really is. In German, there are two words that describe working with gifted students: the aforementioned Begabungförderung and Begabtenförderung. While the two words look and sound almost the same, they have very different meanings. *Begabten*förderung are gifted programs. It covers working with and developing gifted students and only gifted students. It is akin to any gifted programs in schools in the United States, such as Advanced Placement courses in high schools. *Begabung*förderung, which is what is discussed in this paper, does not mean gifted programs as they are typically thought of in English and/or the United States. It includes gifted and talented students, but as will be discussed in the INTENSE 2.0 section, it also casts a wider net, offering advancement and development of *interested* students too.

INTENSE 2.0

The second version of INTENSE began on 15 July 2018 and has funding through 31 December 2019. The funding this time has a very different donor and purpose. Funding for INTENSE 2.0 comes from the Senatsverwaltung für Bildung, Jugend und Familie (BJF) in Berlin (the Senate Administration for Education, Youth and Families in Berlin) with an intense focus on Begabungförderung in MINT (Mathemathik (Math), Informatik (Computer Science), Naturwissenschaft (Natural Sciences) und Technik (Engineering)—the German version of STEM) subject areas. The funding helps to keep the price point very low and fair so that all schools who have an interest can book INTENSE.

Teachers have the ability to book INTENSE for a minimum of three days and a maximum of five days for 200€. The cost includes a day of setup, a day of tear down and up to four days of programs (three full days and two half days on the setup and tear down days). The price also includes at least two moderators to present live, interactive shows to students in the dome and at least three for setup/teardown; rental of a moving van for all the components; any extra supplemental supplies; and teacher development time in the dome if desired. Unfortunately, the funding limits the program to operating only within Berlin (for example, INTENSE cannot go out to our neighboring cities of Brandenburg or Potsdam). The schools in Berlin take advantage of this, and INTENSE has not only booked out for the year, but has added extra weeks to accommodate more schools when possible and keeps a waiting list.

INTENSE 2.0 features a much wider range of programming for all levels. While in the schools, teachers can request not only any programs mentioned above that are unique to INTENSE, but also any live educational programs offered in the two big planetariums, as all three domes use the same digital system. This enables INTENSE to have more options in tailoring programs to the level of the students attending. INTENSE works typically with students in Kita and Grundschule (Kindergarten and Elementary School), Hauptschule (vocational high school), Gesamtschule (mixed high school), Gymnasium (university preparatory high school) and Sondernschule (special education school). INTENSE particularly tries to work with schools that have students with lower Socio-Economic Status (SES), including refugees and immigrants, who may not have the opportunity otherwise to visit one of our other planetariums. Each program is typically 45 minutes long with a 15-minute pause to allow fresh air into the dome. Programs are offered in German, English, and French, however, to-date, shows have only been requested in German and English. As Berlin is a melting pot and has several international schools as well, this enables students who are still learning German to participate too. More advanced students are engaged with a 1.5-hour long workshop that allows them to create for the dome. Students are given fisheye lenses for smartphone cameras and are sent to create content with them. They are then taught how to link their phones to the fulldome digital projection system so that they can show off their work in the dome.

INTENSE also takes part in camps, conventions and festivals. All Weltall-Forscher-Ferien (WFF—two weeks of camp for Spring Break, two weeks of camp for Summer Vacation, and one week of camp for Fall Break) are supported by INTENSE staff, and in 2019 INTENSE had its first separate camp utilizing the dome during the first week of the Fall Break. Children ages 7-12 who wish to partake in the camp can choose days based on theme or they can attend the entire week. The WFF covers the following topics: rockets, telescopes, comets and meteors, the solar system, and the search for extra-terrestrial life.

Fig. 3: Happy Astronauts during a WFF school break camp. ©SPB/*AGreen*

The INTENSE WFF also covers planets, astronaut training, and more about our Earth and environment. When not in schools or supporting the WWF, INTENSE is sometimes booked for teacher conventions, space/science festivals, and community festivals, which is where the project is able attract interested teachers and provide the information needed to book a visit to their school. These events help increase overall visibility of the SPB and help INTENSE find more avenues to potentially interested students.

One of the biggest things INTENSE does is support Begabungförderung. This is not only achieved with higher-level programing in the mobile science theater, but also through other means. INTENSE offers extra help for students in science competitions and in preparation for their Abitur (a very intense exit examination in all subject areas for students at the end of high school, and necessary for moving on to college). Students can contact the INTENSE team with questions or come work with one of the team for in person tutoring too. Not only does this fulfill one of the goals of INTENSE, more importantly, it helps students to feel more confident in preparing for big academic steps in their lives.

Other popular activities for Begabungförderung students are the after school programs: Astronomie-Arbeitsgroupe (Astro AG—Astronomy Work Group) and Weltall-Forscher-Club (WFC—Space Explorer Club). The AstroAGs are held typically at the high schools and they are usually more advanced in subject matter. Students experiment with skills such as soldering and working with electronics to apply to the rockets they build.

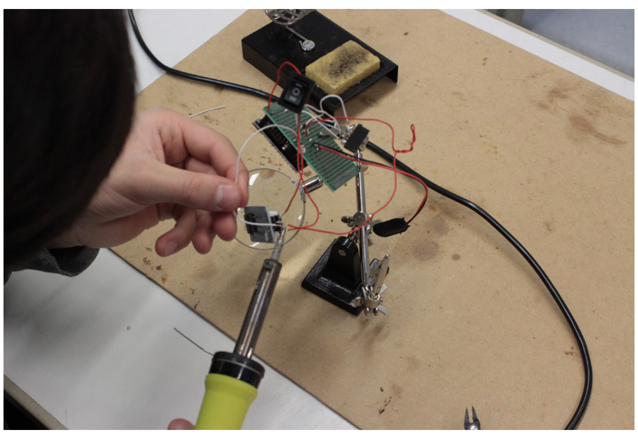

Fig 4. A student in the Astro AG prepares the electronics for a rocket. ©MWüsthoff

The WFCs are held at ZGP, PAI, and ASTW and typically have younger students who are very interested in science. These students also do hands on work to develop their knowledge of MINT subject areas, however the tasks are more age appropriate, such as building 3-D constellations that they can use to explain the distance between stars and why we see them as a flat image in our sky when they are light years apart in space.

The INTENSE 2.0 project has been extremely successful and provided many special opportunities for the students and citizens of Berlin. As of 15 October 2019, INTENSE 2.0 has visited twelve schools (with four more planned in 2019), one specialty teacher program with another planned in November 2019, four festivals (with one more planned for the year), and one INTENSE specific WFF. In these visits, INTENSE 2.0 served an outstanding 18,929 people, and the number of people served between INTENSE 1.0 and 2.0 totaling 31,905. Even with its success, however, major changes lie on the horizon. Changes in sponsors and funding, as well as potential staff changes will affect how the program continues in 2020. INTENSE 3.0 is planned to begin in at the beginning of the fiscal year, January 1, 2020.

INTENSE 3.0

INTENSE 3.0 will not be financed by the Senatsverwaltung für BJF. At this time, it looks like INTENSE become a full part of the Stiftung Planetarium Berlin. The hope is that the funding will come directly from the Senatsverwaltung to cover the salaries of the INTENSE staff. This possibility is looking likely, and will mean that INTENSE staff will be covered the same way as all other SPB staff. Since INTENSE will no longer be an externally funded project, the education department will not be beholden to requirements coming from the funder, but rather can create their own goals for INTENSE.

Even though nothing is set in stone just yet, the team has already come up with many ideas for what they would like to see happen with INTENSE in 2020. Of course the main priority of INTENSE will still be education, visiting schools, and providing more teacher professional development opportunities, with a goal of booking at least ten schools (there is already a waiting list of over ten schools wishing to book for next year). The team would also like to include more advanced options; such as special fulldome programming classes for interested students. With that in mind, the team would like for INTENSE to remain affordable for the schools, but also be able to start earning money as well. This could be achieved through structured pricing (*i.e.* if going to a place outside Berlin the cost would be slightly higher, extra hours to include extra classes would cost a little more, etc.), and finding more bookings around the region.

Berlin has city-wide events where different themed organizations stay open until after midnight and visitors can visit as many as they like with one ticket (*e.g.* Long Night of Museums, Long Night of Science, Long Night of Astronomy, Day of University Open Doors, etc.). While SPB has been involved with many of these, INTENSE has not and would like to partner with a university in the future for one or all of these programs.

Fig. 5: The INTENSE dome at the FEZ Berlin with a group inside. ©SPB/*AGreen*

The team also would like to continue having a presence at conventions and festivals, such as YOUMesse and Didacta (both conventions are aimed at educators), and Raumfahrt Wochenende im FEZ (the Space Travel Weekend in the Children, Youth and Family Center). INTENSE would also like to start renting the dome at places like the Mall of Berlin for a fee that would include the equipment, transport, and presenters while bringing in a little bit of revenue too.

How could these lessons be applied in *your* planetarium?

Due to standardized testing's prescribed benchmarks, formal educators are often forced to focus on improving underperforming students' work, while those of us in informal education attempt to help as best we're able. This is important of course, as every child needs to be supported so that they can succeed. This idea of supporting all children for success, however, must also apply to gifted and interested students. This is where Begabungförderung comes into play in Berlin. Interested students, even if they are only first starting to be curious, have great potential that needs to be developed. As mentioned above in INTENSE 2.0, it is this group of gifted and interested students that INTENSE works with, and is a group that deserves more development.

Perhaps there are not many resources at your planetarium, and you are concerned about adding programs and not having the support to back it up. Fortunately, much of what has been done with the INTENSE program is also done with a small amount of resources. The funding from the senate covers the salaries of the three INTENSE team members only. The rest is achieved by structuring program costs so that income covers the remaining expenses. Even though SPB is a large organization in terms of size and number of campuses, there are only 40 people on staff total between the three locations and INTENSE. The education department has three SPB team members, plus the three contracted INTENSE team members. There are also two contracted young adults in the Freiwilliges Ökologisches Jahr (FÖJ) program (Volunteer Ecological Year program). Often referred to as FÖJler (pronounced [ˈɛfœˌjɔtlɐ] or /eff-euh-yot-ler/) they are typically teenagers who have graduated high school early, and are taking a year to gain experience before beginning university. They are a bit like interns in the sense that they are only with SPB for a year, but they work like SPB employees while being paid by the program. The Education Department's staff time is split between the three to four different sites depending on the week and what is needed (show moderation, camps, birthday parties, tours, bookings, teacher programs, exhibits, educational show production, etc.). While the education department is the largest department, it is still extremely small by comparison to the number of programs (and locations) SPB has.

Like most planetariums, SPB also makes magic happen with limited resources. The key is building a good team and having a president, development officer or interested community partner who can support the efforts with outside funding if necessary. These programs, including INTENSE, did not become as large as they are currently overnight. They grew as capacity allowed. It is okay to start slower and work up to a large program if desired. It is important, however, to not discount an idea or program immediately if things are tight. Carefully analyzing all your options will allow you to find the best structure and timeline for all your desired programs.

In the United States, there are many grant options. One could apply for a private or federal grant to provide the funding to enable schools to have such a program at a low cost or even no cost. Stipulating that the dome could be used for more than just teaching kids about the constellations is key though. Many sponsors and grantors want to know how much can be done with their funding. Adding teacher workshops in the dome as one of the program offerings is a great way to make the program more attractive. Teachers also truly appreciate the opportunity to have more easily accessible professional development. Including the *"A"* in STEAM could also increase potential funding resources. Combining music and physics in the dome can teach students about climatic and atmospheric effects on their instruments, and take their education to a whole new level.

What can be done with a mobile dome, particularly when looking to support gifted and interested students, is really only limited to one's imagination. Often the best programs are born thanks to a question or request from a student. All it takes is that first program to get the ball rolling. Start with that first step and branch out from there as resources allow.

Conclusion

The INTENSE program at the Stiftung Planetarium Berlin has gone through several iterations, always putting the benefit of Berlin's students as its primary interest. The program has grown and expanded quite a bit in the last three years and will continue to grow in 2020. INTENSE serves as a model of how to best support and engage both interested and gifted students, and schools that need a little extra support. It is the hope that INTENSE's ideas can inspire other organizations and planetariums to implement programs unique to the culture and needs of their communities. Finally, what remains important for any institution, including SPB and INTENSE, is to remember to focus on visitors and those the organization serves, and continue to adapt and grow to meet the community's needs.

GOING BEYOND THE STARS IN THE PLANETARIUM

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Abstract: A big part of working in the planetarium field is being able to adapt to your community. Learning how to utilize your planetarium in ways that aren't astronomy-related can be a vital component in increasing your presence in the community. Events such as holiday and movie-themed shows, live demos, and many other activities can help bring a new element under the dome. Being under the dome is an experience and we have the power to decide which experience to deliver.

Introduction

At the Ward Beecher Planetarium, we try to broaden our horizons in order to reach a wide variety of audiences. Some things we do are as simple as adding a theme to a star talk and others are as unique as adding a live song and dance routine to a show. We strive for a healthy combination of fun and learning so that we can entertain any kind of audience.

How do we reach other audiences? How do we get people who never visited a planetarium to visit ours? How do we make a show more interesting and memorable for the audience? These are the questions we ask ourselves all the time at the Ward Beecher Planetarium. Most people have a basic idea of what a planetarium is before visiting one, but one myth that a lot of people have is that a planetarium is a place where all you do is talk about stars. However, a planetarium has the potential to be so much more. You can't describe what a planetarium does in just one sentence, especially not our planetarium.

The goal of this paper is to present some of the ways that the Ward Beecher Planetarium stands out and provide some ideas that you could you use under your own dome. As a university planetarium, we have a large crowd of students to please and everyone likes different things. On top of that, we have field trips for k-12 students and we open our doors to the public on weekends. Our value as a resource for knowledge is what brought in a lot of our public audience, but something we noticed is that we don't get as many college students attending regular public shows. A common thing we hear from our older first-time visitors is "I used to go to school here, but I've never been inside the planetarium". While we're glad to see returning students finally make the visit to our planetarium, we want to know how we could get them to visit sooner. College students spend most of their time in lectures, so when they visit us we don't want them to think of it as just another lecture. So we decided to make some interesting changes to how we do things at the Ward Beecher Planetarium.

Partnerships

We work with many organizations in our local community all the time to help bring new elements beneath the dome. This year we utilized a partnership we made to kick off our opening weekend with a whole new event. Our traditional opening weekend shows used to be a half-hour star-talk followed by an astronomy-related movie, but this year we started our season with a live musical performance from a local band called Moon Station Burning. It was different from our usual shows in the sense that the performances were live and original. The band was accompanied by visual effects on the dome that were various astronomical objects/events from our Dark Matter system mixed with the psychedelic effects created by the band for us to use as well.

A mixture of science and art can connect with people better and shows like these are the ones in which we have tried our best to do so. In this show, we blend science with art and present it among people in a thrilling and intriguing way. This is one of our shows where we were able to bring people of all age groups under the dome at the same time. Student presence has also been high in shows like this. The purpose of such an extravagant opening weekend was to make a good first impression on the community. It's also helped boost our attendance by bringing a new audience of people from the Moon Station Burning community.

However, if you want to stay on the scientific side of things partnerships can help with that as well. For example, we've been partnering with our local astronomical society for many years. The Mahoning Valley Astronomical Society (MVAS) hosts a show at our planetarium twice a year, in which they do a full two-hour show on telescopes. This is different from our usual shows because there's no lecture involved. It's all hands-on learning about various telescopes, whether you're thinking about buying one or have one already that you want to learn to use. It's also a very informal show as well; visitors just come in go as they please and we keep our doors open for the entire two-hour period. Along with the MVAS we work with other local groups in the community as well as other departments on our campus to help provide more hands-on learning. This helps get an audience engaged and encourages learning as well as helping visitors remember what they learned about in their time with us. This also helps with younger audiences who just can't contain their excitement long enough to get the most out of a traditional planetarium show. Every show doesn't need to have live demonstrations or partnerships, but a change in shows every now and then is appreciated by our regular visitors and it's fun for all audiences.

Adding a Theme

This is one of the simpler solutions we've had to encourage attendance as well as draw in new audiences. Themes are fun not just for the visitors, but for the staff as well. A theme can be your chance to tell your favorite constellation story or show your enthusiasm for another aspect of your life that isn't astronomy. For us at the Ward Beecher Planetarium, we love the world of Harry Potter which is the basis of our Wizarding Weekend show. Wizarding Weekend is our Harry Potter themed weekend, a tradition we started roughly three years ago. It's a star talk with a fun little twist thrown onto it. We entertain our visitors with stories that relate to the Harry Potter lore. We dress in costume and we encourage our visitors to do so as well to help get into the wizarding spirit. To make things a lot more interesting, we sort our visitors into a house and we have them compete for a chance to win the house cup in a constellation shoot out competition between the four houses. What's good about this weekend is that it shows off a lot of the fun in visiting our planetarium. It also allows us to connect more with our audience by developing common interests with our visitors.

However, maybe you want to keep your theme related more towards the stars themselves and there's ways to do that as well. There are many stories that are centered around the night time sky and a theme can easily be created by using one of them. For example, one of our lecturers always centers their fall time sky star talk on the clash of the titans story by pointing out the characters from the story in the real nighttime sky. Not only is the story fun to tell and fun to listen to, but it helps visitors remember the sky better. Themes can be exciting and also help improve the quality of learning. It also helps younger audiences stay interested in the sky they're learning about. Themes also help a lecture flow better and are the perfect mix of fun and education. Consider your audience and think about adding a theme to your next show.

Getting into the Holiday Spirit

The Holiday seasons are always a good way to show the fun of visiting a planetarium. At the Ward Beecher Planetarium, we love getting into the Halloween spirit the most. We decorate our dome with many decorations and we encourage our visitors to show up in costume for all of our shows in the month of October. It's truly a fun time for everyone. During the month of October, we play our annual Halloween show each weekend called Nightlights. Nightlights is a show that's meant to entertain our audience and get them excited for the holiday. However, our Nightlights show doesn't have a star talk included with it and this can be troublesome for the regular visitors who want to see stars like normal. The best thing about our Nightlights show is that it's entirely created by us so it's always adapting to the demands of the audience. There's a song in our show called Born of the Night but unlike the bulk of the show which is creepy monsters and special effects on the dome, this song is accompanied by visual effects purely comprised of stars and deep space objects providing a healthy mix of holiday spirit and space enthusiasm.

However, one thing that helps our Halloween show stand out from most is our two songs within the show that involve a live song and dance routine. This is hard to do depending on the size of your planetarium, but it's definitely something worth trying. It wasn't until two years ago that we incorporated dancing into the show. And it took a while before we got the entire routine to flow smoothly. But now our audience always looks forward to it, and it's always fun to see the faces of new visitors who are surprised to see the attention taken away from the dome and brought down to the staff dancing in the front of the room with their wacky Halloween costumes. Our Halloween show allows us to push the limits of our planetarium and portray to the audience that we like to work and have fun. Nightlights is a show that all audiences have come to enjoy and now, in order to reach an even greater audience, we created a kids version of our Nightlights show called Night-Lite. Night-Lite is also all created in house, and this year we have a brand new intro for the show featuring voice acting from one of our own staff members.

The good that shows like these bring is that they highlight the many things we're capable of as a planetarium. We can do more than just pop up the night sky on a dome and with our live song and dance routine, we show that we're not just limited to the dome. The purpose of the show is to have fun and that's just what we do at Ward Beecher. Our visitors are always surprised by the many things we do in our nightlights show and they express their excitement the entire time. It's the best way to show that planetariums are exciting and it helps not only increase attendance by bringing in new visitors, but it also keeps our regular visitors happy as well by providing a nice change of pace.

Throw in some Music

Music is always a good way to add some fun to a planetarium show. And with music, you get to determine the level of the focus you put on it. It can be as simple as having space-themed music running in the background of your normal star talk or as extreme as having a show purely dedicated to music and special effects. Music is a good way to help relax the audience and get away from the lecture feeling by creating a slightly more comfortable setting. For all of our shows at the Ward Beecher Planetarium, music is involved in some way. Last year we created a show dedicated to music called Rock the Dome.

Rock the Dome is a musical show our planetarium holds and has become immediately popular among our community. It's a show that is fit for all ages and only takes minimal effort on our part to run. With the use of our Sky-Skan Definiti Theatre System, we create visual effects accompanied by the songs from famous 70s and 80s bands like Queen, Pink Floyd, Led Zeppelin, the Beatles, the Rolling Stones, and more all-time favorites. We have been able to give people a new experience and a new form of entertainment under the dome. From "Comfortably Numb" to "Hey Jude", we are able to make every age group groove at the same time. The classic combination of Milkdrop visualization and music has enhanced the charm of the show. To make it more exciting this year, we have decided to add famous songs from modern artists like Imagine Dragons, Post Malone, Billie Eilish, and many more.

Another way we've used music to our benefit was by having a show we called Relaxing Under the Stars. This wasn't a public show, but it was a show we held for students around finals week. We played nice relaxing music and kept our star ball slowly turning the time up above on the dome. It was meant to help students de-stress and they were surprised by how relaxing the experience was for them. Shows like this are always a good way to help change people's views of the planetarium.

Bringing It All Together

Partnerships, live demonstrations, themes, art, costumes, and music are all good ways to help add extra excitement to the planetarium. However, the important thing to remember is that it takes a healthy mix of these things to have it actually be of benefit. A planetarium's main duty is to educate and we try our best not to stray too far from the educating aspect. Maybe you don't want to create an entire music show, but adding background music to your regular star talks can go a long way. You can keep doing your usual star talks, but considering adding a theme to the lecture. You can even use the stories of the constellations themselves to help create a theme. The point of these changes was to provide shows that applied to all audiences and while a lecture about the night sky is always fun for us as planetarium workers the thing about the sky is that it doesn't change often. There's only so much a star ball can do on its own and the constellations are always going to be the same. We work hard to provide an entertaining experience for all audiences and sometimes you might have to go beyond the stars to do so. Think about your audience and what you're capable of as a planetarium and find out what works for you. Being under the dome is an experience and it's up to us to keep that experience ever changing.

IMPLEMENTING THE OPEN SOURCE ASTRONOMY SOFTWARE OPENSPACE FOR PLANETARIUM AND FLOOR PROGRAMS

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Abstract: Morrison Planetarium and the California Academy of Sciences have been partners on the American Museum of Natural History in New York's OpenSpace software development project, a project largely funded by NASA. We will review some of our experiences so far implementing the free software for public floor programs, specialty planetarium lectures, and regular daily shows, including both the technical hurdles of still-developing software and connecting it to the educational and entertainment desires of our audiences.

OpenSpace is an open source, interactive, science visualization software aimed at producing high-quality, high-accuracy simulations of the known universe. The software was born out of a collaboration between the American Museum of Natural History and Linköping University in Sweden to push visualization techniques not currently being applied in other software and also to create a freely available, open source astronomy software that wouldn't just be useful in planetariums, but could also be downloaded and run by anyone on their home computer.

As the nascent program successfully demonstrated its first goals of visualizing the New Horizons mission, Mars terrain data, and high-resolution time-series weather data on the Earth, it received a grant from NASA to further its development with a focus on visualizing NASA's Science Mission Directorate's work to observe the Solar System and Universe beyond. This grant allowed the original team to expand their partnership to include New York University, the University of Utah, and multiple informal science education institutions, including the California Academy of Sciences.

Over the course of our participation in the OpenSpace grant we first engaged in several one-off presentations. As the program progressed through its earliest stages of development these enjoyed various degrees of success. In late 2016 we briefly demoed an early version of OpenSpace's ability to ingest high-resolution satellite data for a private presentation for planetarians and geologists as part of the American Geophysical Union's annual fall meeting in San Francisco. This presentation was well received, along with additional demos of high-resolution data in Uniview and WorldWideTelescope. At this time, the early version of the program was optimized for data pulls, but not necessarily memory management, and without care it could quickly overload the available RAM of the computers as it ingested massive amounts of data.

One of the first successful public presentations wouldn't come until mid-2018, when our monthly Dean Lecture series featured Dr. Carter Emmart of AMNH, the project's creative lead, and Dr. Jeff Moore of NASA Ames. The pair took our audience on a live tour of Mars using the high-resolution terrain features of OpenSpace, including the implementation of the Mars Reconnaissance Orbiter's HiRISE camera's 30 centimeter-per-pixel imagery and 1 meter-per-pixel Digital Terrain Models for select sites of interest on Mars. As the program evolved we had to do new work to calibrate it to our dome and create a configuration file with the appropriate viewport frustums for our projectors, as well as to make sure all needed data were either locally cached or streaming effectively. The presentation was a success and we were encouraged to start using OpenSpace for more programs.

After we were unable to participate in the Mars Insight Landing domecast that fall, we briefly piloted a program based on Emmart & Moore's presentation, where our staff, using a high-powered laptop at our Science Today flat-screen presentation space, took Academy members on tours around Mars. With these first few public floor programs, presenters got to explore Mars themselves with the high-resolution mapping in OpenSpace. Guests were very excited to be able to see Mars features up close, especially when informed that what they were seeing was actual data and imagery from the surface. Presenters did encounter some challenges during this time, however. The interface of OpenSpace at the time was not very intuitive or user-friendly, with presenters having to navigate a complicated object tree along with no pre-programmed buttons for flights or targets as they were used to having in Uniview. The view was a bit awkward as well in the sense that it wasn't possible to remove the control display from the presentation window, though presenters were able to use this as a way to explain to guests that the software was currently in development and they could use it at home, so what they were seeing was the same as what they would see if they downloaded the software themselves. The presenter team was also able to approach these first presentations as a special perk to members, a type of presentation never seen before at the Academy.

As we got more used to the program, we took advantage of some of the lunar data being prepared for the Apollo 50th anniversary programs. Our December Dean Lecture featured Dr. Brian Day of NASA Ames, whose presentation kicked off Apollo anniversary events with a tour of the Apollo landing sites, visible in the Lunar Reconnaissance Orbiter's Narrow Angle Camera strips. Due to limitations of the interface at the time, Dan Tell worked with Dr. Day to navigate live from the full lunar view to the individual pixels of each lander and explore the terrain features and human artifacts left behind by the missions. Dr. Day's presentation also included a general overview of lunar geology and discussion of future landing sites and lunar mysteries to be explored when humans return to the Moon. This program was one of our first opportunities to ingest new high-resolution data into OpenSpace ourselves, as well as try out still more recent versions of the program. Encouraged by this success, we began to look forward to additional OpenSpace opportunities in 2019.

The next opportunity would come a few months later in May of 2019, when Dr. Jacqueline Faherty of AMNH came to the Academy to present her research on the Gaia mission's discoveries for another Dean Lecture. Dr. Faherty is a regular presenter at the Academy and works at the forefront of research into star formation and motion. We had worked with her several times to ingest and visualize her research on young stars and stellar associations in Uniview, and for months had been working with her to visualize several subsets of the Gaia data. However, as Gaia's data releases are enormous, we were limited by how much data we could convert and present with Uniview or other software packages (our work on this was presented last year at this conference in Tell & Bhatt (2018), Processing and Storytelling with Gaia DR2 Data. *GLPA Conference Proceedings, 2018,* pp. 36-42[1]). Dr. Faherty, as a researcher with deep enthusiasm for using planetariums for data visualization, had already been working on her own subsets of the data and working with the OpenSpace development team. OpenSpace was able to ingest much larger subsets of Gaia data, and could be used to explore the motions of millions of stars. Dr. Faherty gave two presentations using this data, one in New York and one at the Academy in San Francisco, exploring the richness of the Gaia data and the incredible new insight it has already given us into the formation and evolution of the Milky Way.

Shortly afterwards, while attending the OpenSpace consortium meeting in New York in June of 2019, encouraged by the community discussions and collaboration Josh Roberts, Dan Tell, and Ryan Wyatt saw the next opportunity for an OpenSpace event. The Academy was invited to the USS *Hornet's* Apollo 11 50th Anniversary "Splashdown!" event in July, the quinquennial celebration of the *Hornet's* service as the prime recovery vessel for Apollo 11 upon its return from the Moon. For the 45th anniversary celebration in 2014 we brought out the Geodome portable planetarium and took audiences on a tour of the Moon driven by Uniview to explore major lunar features and the Apollo landing sites. This event was early in our experimentation with using high-resolution data from LRO, and the set-up involved bringing a small subnet of devices, including a MacMini to act as a portable WMS server to deliver the data. Although we had been planning a similar set-up for 2019, we realized that OpenSpace could now provide these features in one package, while improvements in the interface would make the tour easier for our presentation staff; with the added bonus of demonstrating software to the public that they could download and use at home, while also meeting programming goals for the grant.

Once again, for this presentation we revisited the data we prepared for Dr. Day's talk months earlier. As the *Hornet* is an aircraft carrier moored at the edge of Alameda's former naval air station, across San Francisco Bay, we did not expect to have reliable high-speed internet, which meant storing and using all of the data we would need offline. For the Moon this would total about 25 gigabytes, easily storable on the solid-state drive of a laptop powerful enough to drive the portable planetarium. As websocket features had been added to OpenSpace this also enabled us to write javascript driven controls that made it much easier to tour the Moon, target the landers (which now had photogrammetry produced models, made by Dr. Emmart using the LEM at the National Air and Space Museum), fade up auxiliary images, and explore the details of the landing sites with far greater ease. Between the presentation on the *Hornet* and a parallel program on flatscreen displays at the Academy, we were able to take approximately 800 guests on tours of the Moon with maxed out audiences the entire day. While preparing for our visit to the Hornet, we also took this opportunity with new Apollo Moon assets to experiment presenting out on the public floor. A couple of nights in July for the Academy's weekly NightLife event, presenters brought out OpenSpace at Science Today and explored the Moon with guests. They were able to use the high-resolution Apollo landing sites to talk about the upcoming anniversary and occasionally even have guests fly around the Moon themselves if they were so inclined.

More comfortable with OpenSpace and feeling that the program was now more reliable, we concluded we were ready to implement it for an experimental daily program in Morrison Planetarium. We had briefly discussed this after Dr. Day's Dean Lecture, but concluded the program was not yet easy enough for regular daily use by our presenter staff, and produced a live Tour of the Moon in Uniview that ran through the spring and summer of 2019. Ready to create an OpenSpace program for the fall, we reviewed the available assets in OpenSpace, discussed what we felt we could add to the program to meet our storytelling goals for our presentations, and ultimately concluded a tour of the Solar System would be our best target for development.

Over the last several years one of the features we've most robustly made use of in our programs is high-resolution satellite imagery of other planets to allow us to explore them in detail and give audiences the experience of visiting these places as other worlds. With this already as a core of our programming, and a robustly developed feature of OpenSpace, it provided a natural connection for creating our Tour of the Solar System. High resolution imagery and elevation models are already enabled in the program for Earth, the Moon, Mercury, and Mars, giving us an easy starting point. We then looked into what data we had already acquired to round out a tour that could take audiences to every planet in the Solar System.

1 "GLPA Conference Proceedings: 2018 | Great Lakes ...." https://glpa.org/proceedingsab2018. Accessed 3 Oct. 2019.

The gas and ice giants don't naturally lend themselves to the same kind of detailed imagery as the terrestrial planets, due to their constantly changing cloud patterns and, in the case of Uranus and Neptune, the lack of orbiting spacecraft. However, the major moons of these planets represent excellent locations to explore. The Galilean moons of Jupiter, major moons of Saturn, and Triton, orbiting Neptune, all have had imagery mosaics made of the many camera passes by the Voyager, Galileo, and Cassini missions. Available through the United States Geologic Survey or the missions' respective data providers, our expertise with this data allowed us to quickly use the Geospatial Data Abstraction Library to configure these maps for use in OpenSpace and we expanded our tour to include these major moons, with special focus on Europa, Io, and Ganymede at Jupiter; and Enceladus, Titan, and Iapetus at Saturn. Voyager 2's flyby of Triton, although brief and reliant on old technology, still provided enough of a wealth of data to construct a high-resolution mosaic of the moon's south polar region. Our team agreed this was an important visit, especially to compare with Pluto, where data from the New Horizon's flyby helps to reveal analogues and relationships between these objects. In addition, Hubble's Outer Planets Atmospheres Legacy program, which takes annual images of the gas and ice giant planets to monitor their cloud patterns and atmospheric changes, released a new mosaic of Jupiter in August, which also let us provide new detailed imagery for Jupiter to explore.

The moons of the Earth and outer planets weren't our only satellite targets. Through our relationship with NASA Ames we were also aware of recent high-quality imagery and shape-model data for Mars' larger moon, Phobos. We implemented this in OpenSpace, replacing the untextured placeholder sphere with a detailed view of this oddly-shaped moon.

In addition to the planets and major moons, we always like to augment our Solar System programs with discussion of the other objects of the solar system. Again, leveraging data obtained from our Dean Lecture programs and relationship with NASA Ames, we selected Ceres and Pluto (with Charon) as our final targets. In both cases, previous OpenSpace modules had been created to explore the bodies visualizing the Dawn mission to Vesta and Ceres and the New Horizons flyby of Pluto. When we started assembling the show in the then current version of OpenSpace (0.14.1) we found the files associated with these missions to be deprecated by changes to the software. Once again we adapted the global mosaics and terrain models from the missions to run efficiently in OpenSpace and updated these objects to enable them in the software.

Consistency and reliability are some of the most important factors for Morrison Planetarium, so we heavily tested and vetted the program as developed to make sure it would run stably across each of the six 4K projectors that drive our dome. During these tests we further optimized the show to carefully load and unload map data as the presenter approaches and leaves the various bodies of the solar system. Once we were confident the show would not affect our reliability requirements, we scheduled it to start its public run.

All totalled, our work enabled us to visit over a dozen bodies in the solar system with some of the best resolution data available, but still allowed the flexibility to construct a variety of storylines as we explored the solar system.

Training the presenter team for this new Tour of the Solar System show in OpenSpace was a relatively smooth process. Most of the presenters had given a very similar program in Uniview before, either with our Solar System Safari show, which we've presented in Hohfeld Hall during two different programming periods in the last two years, or with our 3D Space Adventure which was a Solar System tour for 3rd-8th grade classes in the Academy's 3D Forum Theater. Since the presenters already had the content background for the show, the only training that was needed was familiarizing them with the software and adapting the previous shows to a 20-25 minute long show where we specifically wanted to visit every planet, rather than just a subset. The biggest challenges with learning the software were probably flying speeds and time controls. When zooming in and out in OpenSpace the speed is very slow compared to Uniview, so presenters need to adapt to this wait time by preparing talking points while flying from one planet to the next. Plus, one needs to zoom out relatively far from a planet before retargeting to avoid a very fast and uncomfortable swing in camera view, which is especially important to think about in the dome to avoid motion sensitivity in audience members. Time controls in OpenSpace also have proved to be a challenge. Moving forward in time acts very differently in OpenSpace vs Uniview depending on what you're targeted on and how far away you are from that object, and at least at the moment we have no pre-programmed buttons to change time and instead need to use the OpenSpace built-in interface. The presenter team also needed to adapt their talking points to some limitations in the current software. For example, OpenSpace doesn't currently have an asteroid belt or rings for Uranus, so if a presenter was used to these assets being a big part of their storyline they needed to adjust their talking points accordingly.

With the flexibility of OpenSpace in terms of free-flying and access to more than enough assets for a 20-25 minute show, presenters have been allowed to put their own spin on the show and explore aspects of the planets, dwarf planets, and moons that they're interested in. Presenters have also taken advantage of the fact that OpenSpace is free and open source by sharing with guests that they are able to download the software at home.

Presentations using OpenSpace at Morrison Planetarium and beyond have been very successful so far, especially within the last year. Looking to the coming year, the Morrison team plans to continue the daily run of Tour of the Solar System until at least May 2020 and will be exploring more possibilities for presenting with OpenSpace in the dome as well as other venues. For example, only a few days after writing this (and about a week and a half before GLPA) Mary Holt will be presenting a version of Tour of the Solar System during the Astronomical Society of the Pacific's 131st Annual Meeting at San Francisco State University. As the Academy continues to collaborate on this project we look forward to what new features and possibilities it will present in the near future.

APPEALING TO YOUNGER AUDIENCES AT YOUR PLANETARIUM

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Abstract: How can we engage our youngest audiences at our planetarium shows? We discuss how to captivate younger audiences using a balance between education and entertainment. We focus on using characters and personalities to not only entertain and hold the attention of our youngest viewers, but also to help them retain information that is conveyed in our shows.

Introduction

Planetariums accommodate diverse audiences on a regular basis. One characteristic of audience members that can vary is age. Engaging audiences between the ages of two and eight years old can be particularly challenging but there are several ways to educate and entertain young audiences. One effective way to do this is by using characters to explain or represent information and concepts. Throughout many planetarium shows, we are greeted with memorable characters that excite and involve young viewers in a way that helps them retain the information they learn throughout the program.

Shows That Utilize Characters

There are many shows that are readily available that use this method for captivating the attention of young audiences. For example, *One World, One Sky: Big Bird's Adventure* is a 27-minute long fulldome show that features characters from Sesame Street. The audience follows Big Bird and Elmo on a trip to the Moon to learn about the difference between the Moon and Earth and to learn about patterns in the sky. This show is a favorite among audiences because it is interactive, and it shows that all cultures can look up at the sky together.

The Little Star That Could is another fulldome show that expresses information by using characters. This show is approximately 35 minutes in length and follows the journey of an average yellow star in search of his planets. On the way, viewers learn about many different types of stars and their characteristics as well as other objects in the universe such as planets and globular clusters. Every object encountered has its own personality that is related to the actual characteristics of the object, which helps audiences retain information because they can associate a personality with an object.

Finally, *In My Backyard* is a 31-minute long fulldome show that is created for the youngest audiences. Guests follow along and interact with children's entertainer Fred Penner who helps children identify their surroundings using songs and audience participation. Children learn about the seasons, moon phases, constellations, and more. This show makes use of personal connections by having the main character interact with the audience directly to keep them invested in the show.

Applying This Method

The use of characters for holding the attention of young audiences is not limited to fulldome shows. We use this method under our dome to nurture a comfortable and entertaining learning environment for young audiences. For example, names and personalities can be assigned to objects or tools used in the planetarium. When introducing our staff at the beginning of our star talks, we also introduce our star projector (Chronos by Goto Inc.) as though it has a personality and continue to address it throughout the show. This establishes a sense of familiarity for younger audiences that is helpful in an educational environment. We also assign names to our laser pointers that we use for star talks; the arrow shaped pointer is Arnie the Arrow and the normal laser pointer is Spot the Dot.

Personalities can also be assigned to constellations, as many cultures have done already. When tracing out star patterns in the sky, we emphasize the characters that they represent and the stories behind them which is not only entertaining to our visitors but also helps them retain the information. Props such as toy animals can also be used to add another dimension to the characters that we use to represent constellations.

Finally, visiting the planetarium can be a frightening experience for young audience members. This fear can be reduced by adding characters that children can identify. For example, at Ward Beecher Planetarium, our annual Halloween show (called Nightlights) has been going on since 1974. This show features music, lights, and visuals on the dome and has been a favorite in the community for years. However, many younger viewers are frightened by some of the visuals so this year our team created a child-friendly version of the show, called Night Lite. One way that the show was modified to make it suitable for young audiences was by adding characters. Ginny L. Phillips, a student employee at Ward Beecher Planetarium, drew several Halloween themed characters that were then translated to the dome by Ward

Beecher's Planetarium Engineer, Curt Spivey. Characters include familiar Halloween figures such as skeletons, scarecrows, and other monsters, but Youngstown State University's mascot (a penguin) has also been included and can be seen wearing many costumes throughout the show.

Conclusion

An effective way to educate and entertain young guests in the planetarium is by using characters. There are many fulldome shows that take advantage of this method, but it can also be applied by the planetarium staff to improve existing programs. Using characters to express concepts, engage the audience, and tell a story are all helpful strategies for allowing audiences to get the most out of planetarium shows.

GETTING A FEEL FOR LUNAR CRATERS: APOLLO 50TH COMMEMORATIVE EDITION

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Abstract: With support from NASA, The College of Charleston, and Edinboro University, we were able to create another tactile book commemorating the 50th anniversaries of the Apollo landings. This book uses the original diagrams from our previous book, "Getting a Feel for Lunar Craters," with an additional section highlighting the Apollo missions.

This book once again targets those who are blind or visually impaired, but can be used with all learners. Quinn and Hurd have found valuable feedback from members of GLPA that have improved subsequent iterations and we have also enjoyed hearing how these books have helped meet the needs of blind and visually impaired who frequent their institutions.

A limited number of books will be available for free distribution. If you need additional copies or don't receive a copy, contact Kenneth Quinn to learn on how to receive a copy.

Obviously, astronomical events and significant astronomical anniversaries draw a lot of interest to astronomy and in specific planetariums. With the influx of visitors, those with visual impairments are often overlooked.

This paper highlights the unique aspects of our Moon while focusing on craters and the anniversaries of the six Apollo landings by providing detailed tactile graphics and QR code technology which allows the user to access the text. The book incorporates QR technology for the user to access the text that highlights the tactile book. For easy access the QR code is clearly marked by a raised box on the front of the book. Additional classroom material is being developed and will complement the book. Although it is specifically geared toward those who are blind and those with visual impairments, the newly released book, *"Getting a Feel for Lunar Craters: Apollo 50th Commemorative Edition"* has appeal for all. It can be used in the regular classroom as well as at schools for the B/VI. The book was funded and supported through the NASA Solar System Exploration Research Virtual Institute (SSERVI), a grant in conjunction with the College of Charleston (CofC), and NASA Headquarters, Science Mission Directorate. It was written, produced, and beta tested by Cass Runyon (CofC), David Hurd (Edinboro University of Pennsylvania), Joseph Minafra (NASA), Ken Quinn (Tactile Evaluator, Erie, PA), and John Matelock (Tactile Illustrator, Edinboro, PA). Special thanks go out to Joe Lang, Operations Manager for Connoisseur Media, Erie, PA for recording and narrating the text for the audio file.

NASA has taken great strides in providing ALL learners with the opportunity to explore the wonders of our solar system and universe. Their support of astronomy related material for the blind and visually impaired has been particularly noteworthy in the past and continues today.

In this book, the authors have also exaggerated relief for haptic effect and many tactiles are not to scale by relief, size and/or distance, but all such divergences are detailed in the text.

The book comes complete with a Quick Response Code (QR code) to access the text and supplemental materials and audio files in both English and Spanish (Figure 1 and 2).

Figure 1: QR code for tactile books—give it a try!

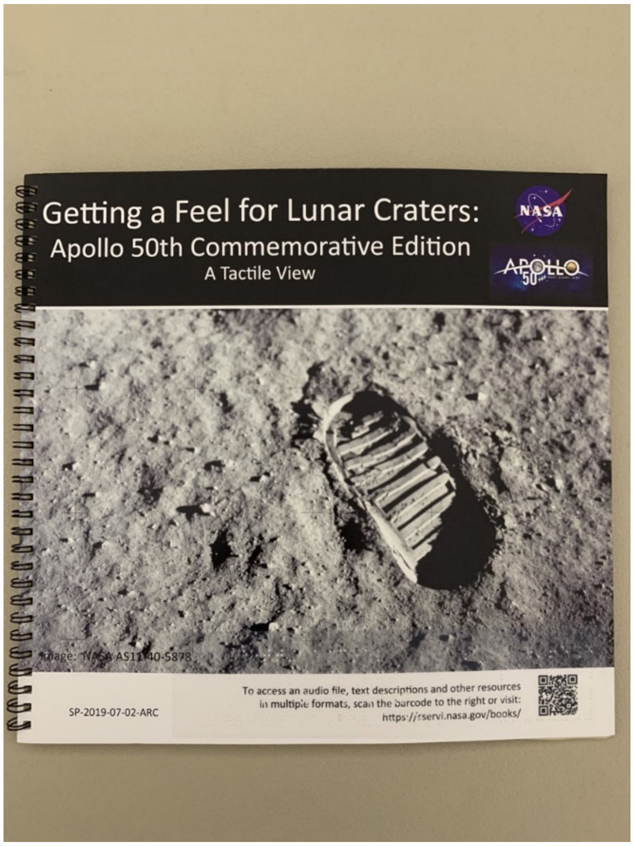

Figure 2: Book cover showing QR code in lower left

Although it is primarily geared toward those who are blind and those who are visually impaired, it can also be used effectively by sighted students through activities and inquiry-based opportunities for each learner. Many of these resources are currently being developed.

EXTRA, SIMPLE, SIGNIFICANT REVENUE STREAMS

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Abstract: How many times have you overheard a guest saying "wouldn't it be cool to watch a movie in here?" Your facility may already have the license to show popular mainstream movies. Even If not, there is a cost-effective way to bring this additional fun revenue stream to your dome. I will demonstrate what we did with movie release parties to raise extra money.

We all can use extra funds!

Most of us are strapped for both funds and content for public events. Why not find a solution for both? Most public schools are required to have a legal license to screen movies (as they are only for home use). In our case the librarians are the keepers of these licenses. I had to simply talk to her and I got a copy of our school license to make my movie parties legal. We license our "Public Performance Site License "through SWANK Movie Licensing USA.

Please note that the rules of this Public Performance Site license are *not* the same as your local movie theater:

- Movie *must* be on a disc.
- Facility *must* own the movie disc.
- You may *not* use public media to advertise name of film…
  However, newsletters and other direct communication is OK!
- You *may* charge fees (admission fees and food sale prices)
  *room/equipment usage "to cover costs."
  *concessions (not included in license)

So no, you're not making money on the public screening of these films. You are covering your costs by paying for theater/equipment rental fee for your movie event. (In our case that's $60- $100 per hour.) You *are*, however, making money on your concessions!

Concessions—the real money maker but what about the mess on the carpet and chairs?

I worked with my custodial staff and we performed step and grind tests on the carpet. Popcorn, water, and fruit snacks did not create any non-removable residues on the carpet. We deem them here as "theater safe" foods. Clean up takes me about an hour and there haven't been any stains or major problems.

Real Case Example Data

I've tallied our sales data for only 5 movie parties per year over 4 years.
$1,645 net profit so far. This will take a big bite out of a new fulldome show!
Other revenue paid for all supplies, movie discs, deluxe (8 oz kettle) popper, 4K Blu-Ray player.

Before you make the posters…This might not be for every planetarium

If you're not in a school with an existing license, you may be able to acquire one for a reasonable price but that will affect your overall bottom line. It's important to ensure a great movie watching experience *before* you invest hundreds of dollars in equipment for long term movie capabilities. You should think about:

- Is your dome tilted or horizontal? Will your guests be looking up high for two hours?

- Is your seating comfortable with adequate neck support for a long sitting (maybe looking up)?

- Is your sound system in surround and robust enough? Is your video projector high definition and looking good enough to warrant a "better then home" viewing experience?

Ideas for Marketing

I have found that "themed" or timed events work best. Examples being:

- Special fund raiser for a fulldome show you're saving for.

- As a reward night for the "friends of the planetarium" group.

- I only choose movies that are science (or Sci-Fi) based in some way and are family friendly.

- Blu-Ray release dates are a good time to celebrate a new movie.

- Halloween "Thriller Theater." Movie choice is old school horror film.

- Anniversary release dates of older movies or events those movies were based on.

- Use release of current movies by playing the pre-quel.

Final Thoughts

- I could run more movie parties than 5/year but want the focus to be dome education. I don't want to ever telecast that we are "a movie house" or lose sight of our primary mission.

- *Don't* even consider running this through your digital fulldome system. The price of a single HD projector is probably equal to a single set of lamps on your fulldome system. Don't burn precious hours on your main projection system for a rectangular movie.

- Private groups have asked for a "movie night" instead of a dome presentation. My response has been that movie parties are a rare bonus/fun event only. *If* they are paying the ~$75 per hour and want to watch a movie, I'm OK with this. However, no one has taken me up on this as ~$150 to watch Star Wars in the dome was apparently untenable.

- Have fun with this, movie magic is powerful when used correctly. I've seen young families enjoy and laugh together at black/white horror movies. We've shared a tear together too.

BIG ASTRONOMY PROJECT: (NEARLY) FREE SHOW AND GREAT RESOURCES!

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Abstract: Big Astronomy is a National Science Foundation funded project to explore the Dome+ model—a planetarium show distributed for a minimal fee in both English and Spanish, plus a website that hosts resources and live programs to extend the learning beyond the dome. Research on the effectiveness of this method will be carried out by Michigan State University. *Big Astronomy I Astronomia a Gran Escala* will share the story of the people and places who make big astronomy happen. Learn more about the project and the resources that will be available to your planetarium in this presentation.

About the *Big Astronomy* Project

When we think of big astronomy, we think of big telescopes. But *people* enable discoveries! *Big Astronomy I Astronomia a Gran Escala* shares the story of the people and places who make big astronomy and big science happen. A bilingual planetarium show takes visitors to the extreme sites where astronomy happens at the highest heights in the most extreme environments and with some of the most interesting people. This show, produced by the California Academy of Sciences, will be distributed internationally for free, in both English and Spanish. Extend the learning through live conversations with observatory staff, exclusive behind-the-scenes footage, educational activities, and ongoing science experiments all on our website at bigastronomy.org

Big Astronomy is a National Science Foundation (NSF) funded project. The project was conceived by Shannon Schmoll and Renae Kerrigan, who both visited the NSF funded telescopes in Chile as part of the Astronomy in Chile Educator Ambassador Program (ACEAP) in 2015. Shannon and Renae wanted to make a planetarium show about the telescopes, but it would have been quite limited. Tim Spuck, who leads the ACEAP project, worked with Shannon and Renae, plus our partner at California Academy of Sciences, Ryan Wyatt, to submit an Advancing Informal STEM Learning (AISL) grant to the NSF. The project was funded in late 2018.

The main goal of the *Big Astronomy* project is to help young people and general audiences understand that it takes many diverse skills and careers to operate the large astronomy facilities where today's major discoveries are uncovered. By showcasing men and women with different educational backgrounds, of different ethnicities, and performing various jobs, we hope to support young people envisioning themselves contributing to science. The major components of the grant are a planetarium show about the NSF-funded telescopes in Chile and the people who make them work, a website with more information and ongoing live events with observatory staff, educational kits and activities, and research on this new "Dome+" production model.

Figure 1.

Big Astronomy: People, Places Discoveries is a planetarium show produced by the California Academy of Sciences that explores some of the most advanced telescopes in the world, located along the Andes mountains in Chile, and the diverse people with different skills and backgrounds needed to enable the science. See a scene from the flat screen version nearby. (Figure 1) Cerro Tololo Inter-American Observatory (CTIO), Gemini South, and the Atacama Large Millimeter-submillimeter Array (ALMA) are featured, as well as the upcoming Large Synoptic Survey Telescope. The show is produced in 4K, and will be available in 4K, 2K, 1K and flatscreen versions, for free download or for the small cost of a hard drive plus shipping and handling. It is a bilingual show, produced in both English and Spanish, with a music and effects version available for other translations. The show is narrated by Chilean astronomer Barbara Rojas-Ayala in both English and Spanish versions. It will be released on May 2, 2020. For more information and to sign up for show updates, visit bigastronomy.org.

More than a Planetarium Show

A major goal of the *Big Astronomy* project is to encourage planetarians and planetarium guests to utilize bigastronomy.org as a prime resource for further learning and exploring large astronomy facilities in Chile. In addition to being the place where planetarians can download *Big Astronomy: People, Places, Discoveries* show or request a physical copy, this website (Figure 2) will also host a wealth of additional resources including opportunities to interact with observatory staff, hands-on activities and educational resources, a photo gallery, and even citizen science initiatives through observatory resources.

Figure 2.

A highlight of the website is that it will publicize and archive ongoing live events with observatory staff. In order to continue learning and engagement beyond viewing the planetarium show, we will host 52 live events, many of them conversations with staff from CTIO, ALMA, and Gemini South— the folks who are featured in the planetarium show, plus others. The goal is to create authentic interactive experiences between the public and the diverse people at the observatory and to showcase the many skills and educational backgrounds it takes to run a big observatory. Examples include astronomers, engineers, machinists, transport drivers, computer scientists, publicists, and cafeteria workers. These events will be roughly every two weeks, hosted on Facebook Live, Twitch, and YouTube.

The Astronomical Society of the Pacific is creating educational activity kits to be distributed to amateur astronomers and museums around the country. The activities in these kits support the learning goals in the show and the larger project. Physical Toolkits will be distributed to 200 astronomy clubs and 100 museums in locations where the planetarium show is playing and beyond. Activities range in uses and can be used under the night sky or inside, with audiences as young as 6 through to adult, in groups small or large. Designed for informal educators, these activities include hands-on demos to explore dark skies, types of telescopes, and cultural astronomy around the world with a common theme that astronomy is open to everyone with a desire to look up. If you are interested in signing up for information about the physical kits, you can do so on the bigastronomy.org website or here: https://forms.gle/RGGaxVYoniShqTtx7 Digital versions of these toolkits will be freely available online.

Researching a New Planetarium Show Model

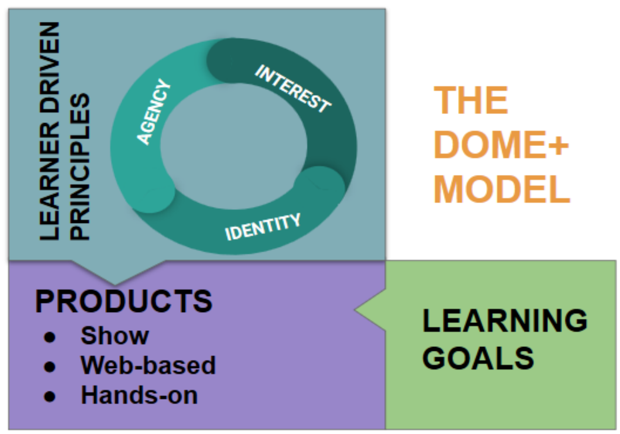

Figure 3.

This project is built around what we are calling the Dome+ model (see figure 3). A major goal is to not only bring the wonders of observatories in Chile to as many people as we can, but to offer opportunities for people to engage in the content well beyond their planetarium visit. We will do this through these various components described above. Additionally, offering many entry points into the content presented in the show created more opportunities for people to learn about the show as well.

One of the major components of this model is the understanding that people need multiple exposures to ideas and content to fully learn something (Minstrell, 1989; Posner, 1982). A planetarium show, by itself, is not enough to teach people a great deal of material. So we need to create multiple opportunities for people to learn the concepts presented in a show. Additionally, multiple exposures are helpful in reducing novelty effects, which have been noted in planetarium shows, so people are able to more fully process new information (Falk and Storksdieck, 2005; Ridky, 1975).

Even though a planetarium show cannot expect to teach a subject in depth with one viewing, it does have a strong record of building student interest and excitement around a topic (Schmoll, 2013; Lelliot, 2007). This project, through the hands-on activities, portal, and live events, is creating an easy to access means of continuing that learning and acting upon interest built at the planetarium.

A major characteristic of informal learning environments is also the ability for a learner to control their experience. People visiting museums, aquariums, etc. can choose where to go and spend most of their time (Falk and Dierking, 2000; Falk and Storksdiek, 2005). Planetariums, on the other hand, often do not allow that same level of agency since people will sit and experience a show according to a set program. But the web portal and hands on activities introduce choice. We create multiple entry points and opportunities for people to engage in the content presented in a planetarium show, giving people more agency in their learning.

Finally, a key component of how people learn science is they need to feel like they are someone who can learn science (NRC, 2009). As a result, we need to support a science identity for learners. Learners need to feel like they belong to choose to learn more, to be interested, and continue learning. There are numerous ways for people to build a science identity. One is through role models, seeing people who are like them represented in science. Identity, in general, is very complicated as well. People have multiple identities related to their families, cultures, languages, interests, etc. They do not exist in a vacuum relative to one another (Shanahan, 2009). To support a positive science identity, it is also critical it is something that can be integrated with other identities or not be in conflict with one another. As a result, a planetarium show and additional materials should somehow address the multiple facets of doing science so there are more opportunities for building a science identity.

How these elements work together and are addressed will be determined by a project's learning goals. For this project, our focus and learning goals are helping people understand why Chile is an ideal place for astronomy, that big astronomy requires a lot of people from diverse backgrounds, and that there are numerous careers involved in making science happen. We also have a separate goal of helping create an informed citizenry to support the movement of more people into STEM careers as the demands for such employees rises.

This implementation of the Dome+ model addresses these issues of identity, agency, and interest by adding a web portal and hands-on activities. The web portal and hands-on activities give multiple points of entry into the content surrounding the show so people can have that agency in what they learn and how they learn it. The web portal in particular will support people in having an easy to access way of continuing their learning directly for the show. Finally, all three weave in different methods of addressing identity. The show, web portal, and live events focus on interviews and conversations with people who work at the observatories. They show diverse jobs that combine different interests, but also will show people as well-rounded with other interests and identities outside of science. This helps emphasize that people can and do have different interests that might attract them to jobs in STEM. These "stars" of the live events can act as virtual role models for students or for adults to point students toward. The hands-on activities also feature specific activities around astronomy through different cultures to emphasize further the idea of integrating cultural and linguistic identities and astronomy.

The Dome+ model is informing and being refined through this project with a major goal of creating a guide for other planetarium show producers and projects to follow in order to extend learning beyond the dome—hence Dome *Plus*. We see other implementations being made after this with different learning goals and specific hands-on and web-based activities. It might night look exactly like this project, but the issues of agency, identity, and interest should still be addressed.

To actually study this, we will be collecting data from our web portal through google analytics to see how often people visit the website, click links to live events, and where they linger on the site. We will also look at the comments and reach of participants on social media events where legally possible. We will also conduct surveys and interviews with audience members immediately after shows at various planetariums around the country and in different in different types of settings. From those initial interviews and surveys we will recruit families for more longitudinal interviews weeks to months after the first visit to see how they use the resources and what motivated them to use them. Finally, we will also interview planetarians who are running the show in order to understand how they used the hands-on activities and encouraged people to visit the site and learn more.

Research will begin in earnest when the show is released in May 2020.

How to get Involved

Planetarians will be integral for getting the word out about all of the opportunities available through the *Big Astronomy* project. Please sign up for our newsletter at bigastronomy.org and follow our social media pages for STEM career highlights and more.

We are also looking for planetariums to commit to playing *Big Astronomy: People, Places, Discoveries* in their domes. It is our hope to be the first planetarium show to have a day and date release, so we would also like planetariums to agree to join us in the worldwide release of the show on May 2nd, 2020. Finally, we will be looking for a select number of test domes for research purposes. This may include interviews with your staff, public, and possibly site visits. If you are interested in the research component of the project, please email us at bigastronomychile@gmail.com

Big Astronomy is a collaboration between Abrams Planetarium at MSU, Associated Universities Inc. (AUI), Association of Universities for Research in Astronomy (AURA), Astronomical Society of the Pacific (ASP), California Academy of Sciences, Peoria Riverfront Museum, Ward Beecher Planetarium at YSU, Cerro Tololo Inter-American Observatory (CTIO), Gemini Observatory, Atacama Large Millimeter-submillimeter Array (ALMA), Large Synoptic Survey Telescope (LSST), and is supported by the U.S. National Science Foundation (Award #: 1811436).

Bibliography

Falk, John H., & Dierking, L. (2000). Learning from Museum: Visitors experiences and their making of meaning. Walnut Creek, CA: Altamira Press.

Falk, J., & Storksdieck, M. (2005). Using the contextual model of learning to understand visitor learning from a science center exhibition. Science Education, 89(5), 744–778.

Lelliot, L. D. (2007). Learning about astronomy: A case study exploring how grade 7 and 8 students experience sites of informal learning in South Africa. University of Wiwatersrand, Johannesburg, South Africa.

Minstrell, J. (1989). Teaching science for understanding. In L. B. Resnick & L. E. Klopfer (Eds.), Toward the thinking curriculum: Current cognitive research (pp. 129–149). Alexandria, VA: Association for Supervision and Curriculum Development.

National Research Council. (2009). Learning science in informal environments: People, places, and pursuits. (P. Bell, B. Lewenstein, A. W. Shouse, & M. A Feder, Eds.). National Academies Press.

Posner, G. J., Strike, K. A., Hewson, P. W., & Getzog, W. A. (1982). Accommodation of a scientific conception: toward a theory of conceptual change. Science Education, 66(211- 227).

Ridky, R. W. (1975). The mystique effect of the planetarium. School Science and Mathematics, 75(6), 505–508.

Schmoll, S. (2013). Toward a Framework for Integrating Planetarium and Classroom Learning. Unpublished Dissertation. University of Michigan.

Shanahan, M. (2009) Identity in science learning: exploring the attention given to agency and structure in studies of identity, Studies in Science Education, 45:1,43-64.

YOU, TOO, CAN HAVE A DARK SKY PARK NEAR YOU!

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__Abstract:__ **Through the efforts of the Champaign County Forest Preserve, the Staerkel Planetarium, and the Champaign-Urbana Astronomical Society, we now have the very first (and only) Dark Sky Park in Illinois in Champaign County. This paper will detail the process of working with the International Dark Sky Association to secure Dark Sky Park status for the Middle Fork River Forest Preserve and what you can do to get a Dark Sky Park near you!**

Background

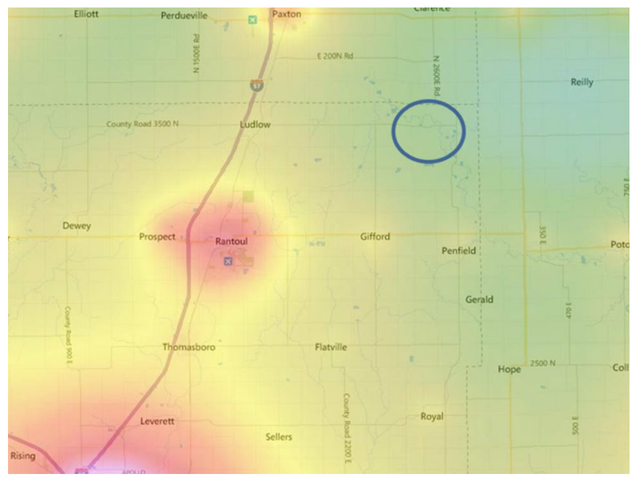
The International Dark Sky Association (IDA) came into being in 1988 to help protect and preserve the night sky as a natural resource. In 2001, they instituted a program of "Dark Sky Places" to recognize local efforts to further their mission. "Places" can be "Dark Sky Communities" (towns which have enacted lighting standards), "Reserves" (larger areas), "Sanctuaries", and "Dark Sky Parks." A "Dark Sky Park" is a "publicly- or privately-owned space protected for natural conservation that implement good outdoor lighting and provide dark sky programs for visitors." A current park list may be found at https://www.darksky.org/our-work/conservation/idsp/parks. Though the list is increasing all the time, as of September 4 there are 76 Dark Sky Parks on the planet, with 54 of these being in the United States. In the GLPA region, there are only five: Newport State Park (Wisconsin), Headlands (Michigan), Geauga Observatory Park (Ohio), Cherry Springs State Park (Pennsylvania) and now the Middle Fork River Forest Preserve (Illinois). *That's it!*

If you are thinking that no place in the Midwest is as dark as the Grand Canyon, know that there are three levels of Dark Sky Park status: Gold, Silver and Bronze. It does not have to be as dark as the Chilean Andes, but policies, procedures, and programming must be put in place that value the night sky.

"So Why Do You Want a Dark Sky Park Nearby?"

A "Dark Sky Park" recognizes efforts put forward to protecting a valued resource—our night sky. Though local wildlife benefit from the absence of stray light, for humans it raises awareness of light pollution, not only at the park, but in surrounding communities. It also creates "astro-tourism." There is even a travel magazine devoted to this (https://www.darkskytravels.com). We have found that, after DSP status was attained, visitors from urban areas like Chicago and Indianapolis increased. The campground at the Middle Fork is often full with each visitor given information on why dark skies are protected here. They take this information back home and the word spreads. It creates programming space for astronomy outreach and even promotes your planetarium.

How to attain DSP status: Step #1 – Identifying a space



As the definition above states, you can't have a "park" in your backyard. There must be public access, it must be maintained, it offers frequent educational programming, and it should be relatively dark. Astronomy clubs are always looking for such spaces and forest preserves outside of the city are a good place to start.

The Champaign-Urbana Astronomical Society (CUAS) formed in 1986 out of the Halley's Comet frenzy. Club members have a history of advocacy for a dark sky. They secured a grant to publish a newsletter to raise awareness of light pollution, created static light pollution displays, and have given many talks on the topic (including the Champaign City Council). The forest preserve contacted CUAS in 2007 to see about offering dark sky observing to the public and, since then, CUAS has offered several "Starwatch" programs annually at both the Middle Fork and Home Lake.

Identify a space near you. You can find global light pollution maps at https://www.lightpollutionmap.info. Can improvements be made, such as shielding light fixtures? Can you be there at night? It is important to measure the skylight at the site using a "Sky Quality Meter (SQM)." You can find these on Amazon for $130. They'll give you a reading measured in "magnitudes per square arc second." We attained 21.38 at our site. Multiple readings are required given variations in sky glow, humidity, and even the position of the Milky Way. John Stone, a member of CUAS rigged an SQM on a tripod connected to his computer. The SQM operated through his car's removable Moon roof, taking readings every minute. Thus he made a light pollution map of the county. From this we determined the Middle Fork River Forest Preserve was indeed one of the darkest spots in Champaign County!

Step #2 – Determines who governs the space

Who oversees the site near you? Is it the city? County? State? The Champaign County Forest Preserve District (CCFPD) operates six preserves in the county encompassing more than 4000 acres. The largest is the Middle Fork River Forest Preserve in the northeast portion of the county. The Middle Fork boasts on-site camping with swimming, an Activity Center, and a waterfowl management area. The CCFPD utilizes a Citizen's Advisory Committee (CAC) to provide public input on facilities and programming.

In 2012, DSP guidelines were sent to the Middle Fork site supervisor to see if there was interest. We received no reply. The issue did not arise again until 2015 in a casual conversation with CCFPD programming coordinators. Later that year, I was asked to present to the CAC. The CAC voted that night to accept the Dark Sky Park initiative as a project. They immediately divided up tasks and put a game plan into place.

Step #3 – Present to the governing body

In your case, ask to present to a governing body at one of their regular meetings. It is key to win over the people in charge! First read the Dark Sky Park guidelines (https://www.darksky.org/wp-content/uploads/2018/12/IDSP-Guidelines-2018.pdf) and be ready to answer their questions. In your presentation, be sure to include:

What is light pollution? (Most don't consider light as a pollutant).

What are the causes of LP and its consequences? Be careful *not* to initially mention astronomy. Many think heavily-lighted areas are free of crime, but statistics don't support this (https://www.darksky.org/light-pollution/lighting-crime-and-safety). Reflecting light downwards can actually *save* money given that a lower wattage bulb will supply the same illumination with a reflector. You can demonstrate this if you have a light meter and light shield. The Hubbell Sky Cap has been discontinued but you can manufacture your own shield/reflector. Knowing a project may pay for itself through cost savings over the long run is vital.

Discuss the DSP program, the process for being awarded status, and the advantages. "Astro-tourism" is a new buzz word!

They'll ask about the benefits of becoming a DSP, the costs involved, the time involved, the application process, and any follow-up reporting. If you are involved with a local astronomy club, get the club to help with the paperwork, especially with any night photography and sky quality measurements.

IDA has wonderful Powerpoint slides, kid's games, pdf documents, and brochures online.

Step #4 – the "Lightscape Management Plan"

At the heart of the DSP application is the "Lightscape Management Plan (LMP)," a comprehensive document that includes:

Mention of any local lighting ordinances and/or policies already in place. City? County?

Park policy to determine what needs to be lighted at night and at what times.

A map showing lighting zones (stated by the IDA) defining acceptable ambient light

A commitment to fully-shielded fixtures throughout the park

Park policy for types of lamps used (including color and efficiency). Lamps should not exceed 3000K and be less than 500 lumens.

A lighting inventory of what already exists at the site, what can be removed and what is in need of retrofit.

Familiarize yourself with the LMP and its parts. Many examples appear online at the link stated in the background paragraph. Choose a park that is similar to the one you are working with and see what they included. Why re-invent the wheel?

At the Middle Fork, globe lights were the standard, being installed in the 1980s. Preserve employees began looking at new fixtures in early 2016 and found ones they liked at the St. Louis Zoo! They also found they were horribly expensive. The solution? *They built their own fixtures!* Weather-testing occurred in the summer of 2017 and the retrofit began later that year. Seven fixtures were removed, 14 of 18 building fixtures were upgraded, and 17 roadway globe lights were replaced. The district budgeted $22,500 in fiscal 2017 and grants from the Community Foundation and the Illinois Clean Energy Community Foundation helped complete the transition. The changes can be phased in over time—IDA allows for this. No one likes to be rushed, especially governmental bodies!

Step #5 – "What else is involved before applying?"

Here are a few other suggestions before applying to the IDA:

Take photographs, not just documenting progress, but day and night photos of the area. A good night Milky Way image is a real seller! The IDA likes to have 360 degrees of horizon photos of your site showing sky glow.

Arrange for letters of support. For the Middle Fork we contacted the mayors of surrounding communities (each was happy to oblige), the local convention & visitors bureau (who were happy to promote a new kind of tourism), state politicians, museum directors, park district leaders, county officials, and local college/university officials (especially if they have astronomy departments)

Get the local media involved. Most will not have heard of this type of endeavor and will be anxious to cover it. Publicize this at your planetarium. Maybe even put a light pollution display in your lobby. Acquire and present "Losing the Dark" in your dome (https://www.lochnessproductions.com/shows/ida/ltd_downloads.html)

If you haven't done any education programming at your site, *start!* Get the local astronomy club to do an observing session there. Get people to visit, especially during "Dark Sky Week" usually in early April. Train local staff what it means to be "dark sky compliant" and that it doesn't mean shutting off all your lights. The more people you can get on board, the better!

Don't just push astronomy! Do your homework and learn what animals are affected by stray light at night. IDA has many resources for this.

Pass out brochures! Make your own OR use the printable versions offered by IDA.

Step #6 – "Apply for DSP status!"

There is no form, but the guidelines are online at the IDA web site. A member of IDA must nominate the area for the status. If there are no local members, why not join yourself? It's $35 annually and the application is online. We found the IDA to be very helpful! An IDA liaison looked at several drafts of our application and made suggestions before it went to the committee for a decision. There are three applications deadlines each year—*get them on your calendar!* If the work on site is not quite done, you can apply for provisional status, which allows for extra time to complete tasks. If your efforts are successful, there is an annual report to file with IDA every October 1st. The Champaign County Forest Preserve sent in their final application (https://darksky.app.box.com/s/pcz7cn5uy0ogr1l0a9nex55nw204ugpi) in July of 2018 and we were granted Dark Sky Park status, the first in Illinois, at Thanksgiving time later that year.

Let's spread the word that dark skies are worth preserving!

Interpretative sign at the Middle Fork

A SUPER CERNAN SAMPLER

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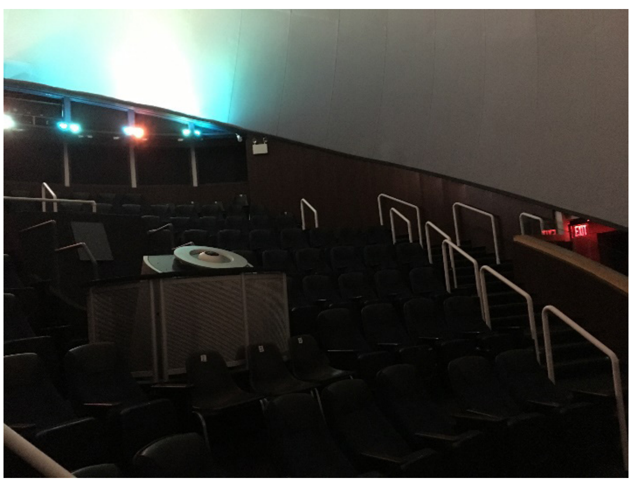
Abstract: The Cernan Earth and Space Center has been busy over the last year working on a wide range of projects involving BSA, FLL, DMX, E&S, MSFC, WTTW, W2W, and more.

The Cernan Earth and Space Center has faced some challenges and achieved some victories over the past year. Here are some of the highlights.

DMX = digital multiplexer

Cove lighting is pretty common in planetariums but is not found in all domes. Some unidirectional theaters have installed large flood lamps behind the audience to wash the dome in light and color. This works but can appear harsh or shine directly into people's and the presenter's eyes.



Some theater architects neglected to take into account the unique environment of the planetarium and put no effort into lighting design. In our case, there was no cove at all, let alone space for lighting or other projectors around the dome perimeter. You walked in to an otherwise conventional theater.

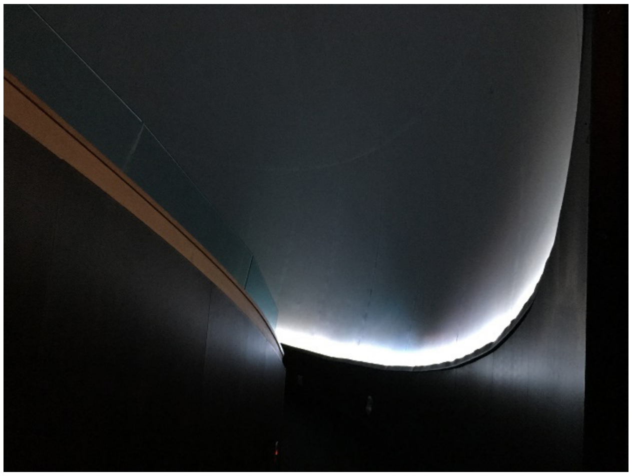
Cove lighting by its very nature can create an ambience. First there were "lumalines", 12-inch tubes with their delicate filament running end to end. There would likely be a huge manually operated potentiometer at the console to dim those lights up and down as desired. One can imagine the faint light shining on the dome from behind the classic cut out 'skylines' that were common in those classic planetariums.

In the late 70s, lumalines were replaced with standard light bulbs and sockets. Bulbs were either translucent or opaque. The see-through glass yielded more vibrant color, while the opaque glass offered a more diffuse glow.

Enter the 90s, and DMX made it possible to control whole lighting systems and even individual fixtures with a computer. DMX "originated as a way for lighting manufacturers to build fixtures that would all be compatible with each other, instead of having individual control stations for each set of lighting."

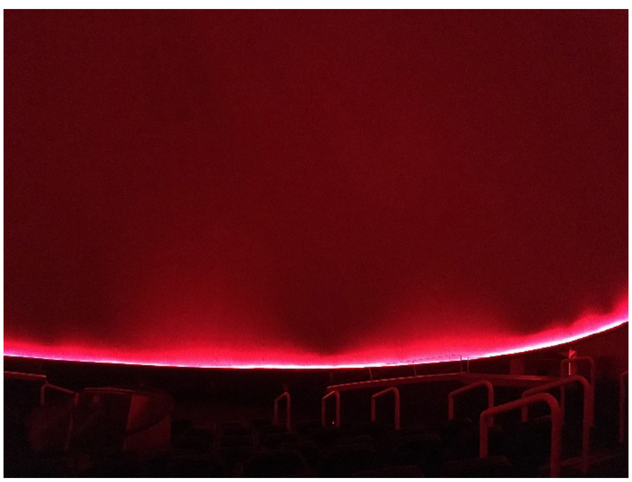
Incandescent bulbs have now been mostly supplanted by LED systems, but all that capability comes with a cost when purchased from the vendors. Now, don't be offended! The commercial systems are beautiful, well-designed, and powerful, but there are some domes where limited funds required a choice between new programs or mood lighting. The programs almost always win out.

When I arrived in Chicago in September 2015, I sorely missed having cove lighting to provide even illumination and set the stage for the special magic about to occur. I talked with several vendors, and they all tried to help us find an economical solution, but the theater design and budget just did not work at the time.



About that time Phil Groce, Michael Mocherman, and others devised a DIY cove lighting option using off the shelf consumer components. It would take two years before we could even start the project.

The first challenge was identifying material to create a trough for the LED strip lighting but could not stick out past the acoustic wall. Add to that the short wall at the front of the dome which meant we needed something that would stand up to kids, adults, and equipment bumping into it.



After much research, googling, and experimentation, we decided to use rubber stair nosing that could be riveted to the top of the acoustic wall panels. The rubber is rigid enough to hold its shape and flexible enough to not hurt anyone should they brush or fall against it.

The major challenge arose while installing the rubber molding around the dome base. The wall and dome are not the same diameter all the way around. Joe Schultz, one incredibly patient human being, spent a great deal of time trying to keep the cove molding the same distance from the dome material in the hope of having a consistent lighting effect. He succeeded in some places and not so much in others.

The dome itself is not in great shape with visible rivets and seams, divots and bumps all over, and just not being a smoothly rounded hemisphere. As time allows, I would like to experiment further with the distance and angle of the lighting strips, but for now, we have some cool colors, and it feels more like a planetarium.

FLL = First Lego League

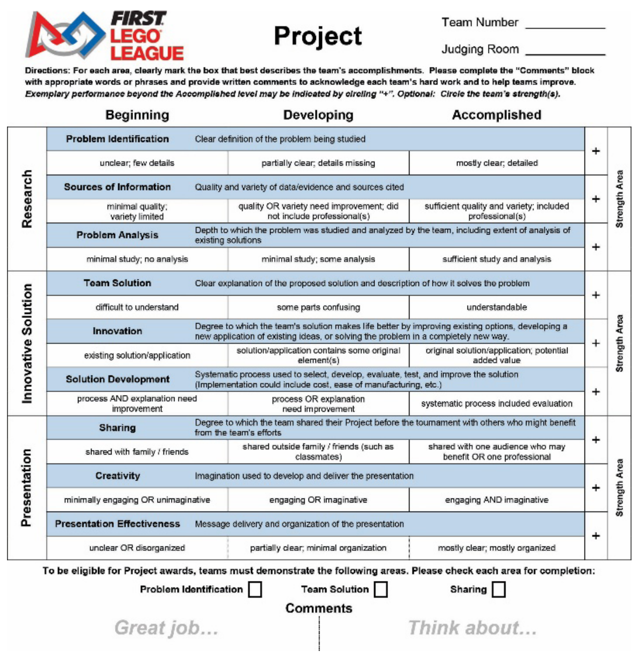
Many of us are familiar with the FIRST Robotics Competition where high school students build complex robots and then combine into teams to accomplish specific tasks and earn points while battling an opposing team in the arena.

There are also starter programs for middle school and lower elementary students where they have to ask questions, conduct research, propose solutions, build projects, and make presentations.

Of course, the theme for all the FIRST programs during the 2018-19 school year was built around space exploration and the 50th anniversary of Apollo 11. I was not aware of any of this until I received a call in fall 2018.

(insert Mission Impossible theme music here)

Your Team's INTO ORBIT Project Challenge:



FIRST LEGO LEAGUE

Project

Team Number __________

Judging Room __________

Directions: For each area, clearly mark the box that best describes the team's accomplishments. Please complete the "Comments" block with appropriate words or phrases and provide written comments to acknowledge each team's hard work and to help teams improve. ***Exemplary performance beyond the Accomplished level may be indicated by circling "+". Optional: Circle the team's strength(s).***

		Beginning	Developing	Accomplished		
Research	**Problem Identification**	Clear definition of the problem being studied			+	Strength Area
		unclear; few details	partially clear; details missing	mostly clear; detailed		
	Sources of Information	Quality and variety of data/evidence and sources cited			+	
		minimal quality; variety limited	quality OR variety need improvement; did not include professional(s)	sufficient quality and variety; included professional(s)		
	Problem Analysis	Depth to which the problem was studied and analyzed by the team, including extent of analysis of existing solutions			+	
		minimal study; no analysis	minimal study; some analysis	sufficient study and analysis		
Innovative Solution	**Team Solution**	Clear explanation of the proposed solution and description of how it solves the problem			+	Strength Area
		difficult to understand	some parts confusing	understandable		
	Innovation	Degree to which the team's solution makes life better by improving existing options, developing a new application of existing ideas, or solving the problem in a completely new way.			+	
		existing solution/application	solution/application contains some original element(s)	original solution/application; potential added value		
	Solution Development	Systematic process used to select, develop, evaluate, test, and improve the solution (Implementation could include cost, ease of manufacturing, etc.)			+	
		process AND explanation need improvement	process OR explanation need improvement	systematic process included evaluation		
Presentation	**Sharing**	Degree to which the team shared their Project before the tournament with others who might benefit from the team's efforts			+	Strength Area
		shared with family / friends	shared outside family / friends (such as classmates)	shared with one audience who may benefit OR one professional		
	Creativity	Imagination used to develop and deliver the presentation			+	
		minimally engaging OR unimaginative	engaging OR imaginative	engaging AND imaginative		
	Presentation Effectiveness	Message delivery and organization of the presentation			+	
		unclear OR disorganized	partially clear; minimal organization	mostly clear; mostly organized		

To be eligible for Project awards, teams must demonstrate the following areas. Please check each area for completion:

Problem Identification ☐ **Team Solution** ☐ **Sharing** ☐

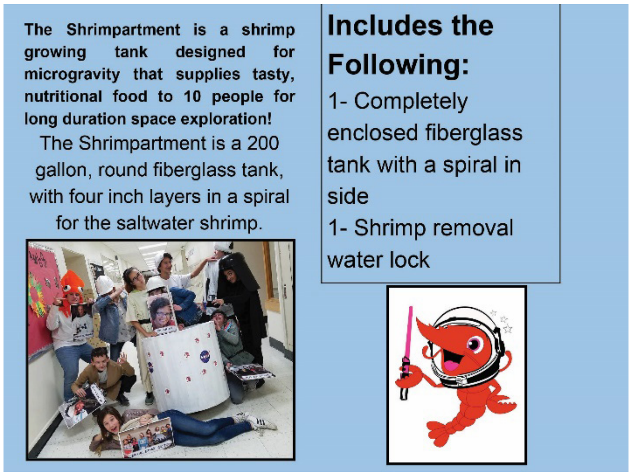
Comments

Great job… | *Think about…*

Have your team identify a human *physical* or *social* problem faced during long duration space exploration within our Sun's solar system and propose a solution.

Just getting humans safely into space for a short time is enormously hard. Designing and building rockets, spacecraft, and basic life support systems is one of the most complex tasks humans can do. Now imagine your mission to explore the solar system will last for a year or more. How will you cope with the physical problems your crew will face?

This was the challenge for middle school.



A number of teams came to the Space Center to learn about space exploration in general. Several saw *Dawn of the Space Age* in the planetarium which I thought was important because it provided them with background and context for the challenge

In addition to growing food in space, getting proper nutrition, and doing enough exercise, a surprising number of groups investigated how to maintain good mental health. Solutions included meditation, yoga, robot companions including a pet, plus board games and electronic games that evolve during the course of the mission.

The students talked to physical therapists, nutritionists, and psychologists before they came to see me. One group called an astronaut to get his perspective on their chosen problem and recommended solution.

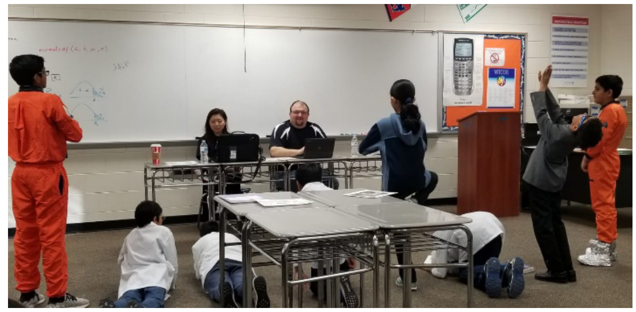
Many teams came to ask questions and have discussions. Most had chosen a topic and already done quite a bit of research. I think they reached out to the Space Center to help fill in the gaps and identify connections between their various sources.

I was able to share information, but I also asked JPL and others for references I could pass along to the various teams. These students were not afraid to dig into the science and mechanics of their problem, and I learned a lot along the way myself.

I knew I didn't have all the answers, so I asked them questions to get them thinking. What if? What do you know about X? What happens if Y? I just wanted to point them toward a possible path and let them run down it.

Once a team assembled all their research and conclusions, they had to give a live presentation before the judges. Every team member had to participate. The talk could not run longer than five minutes, but it had to include a list of specific details to score well.

Now imagine up to nine students ranging in age from nine to thirteen reciting complex information, while acting or using props, maintaining a storyline, and being timed. These turned into tightly scripted and rehearsed performances. Many were quite clever and funny.



Several groups did their presentations for me before going to competition: some in person and some via skype. This gave me the opportunity to coach them on speaking loudly, clearly, and slowly enough for the judges to understand the material; and don't play with your hair or pick your nose while on stage. I also suggested costumes or other actions to keep it engaging.

Over the course of three months I worked with 17 different teams from across the state; some in person and some just by email. One went to state, but I do not know if they went any further. Regardless of their final results, I met dozens of enthusiastic and curious young people who may very well get us to the Moon, Mars, and Beyond.

BSA = Boy Scouts of America, now known as Scouting USA

A five-minute conversation with the Vice President of Business Services about helping scouts earn merit badges has grown into an annual event mainly through the efforts of Johnathan Nelson, our Planetarium Educator.

In early 2017, Johnathan reached out to the Pathway to Adventure Council of northeastern Illinois to ask how we could collaborate. It didn't take long for them to agree Triton College has unique facilities and expertise to assist scouts in completing some of the more specialized or challenging badges. The first Merit Badge College was held in December 2017 and had 100 scouts attend.

Scouts register online in advance for two three-hour sessions from a list of badges. This year, nine of the badge workshops will utilize Triton facilities including welding, architecture, and robotics plus the obvious astronomy and space exploration. Most badges have prerequisites the scouts are expected to accomplish and bring with them to Merit Badge College in order to complete the badge.

The automotive maintenance badge requires both three-hour sessions to complete. During that time, the scouts get plenty of hands-on experience in the lab where service technicians for Honda and other carmakers are trained.

College professors receive a stipend for teaching these classes, but they also must qualify to be merit badge counselors, meaning they have to pass a background check, participate in Youth Protection Training, and adhere to stringent rules for interacting with all scouts.

The registration fee is proportionally split between Triton College and the Council. The College provides facilities, custodial services, and security for the event. The Council handles all the promotion and registration and organizes presenters for other workshops such as public speaking and Citizenship in the Nation that can meet in a standard classroom.

Registration has already surpassed 2018, and we are still four weeks away from the event. By the way, the Pathway to Adventure Council was one of the early-adopters admitting girls into packs and troops, and we have seen plenty of girls participating in Merit Badge College.

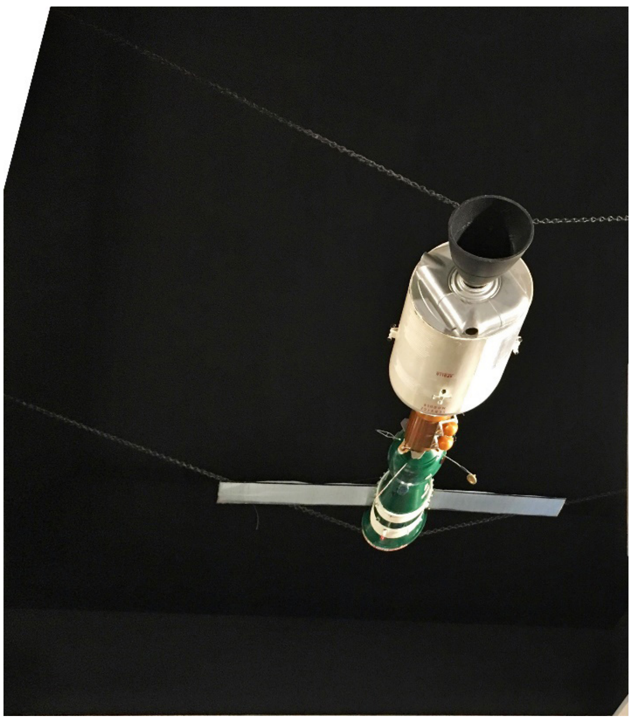
MSFC = Marshall Space Flight Center

In March 2019, the Property Manager at MSFC called about the status of several models which have been on loan to the Cernan Earth and Space Center for about thirty years. I confirmed the four models were still here and three were currently on display.

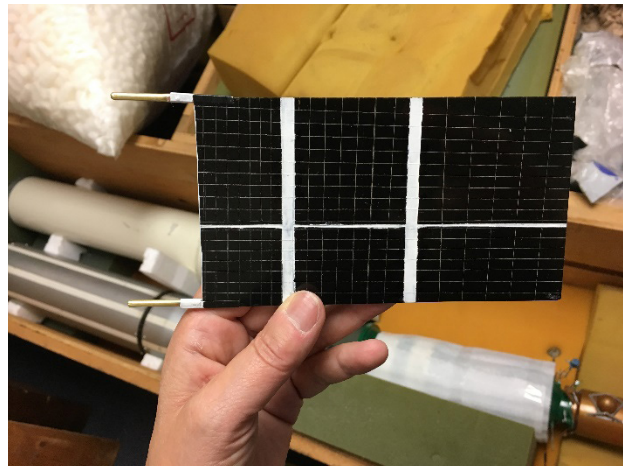
In early June 2019, I was instructed to write a letter to Property Disposal requesting donation of the models to the Space Center. But just as I was about to start writing a letter, MSFC called again and asked us to crate and ship all four models back to them for evaluation.

Taking the models down was easy. Cleaning them thoroughly took time. When something has been there so long, you stop paying attention to the details, and the dust starts to collect.

Upon closer inspection, Explorer 1 had turned yellow, but a little cleaning and she is white again.



Apollo Soyuz had undergone some not so pretty repairs over the years, but a little cleaning and touch up paint made a big difference. We also discovered the Soyuz solar panels were not only poor substitutes for the originals, but they were actually about 30% too long for this mission. Joe Schultz, our technician, fabricated simple replacements to return to MSFC.



I regret not taking better care of the models. I hope they might come back to us in the future, but if not, they will go to a new home and be enjoyed.

In the meantime, I'm not sure what we will do with the two large empty ceiling openings. Maybe you have some suggestions?

Fortunately, we have not been asked to return the Space Shuttle. That would be a major pain to crate and ship. However, knowing what I do now about the condition of the models, we will be giving Challenger a thorough cleaning in the coming months.

E&S = Evans and Sutherland

In late June and early July we completed another phase in our incremental improvements. Bowen Technovation finished up the addition of rear and center channel speakers giving us 5.1 surround. E&S came in and upgraded our software and computers to D6 which has already had an impact on a variety of presentations.

BP 213 = Boilerplate space capsule

After more than 30 years and at least 15 coats of paint, the time came to get our Apollo capsule squeaky clean. This is what it looks after being pressure-washed with at 40,000 PSI. All done and cleaned up in less than a day.

Naked like this, the capsule almost looks like it has been in space. Unfortunately, we can't leave it unprotected. The Triton College welding professor is going to grind down repairs during the winter break, and we are working on a more interesting paint scheme since this is our prime photo op location.

W2W = World 2 War

We talk a lot about using the planetarium for non-traditional programming. Here is a show that allowed us to be topical and impactful. The description of the show is:

World War 2 began in 1939. World 2 War combines fulldome, cinematic battle scenes with informative overviews and historic imagery. World 2 War sets the stage for the conflict and puts the audience in the middle of World War 2's most crucial events!

Audiences have varied in age from the expected senior citizens to parents with children. One high-school student enjoyed the program but lamented it did not cover Italy or the North Africa campaign. I applaud the producers for getting as much history and context into 46 minutes as possible. I like how the script actually begins at the end of World War 1 explaining how we ended up in World War 2 less than 25 years later. We already have several school bookings for this progam.

One viewer commented about the animation of people not standing up to the quality of modern video games. It's definitely not photorealistic, but it's also not cartoonish. The animation achieves its goal of recreating key scenarios to convey the overall experience without being traumatizing. The program is not overly graphic nor does it downplay the nature of war and the heavy price paid by all.

For a transition from the show into our live sky talk after the feature, we can describe how the date for D-Day was chosen based on the phase of the Moon and the high and low tides that benefited the aircraft and their paratroopers and the Navy landing soldiers and equipment on the beaches of France.

WTTW = Window to the World Chicago PBS

To increase awareness and attendance in a big city full of big museums, the Cernan Center sponsored the "Summer of Space" on WTTW PBS Chicago. Every time "Chasing the Moon," NOVA, and other related programs aired, viewers saw a 30-second video produced by the Cernan Center staff before and after each show. You can see the video at bit.ly/33Rhm8w.

This video would not have been possible without the generous assistance of the producers of planetarium content and one composer musician.

Music *Cosmic Storm* by Jonas Erixon

Program clips courtesy of

California Academy of Sciences
Dutch Tilt Studios
E&S Digital Theater
European Southern Observatory
Heavens of Copernicus Planetarium
Mirage3D
Sudekum Planetarium at Adventure Science Center

EXPLORING THE USE OF FORMATIVE ASSESSMENT IN THE INTERACTIVE PLANETARIUM

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Abstract: Modern teaching strategies, like active learning, have consistently shown to move students toward a better and longer-lasting understanding in classrooms, yet are active learning approaches observed among planetarium educators' instructional practices? Because of the nature of planetarium learning environments, could assessment conversations serve as a pathway for planetarium educators to guide the teaching and learning process. Ruiz-Primo and Furtak (2006, 2007) developed a coding scheme to analyze assessment conversations known as the ESRU cycle. This study applies their coding scheme to planetarium presentations to analyze the presence of active learning in terms of this ESRU cycle.

The planetarium has long been established as a non-traditional environment for teaching astronomy. While planetariums are tacitly considered by many to be the best place to learn astronomy topics, it is becoming increasingly difficult for financially strapped school districts to justify field trip expenses as high stakes testing has increased pressure on teachers to focus on measurable learning outcomes. For planetarium visits to remain valuable to teachers, and the administration to whom they must justify the cost and time necessary for a visit, planetarium educators might benefit greatly by describing and documenting how the planetarium learning experience—and the teaching strategies employed during them—can help improve student outcomes.

Bishop (1980) conducted a two-group, pre-test/post-test comparison study of the impact of planetarium education on student outcomes, showing that employing purposeful learning cycles—the premiere active learning teaching strategy of the time—did measurably improve student achievement. Those learning cycles were student-centered and focused on the student experience with phenomena; however, that approach did not emphasize formative assessment, an assessment style where understanding is assessed throughout the learning process instead of at the end like summative assessment. Modern teaching theory suggests *active learning*, which is based on previous work on learning cycles, is the best way to improve student learning and achievement, especially when it includes a focus on formative assessment. Even though planetarium educators have been shown to improve student outcomes in the past when using learning theory to design instruction, it remains to be seen if, as modern teaching theory evolves, planetarium educators are also adapting and implementing the latest approaches in active learning.

Bonwell and Eison (1991) argue that using active learning strategies leads to improvements in student thinking and attitudes. Students who engage in active learning and think about what they are doing and learning (metacognition) tend to learn more and retain the information longer (Francis, Adams, & Noonan, 1998). One core aspect of contemporary active learning that differentiates it from its earlier implementations is promoting timely feedback to students regarding their learning and progress through a focus on formative assessment. Since a planetarium educators' main method of interaction and engagement with their audiences is through their voice, it seems natural that active learning in planetarium environments could easily take the form of assessment conversations, which are a type of formative assessment. Formative assessment, assessment *for* learning not *of* learning (Black, 1993), provides the continuous feedback to students on their understanding and helps to improve teaching and learning, since the teacher can also guide instruction based on the information gained from student feedback (Bell, 2000; Bell & Cowie, 2001; Black & Wiliam, 1998).

Neece, Sayle, Nyela, and Boyette (2013) investigated implementation of active learning strategies in live planetarium programs as indicated by interactivity between the presenter and the audience. In their study, interactivity was measured using evidence of formative assessment-oriented teaching techniques defined as "oral interactions between presenters and audience members" (p. 29). These "oral interactions" were refined as "verbal handoffs" and fell into two categories: (a) any moment a new voice is heard, and (b) any moment when the presenter asked a question with clear intent of getting a response. Thus, the level of interactivity for each program was defined as the "number of interactions during each program" (p. 29), and through this measure, the authors judged that some degree of vaguely defined interactivity (verbal handoffs) was occurring in planetariums.

The focus on and "oral interactions" by Neece et al. (2013) serves as a solid first step in studying formative assessment in planetarium presentations by investigating the amount of verbal exchanges. However, it lacked critical analysis in the quality of interaction or the extent of learning derived from planetarium educators' efforts. Researchers might get a better feel for the quality of the informal formative assessment practices in these presentations by considering the more extensive framework of assessment conversations (Duschl & Gitomer, 1997) in the context of the well-documented ESRU cycles by Ruiz-Primo and Furtak (2006, 2007).

Ruiz-Primo and Furtak (2007) define the ESRU cycles of interactive teaching as follows: In "ESRU cycles—the teacher Elicits a question; the Student responds; the teacher Recognizes the student's response; and then Uses the information collected to support student learning" (p. 57). The key piece of the ESRU cycle is the U, using the information to guide and support student learning. This *using* takes feedback to a deeper level beyond simply evaluating student contributions as right or wrong. "Those teachers whose assessment conversations were more consistent with the ESRU cycle had students with higher performance" (Ruiz-Primo & Furtak, 2006).

Context and Participants

The context of this study is within a planetarium environment. Planetarium educators from across the U.S. submitted audio recordings of their own planetarium presentations during 2017-2018. The participants all have had at least five years of experience as a planetarium educator. The participants were solicited via email and in person. All participants voluntarily submitted their recordings and the accompanying questionnaires. The planetarium educators chosen for this study fall within the above parameters and represent a variety of formative assessment level users.

Data Collection and Analysis

Solicited participants voluntarily submitted audio recordings of their planetarium presentation(s), demographic and contextual information via a questionnaire, and consent forms to an online database coordinated by the author. Eventually, all of these recordings will be coded using the ESRU coding scheme developed by Ruiz-Primo & Furtak (2007). Each AC within the recordings will be coded as complete or varying levels of incomplete (i.e. ESRU vs. E, ES, or ESR). They also will be mapped to two of the three domains of science education assessment: epistemic or conceptual (Driver et al. 1996, Duschl 2003). The social domain will not be included as it is necessarily an aspect of all AC, thus it cannot be separated from the others. The recordings will be quantitatively compared among presenters for number and frequency of ESRU cycles per minute. Frequency will be analyzed to normalize data for variable show length.

The goal of this overarching study is to better understand the use of active learning strategies in planetarium presentations to improve student learning. To do this, the first step is to gain a baseline of what is currently being done in planetarium presentations which active learning strategies are commonplace. The research questions guiding this study are:

What is the extent of formative assessment as part of active learning in live planetarium presentations observed as measured by presence of assessment conversations (ESRU cycles)?

What factors could be influencing the relative use of assessment conversations in planetarium presentations?

Once the current use of formative assessment-oriented active learning strategies among planetarium educators is better understood, steps can be taken to develop opportunities for professional development in order to help address the factors that might be serving as barriers to using assessment conversations. The ultimate goal of this work is to improve the use of modern teaching techniques in planetarium teaching to better understanding and retention for a wide diversity of students.

This presentation is an introduction to and update on this dissertation research.

SOLAR SYSTEM EXPLORERS:
A SHOW SERIES TO KEEP THEM COMING BACK

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Abstract: **The staff of the Minnesota State University Moorhead Planetarium developed a new show series to encourage repeat attendance and serve our families with younger children. The show, called Solar System Explorers, used a rewards-like system involving "passports", stickers, a certificate of achievement, and iron-on patches. This show is a four-part series exploring each planet, some moons, and a few dwarf planets. It was a huge success in our dome and we'd love to share what we did with the community.**

As a small planetarium almost completely dependent on ticket sales to operate, we need people to keep coming through the door. We have recently been trying new things to entice a larger audience and keep them interested in coming back. It can be difficult to get more than a one-time visit out of many families, but this was one way to encourage them to come back three or even four times!

The inspiration came from thinking about what my target audience is at this time. It seems to lie in families with young children. Parents are often looking for educational and fun experiences for their families that will not break the bank. Our ticket prices are already pretty low, so the problem was giving them something they wanted to come back for. Thinking about children and what interests them I came across the idea of "passports". Kids like to earn things; think of sticker/reward charts and kids *love* stickers!

Solar System Explorers Certificate, Passport, & Iron-on Patch

Thus, was born the idea of a multi-show event where kids could earn "badges" for touring our Solar System. I created a passport for which they would earn stickers at each show they attended. At the end, if they attended enough shows and got enough stickers, they would get a certificate of completion. They would be an official "Solar System Explorer" and receive an iron-on patch to prove it.

Solar System Explorers Poster

The Solar System Explorers (SSE) program is broken up into four different shows, based mostly on what stickers I could get to represent each show. We start off with Sun, Earth, Moon for Tour 1; Tour 2: Rocky Planets; Tour 3: Gas Giants; and Tour 4: Dwarf Planets and Moons. Within each tour, we also created mini-missions for the kids to investigate along the way, like comparing one planet to another. We did split each tour into two age ranges so we could better cater to the audiences. The first was called "Twinkle Tots" for ages 2-5, the second was called "Space Cadets" for ages 6-10. This worked well to specialize the content level for each learning level.

SSE took a bit of initial set-up, but once everything was created and ready to go, it was fairly easy to sustain. I ordered the stickers and iron-on patches in bulk online, and we created and printed the passports and certificates in-house. I created the marketing materials with the help of our students, and away we went!

The shows were a huge success and kids and adults alike were coming back again and again. We even had to open up a few extra tours for people who missed some of the first few tours. We hold one weekend each month for one tour so it spreads things out through the semester. We have chosen to offer these shows only through Jan-May to keep interest strong.

This program has been a great way to get repeat visits and garnered a lot of interest from our community. The kids loved the stickers and filling out their passports. The certificate and badge at the end are just bonuses. We found this to be a great success and I am happy to share more information with anyone else who might like to try it out.

THE RISE AND RISK OF SCIENCE IN AMERICA? A PERSONAL VIEW

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Abstract: An essay written for my 50th college reunion book. It describes advances in astronomy and planetary science since 1970 and considers the challenges to science education in America.

We have discovered the solar system in the last fifty years. We have unmasked untold wonders of the Universe. You have seen all this in print and on your computer screen. But we are in danger of losing the whole Universe. Since 1970, I have watched these discoveries as a planetary scientist and watched the risks as a science educator at a midstream state university.

Discovering the planets

In 1970, we knew the planets as distant worlds only grudgingly revealing themselves to telescopes. We knew that Venus was veiled with clouds, but didn't know what the clouds were made of or even whether the surface was hot or cool. We had a few pictures of craters on Mars sent back by the first spacecraft. We had only fuzzy pictures of cloud bands on Jupiter and Saturn. Uranus, Neptune, and Mercury were dots of light in a telescope. Of Pluto, we knew next to nothing, its size and mass mere guesses.

Then the veil was lifted. We sent forth an armada of robots to see the planets aright. Magellan, Mariner, Pioneer, Venera, Viking, Voyager, Galileo, Sojourner, Spirit, Opportunity, Cassini-Huygens, New Horizons, and more—brave names and bold missions. Streams of data and thousands of photos flew home. Radar from the circumnavigating Magellan pierced the battery acid clouds of Venus to reveal a world of exotic volcanoes and cliff-scarred continents too hot for oceans to wash. Vikings sped away to Mars. They coursed over colossal volcanoes, craters, canyons, and ice caps, and they landed to eat the dusty soil in search of life, but found they were alone. Sojourner, Spirit, and Opporunity rovers rolled across the Martian plains, sniffing ancient rocks, snaring signs of ancient water, and scouting for evidence of erstwhile life. Pioneers, Voyagers, Galileo, and Cassini rode the gravity lines to the outer planets, to Jupiter, Saturn, Uranus, and Neptune. Roiling bands of clouds and storms the size of Earth posed for the distant cameras and a score of moons become worlds in their own right. Huygens descended to the icy surface of frozen, cloud-covered Titan, the largest moon of Saturn. New Horizons sped by Pluto and its moon Charon in 2015, completing the reconnaissance of the classical planets. Our robots have carried our eyes and ears across the solar system, to all the planets. For the first time. All since 1970, in our adult lifetimes. We are a privileged generation. The planetary veil was lifted during our lifetimes, while we watched.

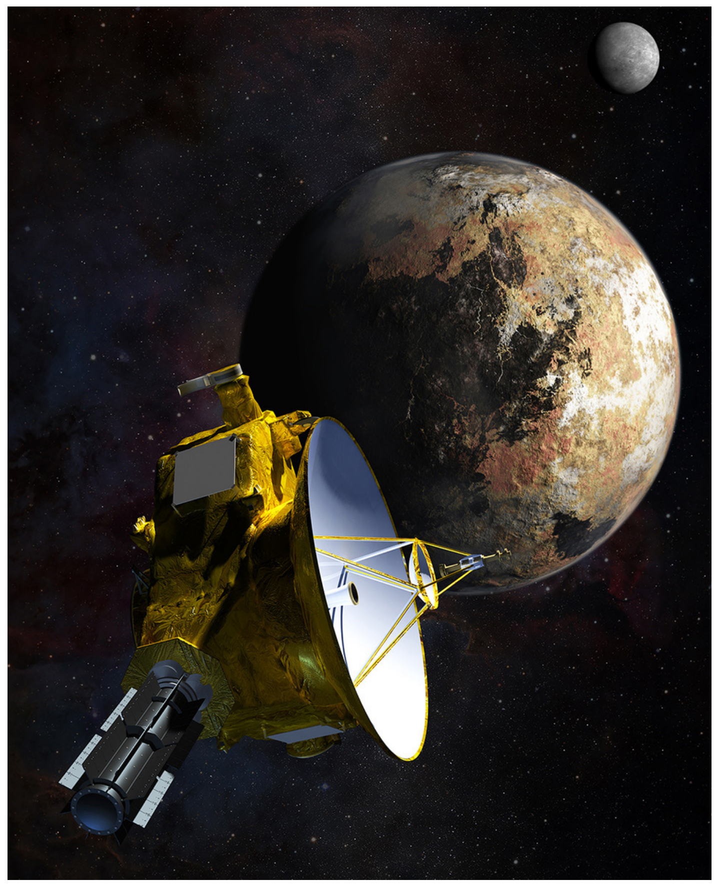

Figure 1. New Horizons at Pluto (artist's conception) 2015. Credit: NASA.

To the Moon

In 1970, we were in the midst of landing men on the Moon. Out of the cradle for the first time. And in our lives so far, the only time. Neil Armstrong took the first step ten months before our graduation from Colgate. Two years later, Harrison Schmitt, the only geologist among eleven test pilots, took a last step. Today, the six Apollo landers gather lunar dust, awaiting, perhaps, a rebirth some day as a remote national park. From the lunar rocks brought back, we gleaned the likely origin of the Moon—reassembled from a spray of rock wrenched away from the Earth when our planet was struck by an interloper the size of Mars more than four billion years ago. Today, the last of the great Saturn V rockets lies prone on the ground at Cape Canaveral, its engines silent, consigned to life as a museum piece. Today, we can no longer launch men to the Moon or even a Voyager direct to Jupiter. The 1995 Galileo mission to Jupiter had, for the lack of an adequate rocket, to be launched inward toward Venus to pick up the requisite speed to head outward.

Figure 2. Last liftoff from the Moon 1972. Credit: NASA.

Around 1420, Prince Henry the Navigator of Portugal set his sights to the south. He set his seaman feeling their way down the west coast of Africa, launching an effort that would cost as much as the Apollo program in terms of percent of GNP. By his death in 1460, they had barely rounded Cape Verde. Only in 1487 did Bartholomeu Dias reach around the Cape of Good Hope, and open the door to India. It had taken seventy years of perseverance. In 1497 Vasco Da Gama completed the journey to India, and tiny Portugal became a world power. We went to the Moon in a decade, beat the Russians, opened the door, and stopped.

New Technology Telescopes

In the early 1970s, I was fortunate enough to use the great 200-inch telescope atop Palomar Mountain for my dissertation research. Opened in 1948, it was still the world's largest working telescope nearly three decades later. Then Colgate classmate Mitch Ruda '71 went into optical design and later described to me a telescope project he was involved with. The Multiple Mirror Telescope would bring the light from six separate mirrors, each two yards across, to a single focus. I never believed it would work. In the mid-80s, I was using it, and yes, it worked. Today in Hawaii the twin Keck telescopes have light-collecting surfaces ten meters across: they are honeycombs of thirty-six separate mirrors, each polished to a millionth of an inch and computer-controlled so that to the astronomer, the ensemble acts like a single, huge mirror. Even bigger telescopes are in the offing, both to see first light in the 2020s. The US will see the Thirty-Meter Telescope in Hawaii and the Europeans are building the 39-meter Extremely Large Telescope in Chile. The ELT will have 798 hexagonal mirrors each 1.4 meters across acting in concert as if they were a single mirror bigger than the largest lecture hall at Colgate.

Figure 3. Twin Keck Telescopes in Hawaii. Credit: NASA.

The computer technology to control these multiple mirrors did not exist fifty years ago. Today it seems routine. The mainframe computer on which I did the number-crunching for my dissertation? The word-processor on which I'm typing this essay uses more memory than that mainframe had, and it occupies only a small fraction of my computer. You all have more memory in your home computer than that big mainframe had in the late 70s.

The Hubble Space Telescope has been snaring and sharing images of the cosmos since 1990. It was launched and then serviced by the now-retired Space Shuttle, itself just a dream in our student days. An even larger space telescope, the James Webb, is planned for launch in 2021 and will peer back almost to the beginning of time. The large ground-based telescopes—the existing ten-meter ones and the larger ones to come—have resolution (sharpness of view) that surpasses Hubble. With adaptive optics reshaping correcting mirrors a hundred times a second, these telescopes remove the blurring effects of the Earth's atmosphere, and they can be built much bigger than Hubble at a fraction of the cost.

With the Hubble and soon with its successors, we are unveiling the universe in richer detail than we could have imagined a generation or two ago. You can see the images on the news and you can retrieve them from the web on your computer. Colgate's first computer center was established in our junior year.

Invisible Universe

Since 1970, we have discovered planets around other stars—we now know that half of all stars have planets—and we have discovered that we cannot see most of the universe. Fifty years ago we thought that stars made up most of the universe—stars spaced with some interstellar gas between them and assembled into great collections called galaxies. Whatever the details, the universe was made up mostly of stars whose arrangement and inner workings we were figuring out. Then came the shock—the stars we can see make up only ten percent of the mass in the Universe. When we watch how these stars move, we can tell they are feeling the gravity of ten times more mass than we can see in any form. Nine-tenths—90%—of the universe is dark and we have no idea what the dark matter is. Despite much investigative work, we have realized to our humility that we still do not know what most of the universe is made of. We are in a room with a hundred people, but we can see only ten of them: ninety are still invisible and made of we know not what. For all we know, it could be oobleck. But in 1970, we didn't even know the other ninety were there at all.

Worse, there may be more energy in the universe than all the mass, both visible and dark, put together. In 1970, we knew the universe was expanding. The question was whether gravity was slowing it down enough to make it eventually collapse. Then in the late 1990s, we found that was the wrong question—the expansion isn't slowing down: rather, it is speeding up! Like an ascending rocket speeding up *after* the engines are turned off. The universe is destined to thin out into oblivion over the next trillions of years, blotting out all our achievements and aspirations. Isn't that a cheerful thought? But what powers the expansion's acceleration? Perhaps something the theorists call dark energy, though they have no idea what it really is. If this dark energy exists, it is the dominant form of energy in the universe, outweighing all the matter, both visible and dark. But it is completely invisible.

Light Pollution

We are in danger of making the universe invisible in another way as well. We are polluting our skies with light. Astronomers flee to remote, dark mountaintops to escape the urban sprawl and build their telescopes. But even here the light pollution creeps. The great telescope atop Palomar Mountain has lost half its ability to see as the bright skies of southern California creep up the mountain slopes like a plague. The electromagnetic chatter of human commerce threatens to drown out the faint signals that astronomers glean from distant stars and galaxies as they seek to decipher the secrets of the universe.

But it is not only the astronomers who lose. It is everyone. If you live in a city, perhaps you cannot see the night sky at all. Or if you can, it is only a vestige of what my grandfather, a farmer, saw. I live in a small city of barely 30,000 set among the farm fields of northwest Ohio, and we can see at best a third of the stars you could see in 1970 from the Colgate Observatory grounds near the president's house. We who operate planetariums are alarmed at the prospect of our theatres becoming sky zoos—the only places you can see a truly dark sky. When we can no longer see the sky for ourselves, we will have lost our roots.

It would be a sad irony if we were to lose the sky in the same generation in which we are discovering the role the sky played in the world-views of our forebears—discoveries spearheaded in so many ways since 1970 by the pioneering work of Colgate's own astronomer-anthropologist Anthony Aveni. To the first peoples of the Americas, to the Maya and Inca, to the ancient cultures of Africa, to the neolithic builders of Stonehenge, to the tropical navigators of the Pacific, the sky was a dark tapestry alive with the lights we now call the stars, planets, Moon, and Sun. The ancients knew the splendor of the sky and the dance of its intricate cycles. The sky was a calendar to them, the sky filled their rich mythology, and the sky inspired their architects to align buildings and streets with key celestial directions. The Maya turned building after building to face the setting of Venus. Today not one person in a hundred will even notice Venus, the brightest planet, when it dominates the evening sky. Some years ago, after Venus had dominated the evening sky for three months, when I asked a college class and a school class who among them had seen it, of over 120 people, not a single hand went up. We not only ignore it, we now try to shoot it down: the Luxor Hotel in Las Vegas aims a 40-billion-candle-power shaft of light to illuminate the sky for whoever would like to read a newspaper while floating at fifty thousand feet. Sacrilege, a Maya priest would weep.

Figure 4. Anthony Aveni and the author, Mexico, 1970. Credit: Jeff Fischbeck '71.

Figure 5. Caracol at Chichen Itza, Mexico, in foreground, is aligned with rising and setting of Venus. Credit: author.

Figure 6. Moon, Jupiter, and Venus in morning sky 2019. Credit: author.

Science at Risk

But we are losing the universe in an even more insidious way. From the heady heydays of 1970 when we were winning a contest to send men to the Moon, we have as a nation begun to lose interest in science. The Apollo program was one requiring an expensive initial investment followed by comparatively inexpensive subsequent flights. Yet once the initial investment had been made, the program was cancelled before the full scientific rewards could be reaped at a cost of only a few percent of the initial outlay. If we believed that we went to the Moon for science, we were living with an illusion. The science was a hitchhiker.

Physics was also a hitchhiker during the cold war. It had practical value because it had obvious applications to national defense. With the end of the cold war, US funding for physics has diminished. The Higgs boson, the long-sought particle that gives the universe mass, was discovered in Europe, not in the US. Europe is building the largest telescope. The American physics community has faced a time of readjustment.

It is an adjustment that astronomers can well understand. We have always been in a science in which the knowledge is acquired for its own sake, for the pleasure it brings to the discoverer, and for the insight and understanding it brings to the interested public and other scholars who learn from it.

Challenges to Science Literacy

Understanding the content of science is often a challenge to the lay person. The science of professional journals is cloaked in a complex web of precise technical jargon and the language of mathematics. To most people, including most college graduates, these are foreign languages. The science educator can translate the jargon and communicate the content in more colloquial terms. The educator can convey information, and thereby provide the opportunity for the recipient to obtain knowledge and understanding as well. But to gather either information or understanding, the recipient must bring proper learning skills. Today, these skills are often absent.

Despite the explosive growth of modern communication, many listeners do not absorb even basic scientific information. In one informal poll of graduates and faculty taken at a Harvard commencement, only two of twenty-three could explain why we have seasons, and in polls of other populations, many of those asked could not correctly identify that the Earth goes around the Sun. It is the tip of an iceberg of ignorance that descends far deeper. If I think the Sun orbits the Earth, why should I support the extravagance of a mission to another planet? Or could I understand the seemingly unrelated appeals to retain even the limited federal support for public broadcasting and for the arts?

Only if basic information is in hand does one have any chance of moving on to knowledge and understanding in the sciences. To make that move, one must also possess a basic level of numeracy and analytic reasoning and have the patience to internalize ideas. These skills are absent from the repertoire of an alarming number of American students today, if the populations I see in large classes at a midstream state university are any guide and if they bear out the results of surveys taken over larger samples of students. My colleagues and I see many students today who are unable to read graphs or do even simple math and who are unable to follow a chain of analytical reasoning. If these basic skills are absent, then access to the world of understanding beyond mere information is closed. Grasping the elegance and beauty of science and the conceptual splendor of the natural world is made impossible. Science becomes an alien world disguised as a morass of facts, largely incomprehensible facts whose primary value may be seen to lie only in whatever technical application they might have. To a scientist whose primary work is now in science education, these are tragic losses.

One late US President quipped that he did not understand his science courses at Yale, then proclaimed a program to make American students number one in the world in math and science. The challenge is much greater than he could have imagined, both in the lay population and for the smaller fraction who will choose science as a career. Many graduate programs in the physical sciences would be shut down or drastically curtailed for paltry enrollments if they were populated only by American-born students. General science literacy shrinks despite the wealth of discovery and the abundance of means for sharing that wealth. I fear that many scientists do not realize how far removed their world is from the world of the general population. Certainly I did not, either as an undergraduate or graduate student. Now with almost daily contact with general public audiences and with mass market college classes, it has become very clear, though many of my students would claim I still don't understand it.

Hope and Risk for the Future

I do not know if the battle for science literacy in this country will be won or even if it can be won. But the efforts being mounted are substantial. New federal science education standards have been developed. The National Science Foundation now requires an education component for many research grants. Societies of research scientists are paying more attention to education in their fields. New, more interactive teaching strategies abound.

Science museums and planetaria have wonderful new technology to help them communicate their message. Full-dome video technology has become the new norm in planetariums and with video that immerses the viewer, it can give awesome simulations of a host of science environments. You can see these simulations in many planetariums, including Colgate's own Vis Lab commanded by Joe Eakin.

Figure 7. Vis Lab at Colgate with fulldome image of Meteor Crater, Arizona. Credit: author.

We in planetariums see the excitement in the faces of our elementary school visitors (and sometimes in the faces of our older visitors) and hope the excitement can be maintained as these children grow. I am awed by the talent and dedication of so many of my colleagues at all levels of the educational ladder.

Yet the challenges to general science education are formidable and probably growing—the literate and numerate skills required, the patience required, the confusion of video information with internalized understanding, and the compartmentalization that besets most academic institutions.

In the 1950s, the English novelist-scientist C. P. Snow penned a little book called The Two Cultures in which he decried the gulf between the sciences and the humanities. Most of us were in fifth grade the year he wrote it. Sadly, I fear that little progress has been made in bridging that gulf in all the intervening time. But the tradition of the liberal arts sees all our separate fields in an interdisciplinary context. The physical sciences, the social sciences, the humanities, the arts, and the everyday world should be inextricably linked. The sciences and the other elements of our culture shape each other. As the tools of science to investigate the physical world grow sharper, we are challenged as a nation to maintain the scientific literacy to use those tools wisely and to integrate the understanding of the physical world in the broad context of human knowledge and endeavor. I suspect that the attendant risks and rewards are both greater than they were fifty years ago, and that the outcome is less certain than I would have believed then.

This essay reflects the musings of a liberally educated scientist/educator who passionately believes in the elegance of his science and in the placement of science in an interdisciplinary context, and who is deeply worried about the fate of science literacy in his country. The essay is a revised and updated version of a draft written for my 25th reunion classbook in 1995.

FESTIVALS OF CLASSIC SHOWS

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Abstract: In spring 2018 and 2019, we ran festivals of dozens of classic shows from our thirty years of operation prior to going fulldome, including both purchased shows and shows created at BGSU. All these shows had been digitized to run on our Spitz SciDome XD system. Strong attendance showed audience interest in these classic shows on a wide range of topics.

In 2014, we installed Spitz SciDome XD as our fulldome system (Figure 1).

Figure 1. SciDome XD console with Minolta console in background.

In thirty years of prior operation, the BGSU Planetarium had developed an extensive roster of classic slide-based planetarium shows, some including video segments. This roster included 64 purchased shows, 20 shows created at BGSU, and 11 additional shows acquired later from GLPA and Youngstown. I was determined that this roster not be lost as we moved into the fulldome era.

In fact, one of the reasons for choosing SciDome as our fulldome system was the prospective ease of encoding classic shows with its ATM-4 automation system. I have described this encoding effort in previous talks and papers. In 2011 (prior to acquiring SciDome), we digitized 24,000 show slides and organized them into folders by show and tray, in the process solving a host of folder organization challenges. In 2014, we did image adjustment (brightness, cropping, etc.) on all these scans. In 2014-2015, we digitized all the show soundtracks that had come in analog form and digitized video clips for all the shows that contained them. Then in 2014-2016, we entered cues in ATM-4 to control images, video, and sky sequences. I note that we did almost all of the cue entry with the projection lamps off; only after cue entry did we turn the lamps on and proof each show, correcting errors and tweaking the visual design as needed. We found that the digitized versions of the shows were superior to the analog versions: images were brighter, the soundtracks were brighter, the sky sequences were automated rather than run manually, and the visual design was improved and more flexible. Thus the shows were not only preserved, but also enhanced. Each show was completely self-contained, so to run it simply requires finding the file and pressing play. So each show will be available for the foreseeable future alongside the roster of fulldome shows.

Concurrently, we have built up our roster of fulldome shows. We funded this by spending down accumulated carryover from the operating budget (the result of very careful management for many years), using remaining funds from the renovation budget (which we ran under budget), a substantial gift from me, and matching funds from the Provost and the Arts & Sciences Dean. This one-time combination of funds gave me wide latitude in choosing purchases to cover a variety of topics and age levels. We have added additional shows more recently, funded primarily by gifts from me to make up for 40% slashes in our operating budget. This selection of shows is detailed in Figure 2. Altogether, we have now invested over $100,000 in fulldome shows.

INCLUDED AT INSTALLATION
Oasis in Space (Spitz)
Two Small Pieces of Glass (Imiloa)
IBEX (Adler)
Secret of the Cardboard Rocket (Clark)
Dawn of the Space Age (Mirage 3D)

FREE
Caesar & Socrates (Colgate)
Earth to Universe (ESO)
Back to the Moon for Good (Google Lunar X-Prize)
Hot Energetic Universe (ESO)

FUNDED BY CARRYOVER ($27236+)

GLPA
Cosmic Colors

MILWAUKEE PUBLIC MUSEUM
A Teenager's Guide to the Galaxy
Chasing the Ghost Particle
Cleopatra's Universe
The First Stargazers
Space Aliens
Did an Asteroid Really Kill the Dinosaurs?

FULL DOME FX
Stars to Starfish
Trip Through Space

GEOGRAPHICS IMAGING & CONSULTING
FireFall
The Alien Who Stole Christmas

LOCH NESS PRODUCTIONS
Light Years from Andromeda
Natural Selection (Mirage 3D)

RESOURCES

renovation surplus	15880
my gift (2016)	20000
A&S + Provost matching	20000
TOTAL RESOURCES	55880

order from Audiovisual Imagineering
Black Holes (Clark)
Exploding Universe (Clark)
Our Place in Space (Nashville)
Rusty Rocket (Nashville)
We are Stars (NSC Creative)
We Choose Space (Houston)

order from Spitz
Edge of Darkness (E&S)
Life Under the Arctic Sky (Mirage 3D)
Stars of the Pharaohs (E&S)
Tales of Maya Skies (Chabot)

order from Loch Ness
One World, One Sky (Adler & Beijing)
Undiscovered Worlds (Boston)

TOTAL OF ORDERS=$56075

2019 additions
($10100)

JENKS	MILWAUKEE
The Sky We Don't See	The Solar System Show
Compass, Calendar, & Clock	Sky Wars
Sistine Chapel	Spooky Space
My House Has Stars	Defying Gravity
Apollo 11	Cosmic Recipe

Figure 2. Budget for fulldome shows.

Our current roster includes 17 live interactive shows, 95 classic shows, and 44 fulldome shows.

Once most of the classic shows had been encoded, we ran them as part of our public show schedule. In spring 2018, we ran almost all the classic shows we had purchased. Given the number of shows, we ran most for just one or two showings. In spring 2019, we ran all the shows we had created in-house over the years. These we ran for a week each, or four showings apiece since we run public shows on Tuesday, Friday, and Sunday evenings and Saturday afternoon. This schedule is detailed in Figures 3 and 4. We had good attendance at these runs of classic shows, including visitors who returned to see several shows. I conclude that even in the fulldome era, well-done classic shows can be attractive to audiences and have educational value.

	year	show	source		console guide	
2018	1984	All Systems Go!	reel	F	no	
2019	1985	Star Tracks	IN		no	
2018	1985b	Springtime of the Universe	reel	F	no	
2019	1985c	Halley: A Comet's Tale	IN		no	with Youngstown
2019	1986	Planet Quest	IN		no	
2018	1986	Universe of Dr. Einstein, The	reel		no	
2019	1987	It's About Time	IN		no	
2018	1987	First Light	cass		no	
2019	1988	Journey to Earth	IN	V	no	
	~~1988~~	~~Mars Show, The~~	~~reel~~			OMIT (replaced by MarsQ
2018	1988	Stellar Thread, The	reel	F	no	
2019	1989	I Paint the Sky	IN		no	
2018	1989	Land of the Southern Cross	reel		no	
annual	1989	Secret of the Star	IN		no	
2018	1989	Footsteps	reel	F	no	
2018	1989	More Than Meets the Eye	CD		no	
2019	1990	People, The	reel		no	
2018	1990	Voyager Encounters, The	reel	F	no	
2018	1990	Little Star That Could, The	reel		no	
	~~1990~~	~~Secret of the Cardboard Rocket~~	~~reel~~			OMIT (have full-dome vers
2018	1990	Life Beyond Earth	cass		no	
2018	1990	Adventures Along the Spectrum	reel		yes	dialog with Prof Photon
2018	1990	Islands in the Sky	reel		no	
2019	1991	Sky Stones	IN		no	
2018	1991	Destination Universe	cass		no	
2018	1991	Larry, Cat in Space	reel		no	
	1991	Humanities and the Stars series	cass?		no	
	future	*Babylonian*	reel		no	
		Celtic	reel		no	
		Chinese	reel		no	
		Egyptian	reel		no	
		Eskimo	reel		no	
		Greek	reel		no	
		Hindu	reel		no	
		Mayan	reel		no	
		Norse	reel		no	
		Plateau	reel		no	
		Polynesian	reel		no	

2018		1991	Day the Earth Turned the Wrong Way	IN		no	Robin Streichler's show
	2019	1992	Water World	IN		no	
	2019	1992	New Worlds?	IN	V	no	
2018		1992	Bear Tales	cass		no	
2018		1993	Cosmic Catastrophes	CD	V	no	
	2019	1993	Seabird Show, The	IN	V	no	
2018		1993	Light-Hearted Astronomer, The	reel		no	
	2019	1994	Unworldly Weather	IN	V	no	
2018		1994	Endless Horizon, The	CD	V	no	
2018		1994	Serpents of the Sun	theirs		no	
2018		1994	Magellan: Report from Venus	reel		no	
	2019	1995	To Shine Almost Forever	IN	V	no	
2018		1995	Through the Eyes of Hubble	reel	V	no	
	2019	1996	Dinosaur Light	IN	V	no	
	2019	1996	They Found a World of Ice and Beauty	IN	V	no	Michael Kreutzfeldt's show
2018		1996	Don't Duck, Look Up!	cass		yes	dialog with Duck
2018		1997	Comets are Coming!	CD	V	no	
2018		1997	Cosmic Explorer	reel		no	
2018		1997	Star Stealers	reel	V	no	
	2019	1998	Alphabet Universe	IN	V	no	
2018		1998	In Search of New Worlds	CD	V	no	
	2019	1999	Is This the End of the World?	IN	V	no	
2018		1999	Magical Millennium Tour	CD	V	no	
2018		2000	Planet Patrol	reel	V	no	
2018		2001	Aurora!	CD	V	no	
2018		2001	Hubble's Universe (Images of Infinite)	CD	V	no	
2018		2001	Lunar Odyssey	CD	V	no	
2018		2002	MarsQuest	CD		no	
2018		2002	Saving the Night	CD		no	
2018		2002	Amazing Stargazing	CD	V	no	
	2019	2003	Star-Spangled Banners	IN		no	
2018		2003	Centuries	CD		no	
2018		2004	The Wright Way to Fly	CD	V	no	
2018		2004	RingWorld	DVD	V	no	
2018		2004	Transit of Venus	DVD	V	yes	show constellations
2018		2004	Space Dreams	CD	V	no	
		2004	Holst				OMIT (Jason's show)
2018		2005	Skywatchers of Africa	CD		no	
2018		2005	Spirits from the Sky	CD		no	
2018		2005	Hubble Vision	DVD		no	
	2019	2006	Worlds in Your Wallet	IN		no	
2018		2006	Once in a Blue Moon	CD	V	no	
2018		2007	Nine Planets and Counting	CD	V	no	
2018		2007	Navigating with Lewis & Clark	CD		no	
2018		2007	Oceans in Space	DVD	V	no	
2018		2008	Blown Away	CD	V	no	
2018		2008	The Cowboy Astronomer	CD		no	
2018		2009	Bad Astronomy	CD	V	yes	green laser thru Joy
2018		2010	Galileo	CD	V	no	
2018		2015	Grand Canyon	web		no	
	future	Jun 2017	321 Blastoff	CD/DVD		no	
		Jul 2017	Stargazer	DVD	V	no	
		Nov 2017	Stellar Extremes	CD	V	no	
		Nov 2017	Hercules	DVD	V	no	
		Dec 2017	Winter Wonders	DVD		no	
		Dec 2017	Hotter than Blue	DVD	V/s	no	
		Dec 2017	Briefer History of Time	DVD	V/s	no	
		Dec 2017	Relics of the Big Bang	CD/DVD	V/s	no	
		Dec 2017	Zubee	DVD	V	no	
		Jan 2018	George and Oatmeal	CD		no	
		Jan 2018	Wilbear	DVD	V	no	

red=created here — V=video
blue=came digital — F=film now video
black=came analog

Figure 3. Classic shows, original year run, and festival year run.

Figure 4. Classic show festival posters.

For completeness, I have also included our schedules of fulldome shows in Figure 5. For the current academic year, we are running just fulldome shows on the public show schedule. Schools and other visiting groups can request either classic or fulldome shows.

Figure 5. Posters for fulldome shows.

THE SCHULTZ, JR. PLANETARIUM PROJECTOR: A NEGLECTED PIECE OF PLANETARIUM HISTORY

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Abstract: The explosive growth of U.S. planetarium facilities in schools and small museums in the 1950s and 1960s was largely driven by Armand Spitz and his revolutionary pinhole projectors beginning with the Model A. Perhaps the most abundant Spitz planetarium model is the Spitz Junior. This projector might never have reached the market but for a would-be competitor, the Schultz, Jr. projector. This paper describes the Schultz, Jr. planetarium projector and its remarkable inventor, William Schultz, Jr.

Sooner or later, most of my colleagues in the planetarium world discover the history of the modern projection planetarium. It traces back to Walther Bauersfeld and the invention of the revolutionary Zeiss Model I projector in 1923. Arguably, the planetarium profession as we know it began at that point in time. If that marked the birth of the indoor universe, I think it can also be said that the 'inflation' moment in history of the planetarium universe occurred when Armand Spitz put his Model A on the market for $500 back in 1947. At that time, I estimate that the Zeiss projectors cost $213,511[1] .

So, Armand Spitz's reputation as the 'Henry Ford' of planetariums is well deserved. Combine the low Spitz planetarium price with the sudden American interest (some might say panic) in space science and astronomy education sparked by Sputnik in the late 1950s. The result was an explosion in the number of small planetariums in schools and smaller museums in the U.S. in the 1950s and 1960s.

Early in this planetarium boom came the first planetarium in Michigan—a Spitz A1 installed at the new Robert McMath Planetarium which opened in October 1955 at the Cranbrook Institute of Science. On hand at the dedication on September 30 were, among others, astronomer Robert McMath, Armand Spitz, and William Schultz, Jr.—an amazing gentleman and the star of the story I'm about to tell you.

Fig. 1. William Schultz, Jr.

William Schultz, Jr. was born in Rogers City, Michigan on April 27, 1904, the fifth of nine children in a family of modest means. In high school he was captain of the basketball team and founded the local Boy Scout troop. After high school graduation, he wanted to attend the University of Michigan but the family could not afford to send him. Undeterred, he went to work to raise the money. He found employment as a typesetter at the local newspaper and as an electrician at the local calcite plant. At college he played French Horn in the famous University of Michigan marching band. He graduated from the University of Michigan in 1930 with a degree in electrical engineering and later received his Master's

1 Based on $135,000 paid in 1938 for the Buhl Planetarium Zeiss, adjusted for inflation to 1947. See history of Buhl at: http://buhlplanetarium.tripod.com/Buhlbriefhistory.html).

in Education in 1938.

After graduation, Schultz joined the world-famous Cranbrook educational community in Bloomfield Hills, Michigan as a teacher in 1930. Truly a modern renaissance man, he taught general science, mechanical drawing, typing, chemistry, and physics, and was chair of the science department from 1938 until he retired in 1969. In addition to teaching, he coached soccer, golf, track, and varsity basketball. He was also the advisor to the radio club, the rifle club, the model club, and the school band. He also directed the Cranbrook Kingswood Summer Day Camp, which he founded. Outside of Cranbrook, he operated his own printing press, was president of the Detroit Astronomical Society, belonged to the local chrysanthemum and mineralogical societies, and was a ham radio enthusiast. His son Robert recalls that the family's first TV was a discarded one that his father found and repaired and that lasted for many years afterwards.

Shortly after joining Cranbrook, Schultz took on the task of supervising the relocation of the school's 6-inch Fecker refracting telescope that had been poorly housed in a tower observatory attached to one of the school buildings. Nearby smoke stacks and heated air rising from the building's poorly insulation roof spoiled the views through the telescope and caused ice buildup inside the dome. It was decided to move the telescope to a new home, the Hulbert Observatory, attached to the new Cranbrook Institute of Science nearby. With the telescope relocation, Schultz became the resident astronomer for the new observatory, in addition to his teaching duties.

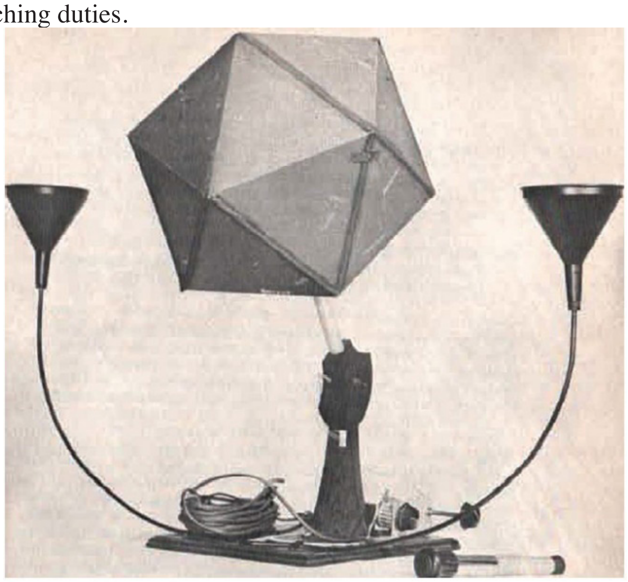

Fig. 2. The Schultz, Jr. Planetarium

At some point, perhaps in the mid-1950s, Schultz decided it would be a good idea to provide a planetarium experience to his students. At the time, there were no planetariums in the entire state of Michigan. And even the new Spitz planetarium was beyond his meager budget. So, William Schultz set out to build his own pin hole planetarium projector. This "45 cent" projector was made from two sheets of 22-inch by 28-inch, black, light-weight cardboard taped together into an icosahedron. It used a 6-volt incandescent lantern type lightbulb with a small filament as the light source. The bulb socket and variable resistor to control brightness were salvaged from an old radio. He spent some 100 hours plotting the star pinholes and piercing the cardboard with various sized needles. These needles were heated red-hot so that the pinholes would not fill in with time and would have smooth edges needed for round stars. The projector had adjustable latitude and could show diurnal motion. Dime store metal funnels were converted into dome lights.

In addition to classroom use, Schultz employed his planetarium as a substitute sky inside the Hulbert Observatory on cloudy nights so that the otherwise disappointed public would have something celestial to view. These ad hoc planetarium shows in the observatory helped to drum up support for building the McMath Planetarium with its Spitz A1 projector. The 'Schultz, Jr. planetarium', as I call it, was demonstrated at the 1958 symposium, *Planetaria and Their Use for Education,* held at Cranbrook and is described in the proceedings of that meeting which are available on the IPS web site, thanks to Jeanne Bishop and John Hare.

Long before I discovered the proceedings of the 1958 symposium, I heard about the Schultz, Jr. planetarium from Bill Schultz himself. You see, he was one of my early mentors. The McMath Planetarium was the first planetarium I ever visited back in the 1960s as part of a cub scout field trip. During my junior high school years, I became a student member of the museum and took an astronomy class there. I would often visit the Hulbert Observatory on public nights where Bill Schultz took me under his wing and taught me to use the observatory telescope. At some point he told me about his 45-cent planetarium projector. He told me that his planetarium projector had been written up in the rotogravure section of one of the Detroit newspapers. He also told me that he'd discussed his projector with Armand Spitz. Schultz said he knew that Spitz had a new, low cost, pin hole planetarium projector that he was thinking of manufacturing and selling. Schultz told me that he threatened to market his 45-cent projector, if Spitz did not put his own projector on the market. Shortly thereafter the new Spitz projector went on the market. This is my best recollection of what Schultz told me some forty plus years ago. When I rediscovered the Schultz Jr. projector in the 1958 symposium proceedings, I began to wonder if the story of the Schultz Jr. planetarium and the Spitz projector could be true. Could the 45-cent Schultz projector have led to the launch of the Spitz A projector? I decided to do a little digging.

I started with a search for the rotogravure article that Bill mentioned to me. I had no idea what date or year it was published or even which of Detroit's newspapers it appeared in. Cranbrook's archivist, Gina Tecos, came to my rescue. She found a copy of the article. Entitled, "Cut Rate Astronomy", it appeared on Sunday, March 29, 1953 in the Detroit News' Pictorial Magazine—their rotogravure section. It included three photographs of Schultz and his planetarium projector. Unfortunately, the article gave few details about the construction of the projector other than to say that it took Schultz about 100 hours to plot the stars for the projector. The article also stated that "Using scrap materials, the instructor has developed an inexpensive substitute for the smallest commercial planetariums which cost $750." This clearly seems to be a reference to the Spitz model A1 projector.

Brach's MINT

2 BIG BARS IN ONE

Brach's MINT CANDY

SMOOTH CREAMY MINT! RICH THICK CHOCOLATE!

Cut Rate Astronomy

TO ILLUSTRATE his astronomy lectures, William Schultz, Jr. head of the science department at Cranbrook School for boys, has made a portable planetarium for 45 cents. Using scrap materials, the instructor has developed an inexpensive substitute for the smallest commercial planetariums that cost $750.

With heavy, black paper Schultz formed an icosahedron and used a hot needle to burn holes representing stars into the surface (right). Accurately locating the stars took him about 100 hours. In the observatory Schultz attaches the planetarium to a telescope and projects the constellations onto the dome (above).

—Photos by Edwin Lombardi, Detroit News Staff

When weather conditions preclude use of telescope, Schultz uses his device for classroom demonstrations. It answers a need among schools for inexpensive astronomy equipment.

Page 26—March 29, 1953 The Detroit News Pictorial Magazine

Guard your dog against energy fadeout

feed him RIVAL DOG FOOD

When your dog starts the day full of pep, but does a "fade out" half way through, the chances are that *his food is at fault.* That just doesn't happen to Rival-fed dogs, because every ingredient in the Rival formula is a rich source of energy! Not just one, but several varieties of body-building, nutritious meat, sun-ripened grains, plenty of natural vitamins, minerals and proteins, keeps dogs peppy and energetic all day long! Rival has a pleasing *natural color,* appetizing *natural flavor*—it is *never* artificially colored. Enthusiastic letters from dog owners who have bought over 800 million cans of Rival to date, all tell the same story: "Rival made him a bundle of energy"—"always peppy"—"rarin' to go." Change to Rival and give *your* dog the priceless gift of pep and vitality that's packed into every can of Rival Dog Food! Chlorophyllin added to prevent odors.

VALUABLE OFFERS on RIVAL LABELS

Rival labels entitle you to take advantage of special money-saving offers available to you as a dog owner.

Want more for your money? BUY RIVAL DOG FOOD

Figure 3. Cut Rate Astronomy article in Detroit News, 1953.

Fig. 4. Spitz Junior projector

I have been unable to find out exactly when Schultz first made his pin hole planetarium. It had to have been before the 1953 rotogravure article but after he joined Cranbrook in 1930. If we assume that Schultz made his pin-hole projector in 1953, it clearly came too late to have influenced Armand Spitz's decision to market the Model A projector. And, since none of the history of the Spitz Model A mentions Schultz as an influence, I think we can eliminate a connection to the Spitz Model A.

Before writing off the Schultz story to bad memory on my part, I gave it a second thought.

I recalled that Armand Spitz also brought to market an even more affordable projector that you may have heard of – the Spitz Junior. It debuted in 1954 for $14.95. This, as you may know, was the first mass-produced planetarium projector. About 3,000 Spitz Juniors were sold—more than any other planetarium projector that I know of.

So now Schultz's story rings true and likely refers to the Spitz Junior planetarium. And this is further supported by the 1958 symposium proceedings where Schultz states: "This planetarium was developed before the appearance of the small $15.00 Spitz instrument…"

In conclusion, it seems entirely possible that the Schultz Jr. planetarium was a key influence on the Spitz Junior planetarium coming to market in 1954.

There remain several questions about the Schultz Jr. planetarium projector:

- What are the construction details of the Schultz, Jr. planetarium?
- What happened to the original?
- When was 'first light' of the Schultz planetarium?
- Was there correspondence between Schultz and Spitz?
- How were the stars plotted on the Schultz Jr. planetarium?

If you know the answers to these questions, or know someone who does, please get in touch with me.

References

Anonymous, "Cut Rate Astronomy." *The Detroit News Pictorial Magazine*. Page 26. March 29, 1953.

Anonymous, "Cranbrook Observatory History." Last accessed: October 8, 2019. https://science.cranbrook.edu/explore/cranbrook-observatory/history

Goeringer, Conrad. "Stars on My Ceiling." *Sky and Telescope*. July, 1992.

Jaggers, Miriam, ed. *Planetariums and their Use for Education*. Ann Arbor: Cranbrook Institute of Science, 1959.

Marché, Jordan. *Theaters of Time and Space: American Planetaria, 1930-1970*. Piscataway, NJ: Rutgers University Press, 2005.

Schultz, Robert W. "Growing Up as a Cranbrook Faculty Child in the 1940s & 1950s." *Tradition*. Winter, 2013. 32-39. Last accessed: October 8, 2019. http://c919297.r97.cf2.rackcdn.com/lisoriailggerutdmhqlsiuxzsfibx-optimized-pub.pdf

Schultz, Robert W. Private electronic communication. May 13, 2019.

Walsh, Glenn A. *Brief History of The Buhl Planetarium and Institute of Popular Science, Pittsburgh, Pennsylvania*. Last accessed: October 8, 2019. http://buhlplanetarium.tripod.com/Buhlbriefhistory.html

CAPTURE CONTENT FOR YOUR DOME EVEN IF YOU'RE A N00B WITH NO MONEY

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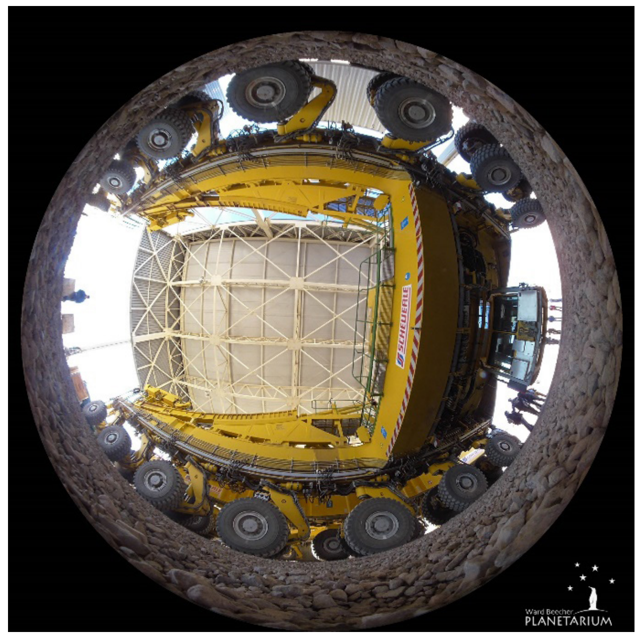
Abstract: **From one newbie to another, yes, you really can capture your own fulldome content and create specialized programming to captivate unique and local audiences. With the development of VR technology, it has never been easier! This paper will highlight some of the low-cost camera equipment and software options available along with tips to get started.**

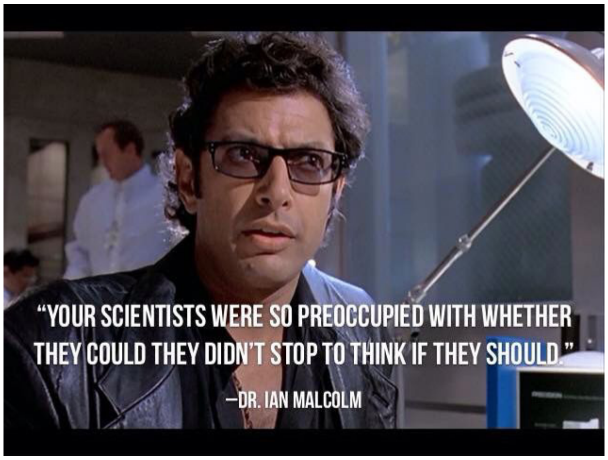
N00b or Noob—noun, slang:
A person who has no idea what they are doing.

I will be upfront and acknowledge that this paper is a little weird. I am taking a risk that the novelty will help me convince *you* that making content for your own dome is a good idea. Besides, who wants to read more Dry Academic Prose? My coffee and I happily present to you: A Backstory.

I began researching cameras for fulldome and Virtual Reality (VR) content after hearing about this wonderful program for called Astronomy in Chile Educator Ambassadors Program (ACEAP) which takes a handful of astronomy educators to Chile each year for exclusive tours and extensive training of the world-class telescopes there. (I recommend any planetarian apply at astroambassadors.com. You won't regret it!) In 2018, I decided to apply to the ACEAP program. In order to draft an earnest application, I needed to make some promises. Based on the resources available to me (a Canon 7D DSLR with a fisheye and kit lens, a Ricoh, and some Go Pros or as I called it at the time… Camera Stuff?) I decided to promise a planetarium live show kit distributed to the planetarium community (see "Additional Links"). With the expedition less than two months away, I was turning to Google with questions like, "What is a DSLR?" and "Why are my photos grainy?" I was, by every definition of the word, a complete n00b.



I did manage to take some great photos during the expedition. Every time I look up in my planetarium and see the Blanco 4-meter telescope towering over me or ALMA's transporters wrapping around the dome, I think, "How did I pull that off? I know *nothing*!" Truthfully, many of the cameras highlighted in this paper are incredibly simple to use. Many of them take photos or video at the press of a button and can be operated remotely through an app on your phone. Some of them require next to no processing and can be put on your dome in seconds.



Maybe you *could* take photos for your dome, but *should* you? Take a moment to consider a unique feature in your community and how you might highlight it in your dome. Perhaps you are planning a vacation to places that offer interesting geologic features your audiences might otherwise never experience. Beyond unique places, what unique audiences could you better engage if you could create content just for them? Maybe you have a new story you want to tell. The possibilities of using your own fulldome photos in the dome are virtually endless. And, icing on the cake, our audiences feel more connected to what they are seeing and learning when they have a personal connection with the content.

Looking for Fulldome Camera Equipment?

The following are some low-cost camera options for capturing fulldome content:

Kodak SP360 ($100): https://kodakpixpro.com/cameras/360-vr/sp360
Good enough for small & portable domes

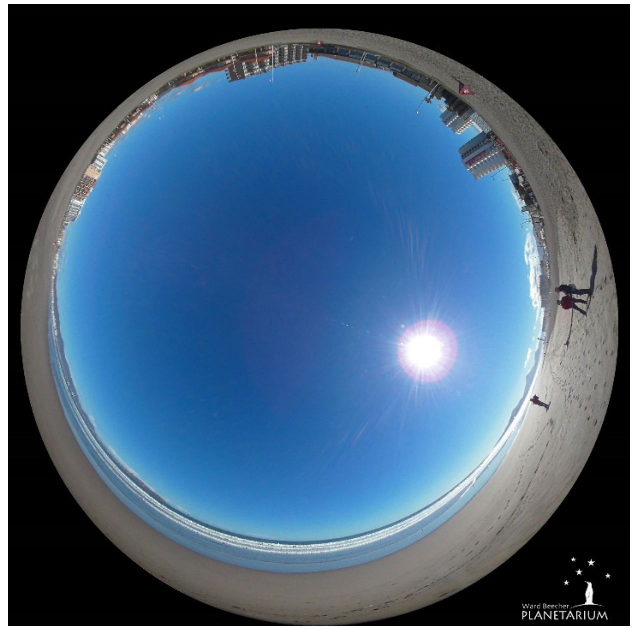
Kodak SP360 4K ($349): https://kodakpixpro.com/cameras/360-vr/sp360-4k
Slightly better than 2K photos; Insanely easy to use and looks great on a 4K system

Ricoh Theta V ($378): https://us.ricoh-imaging.com/product/theta-v/
360 camera; Versatile and Easy

Insta360 One ($190): https://amzn.to/2IXbIca
360 camera; takes RAW images!

Out of these options, I am most familiar with the Kodak SP360 4K. A typical user would purchase two of these units and stitch the two images together for 360-degree photos and video with 4K resolution. Since we are looking for a fisheye image, one unit does the job taking slightly larger than 2K resolution photos that looks great on a 40-foot dome often with few to no edits. The camera fits in the palm of your hand and you can control the camera, its settings, see a live view, and manage the photos all through its free mobile app.

A major downside I have found is The Sun. Whoa buddy, does this camera hate the Sun. If our favorite star is directly in the frame, it often creates massive ugly streaks and aberrations. Usually, clever placement of the camera is an easy fix and *sometimes* the aberrations can be edited in post processing.



[Yuck! This is after feeble attempts to fix in Photoshop.]

If you're thinking about getting a Kodak SP360, it comes with a clear screw-on cover to protect the lens. Use it! It does cut a few degrees off the photo bringing the camera lens right at 180-degree field of view (FOV) but does not affect quality too much especially out of direct sunlight. Unless you have the camera mounted to a tripod, I recommend leaving its lens shield on. These tiny things are easy to drop and too portable for their own good. Also, I suggest toying with perspective a bit. Some of my favorite photos were taken by placing the camera high on a shelf or low on the ground. (Resting on top of your head works too!)

I also have experience with the Ricoh cameras. These take 360-degree photos and video and are controlled very similarly to the Kodaks. Because the Ricoh creates long panoramas meant to create a VR experience, a good bit more processing is required for these to be put in fisheye format. However, what little you lose in convenience you make up for in versatility. Do you want to make a virtual tour of your facility? Congratulations, you have a camera that does that! Do you work in a museum? Now you can preserve those temporary exhibits in digital format. You can immerse audience outside of your dome through VR and 360 viewers online.

Other Camera Options for N00bs with Money

Perhaps the easiest way to take photos for your dome without sacrificing quality for convenience is by using a quality digital camera with a fisheye lens. If you already have a decent camera, I highly recommend investing in a decent fisheye lens. This is the lens that I have used:

Sunex 5.6mm f/5.6 SuperFisheye Lens ($800): https://bhpho.to/2nNJPf5

This lens together with a Canon 7D camera took 185-degree FOV photos in roughly 3.5k resolution. In practice, this setup takes better photos in low-light situations, offering more control in camera settings and a RAW output file type ideal for editing photos later.

Looking for Software Options?

Here are a few software options at a glance:

Adobe Creative Cloud ($20/month)
https://adobe.ly/31hEw5i
includes After Effects, Lightroom, & Photoshop; discounts available for educators and students

PTGui Pano Stitching Software ($150)
https://www.ptgui.com/
ideal for stitching 360 panos

Blender (Free)
https://www.blender.org

It's possible to use Blender to warp panoramas according to Dome Dialogues chatter on the subject.

In the cases of fisheye photos, sometimes all you need is a "mask" placed on top of your images and meant to create a clean springline, covering any chromatic aberrations that even quality fisheye lens suffer from. This can be accomplished in any basic photo editing software. I personally use Adobe Lightroom which makes masking hundreds of fisheye photos quick work.

Processing 360 photos for fulldome can get tricky, but there are options to help you. My limited experience in this is using Adobe After Effects with the Mettle plugin. Others have used the Nevegar plugin as well. Derek Demeter highly recommends the PTGui software (and he has way more experience with this than me).

Everyone is a N00b So Do What You Want

The planetarium community is small and while the technology surrounding our profession is growing at a tremendous rate, it is still considered "niche" with few resources for us to rely on. This means we rely on each other, our fellow newbies embarking on some new technical journey, to come back and tell us what you've learned well before you are confident in your ability to speak intelligently on the subject. I don't have all the answers for capturing content for your dome, but hopefully this paper gives you a place to start.

Acknowledgements and Additional Links

Derek Demeter has been hugely helpful to me along the way and I am thankful he answers my many questions with kindness and patience! Thanks Derek!

Matt Dieterich also helped me along the way, mostly with astrophotography questions. If you need a great step-by-step tutorial for processing astrophotographs, he has a great one at https://www.mdieterichphoto.com/

Dani LeBlanc at Museum of Boston helped us at Ward Beecher Planetarium make an informed decision to purchase the Kodak SP360 4K camera. Thanks Dani, we don't regret it!

"Eyes Over Chile Skies" Live Show Kit https://drive.google.com/open?id=1vhHALAlbXL8kln-AWviovohAPgxn2bOR
To be updated with more fulldome photos and LSST information by end of the year 2019

PTGui Tutorial: "Stitching Complex Panoramas"
https://amazingsky.net/tag/i/?fbclid=IwAR0GjpwY5j3CdOlI1RVXhnVryTNfbnjKCmgcsDuiDxGhDFobEH2SNfLrRHU

EVALUATING LIVE PROGRAMS WORKSHOP

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Abstract: This 45-minute workshop was intended to share ideas for giving and receiving constructive feedback for live, interactive planetarium presentations.

In the "Evaluating Live Programs" workshop, participants worked in small and large groups to reflect on live, interactive planetarium programs that they have attended. There were three areas of discussion:

- *Observations about successful presentations*
- *Observations about less successful presentations*
- *Ideas for providing feedback to presenters in order to improve their live, interactive presentations*

In all of the above discussions, participants first worked in groups of four to six people to generate ideas. After the small group discussion, each question was posed to the whole group in order to generate the lists below.

Aspects of Successful Programs

- *Interactivity*
- *Wow! Moments*
- *Appropriate and effective humor*
- *Enthusiastic presenter*
- *Tension and release work to create a good flow with emotion and/or sense of mystery*
- *Presenter uses names and builds rapport*
- *Relevant and up to date content*
- *Discrepant event challenges audience expectations*

Aspects of Less Successful Programs

- *Massive technological failures*
- *Too much lecture/one-way flow of information*
- *Presenter showing off knowledge rather than following audience's interests*
- *Monotonous/flat voice*
- *Vocal tics/verbal pauses or fillers (uh… you know… I mean, etc.)*
- *Presenters cannot talk and do something else at the same time*
- *Inefficient presentation of content/lack of information*
- *Irrelevant information*
- *Gross inaccuracies in information presented*
- *Bad pointer etiquette—movements are too fast, crazy circles, etc.*
- *Presenter is distracted*
- *Bad microphone manners—popping, feedback, etc.*

Strategies for Improving Live Presentations

- *Reflecting on practice: Video presentations and watch them with co-workers; discuss the recordings. Suggested wording for feedback:*
  - *I notice…(what behavior the evaluator is commenting on)*
  - *I think… (evaluator feedback on how that behavior may have impacted the presentation)*
  - *I wonder... (evaluator suggestion for modifying the behavior in future presentations). For example, "I wonder what would happen if you tried X instead of Z."*

- *Record yourself; evaluate your own performances regularly.*
  - *NOTE: Audio recordings are legally safer than video, as you typically do not need to collect signed agreements. However, you should:*
    - *Inform the audience that you are going to record the presentation and explain how the recording will be used.*
- *Check with your organization's administration to confirm that no signed agreements are required for audio recordings.*

- *Watch others, especially others who are presenting topics with which you are unfamiliar.*
  - *Do they use jargon that impacts your understanding of the topic?*
  - *Do they explain the basics clearly and fully before*

moving on to more complicated topics?

- *If you don't have an evaluation program in place at your institution, a good first step would be to ask others to watch you and give feedback*

- *Be willing and able to talk others off ledges: We are often our own worst critics, and the programs were rarely as bad as we think they were.*

- *Practice, practice, practice! Work on your voice, accent, delivery, etc.*

- *Get data/feedback from audiences:*
  - *Poker chip idea from Mark Webb:*
    - *Give each audience member a poker chip as they are exiting.*
    - *Ask them to drop their poker chip in one of five buckets to rate the show (5 rating is the best). Use emojis/happy faces/sad faces on the buckets to help communicate which is for the highest vote and which is for the lowest.*
  - *Aim for all chips to be dropped in the 5 bucket. A 4 vote may be someone being kind rather than a vote that they actually did like the show. Anyone voting a 5 can be assumed to have genuinely enjoyed the show.*

- *If you are evaluating someone, communicate clearly when you give feedback, so that the evaluee knows what to work on. This is particularly critical if it a formal evaluation (tied to a performance review or potential pay raise).*

- *Don't make excuses for your own programs or for feedback you give to others.*

- *Be open to receiving feedback.*

GLIPSA 2019 WORKSHOP

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Abstract: This all-day workshop was intended to give GLPA attendees a sense of what happens at the annual Live Interactive Planetarium Symposium (LIPS). LIPS is a multi-day gathering that focuses on all facets of live programming: Presentation skills, sample activities, etc. GLIPSA was open to anyone registered to attend GLPA. As with LIPS, ideas and content presented at GLIPSA applied to everyone who does live shows, no matter whether those shows are in a portable dome or fixed, with a digital system or starball. 2019 was the seventh GLIPSA, and there were 32 registered attendees.

Presenter Names (Listed Alphabetically):

Karrie Berglund
Digitalis Education Solutions, Inc.
Bremerton, Washington

Kyle Doane
Digitalis Education Solutions, Inc.
Bremerton, Washington

Dani LeBlanc and Talia Sepersky
Museum of Science
Boston, Massachusetts

Michael McConville
Spitz, Inc.
Chadds Ford, Pennsylvania

Sara Schultz
Minnesota State University Moorhead
Moorhead, Minnesota

Ken Wilson
Pancosmic, LLC
Richmond, Virginia

GLIPSA 2019 presentations were (listed in chronological order):

*** 1.25-hour presentation by Sara Schultz, "Formative Assessment in the Planetarium."**

Sara is currently working on her doctorate in science education, focused on the planetarium as a teaching tool and how to use it most effectively. This session provided an introduction to assessment in general in planetarium programs, followed by an introduction to formative assessment—evaluations of student comprehension, learning needs, etc. during a program rather than at the end.

We were introduced to the coding scheme developed by Ruiz-Primo and Furtak (2006, 2007) known as the ESRU cycle:

* the teacher **E**licits information
* the **S**tudent provides the requested information
* the teacher **R**ecognizes the student's contribution
* the teacher **U**ses the student's contribution to move forward in the lesson

We practiced using this coding scheme as a large group on a sample lesson narrative, then worked in small groups to evaluate text from a different lesson. After the small group work, we came back together as a large group to compare our answers.

*** 1-hour workshop by Karrie Berglund, "Education Theories and Program Planning."**

In this session we reviewed five major educational learning theories: behaviorism, cognitivism, constructivism, design/brain-based, and humanism. These theories have their roots in educational psychology, and each postulates not only how people learn but also where the motivation to learn stems from.

After a brief introduction to each theory, we discussed as a large group how that theory pertained to live, interactive planetarium programs, as well as how awareness of these theories could be used to improve design and presentation of live, interactive programs.

*** 45-minute workshop by Michael McConville, "Explain Like I'm Five."**

This active session took place immediately after lunch and was an excellent antidote to the typical post-lunch energy slump. Explain Like I'm Five was an intellectual challenge to explain the cosmos without talking down to our audiences. We broke into six small groups, each tasked with a randomly-chosen astronomical concept. Each group had 30 seconds to choose props and then three minutes to compile a presentation to explain their concept to the rest of the group.

This workshop stressed storytelling and synthesizing information quickly, while remaining accessible to our audiences.

*** 60-minute all group discussion led by Dani LeBlanc and Talia Sepersky, "Equity, Diversity, and Inclusion."**

This discussion-based session looked at how we can make sure that our planetariums and planetarium programs are truly welcoming for all customers, regardless of race, religion, gender, sexual identity, or disability. Discussion topics included:
What do the terms equity, diversity, and inclusion mean?
What are our institutions already doing well?
Where is there room for improvement?

*** 15-minute activity by Ken Wilson, "Tidal Flexing."**

This was a fast, easy, and free hands-on activity designed to help audiences grasp the abstract concept of tidal flexing. Ken handed out plastic hotel key cards to each participant, and then directed us to fold the card in half once to create a crease. After that initial crease, we were instructed to bend and straighten the card rapidly several times in a row (without breaking it completely in half). After bending and straightening the card several times, we placed a finger on the crease and noticed that a surprising amount of heat had been generated. This was a very effective hands-on demonstration of how tidal flexing can generate internal heat on astronomical bodies such as Jupiter's moon Io.

*** 60-minute workshop by Kyle Doane, "'Say What?' Listening to Understand our Audiences"**

In a truly interactive program, the audience steers the show through their questions, comments, and other reactions. This session provided an opportunity to discover if we are <u>really</u> listening to what our audiences are telling us. A few attendees volunteered to try to determine what was being presented on the screen behind them by asking questions of the audience and listening to their responses.

PANEL: ADAPTING PRE-RECORDED PROGRAMS TO DIFFERENT AUDIENCES

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Abstract: Last year Jeanne Bishop published an article in the IPS Education Committee *Planetarian* column "Seeking What Works." This is a discussion of ways that a number of planetarians have adjusted showings of their pre-recorded programs to fit the needs of different groups. These procedures include students of different ages, community groups, and groups with special needs. In this panel, experienced presenters will continue the discussion with ways to adapt full-dome shows to their different audiences. Audience interaction and discussion will follow.

Jeanne Bishop

This discussion is important because a pre-recorded program has only one narration, one length, and no recognition of differences in audiences. Many planetariums present full-dome or other pre-recorded shows and have different audiences. Knowing possibilities for making adaptations should be useful, because a particular purchased or home-produced program then can be more versatile. Audiences will learn and enjoy the program more. After my introduction, the order of speakers is: Robin Gill, Katy Downing, Sara Schultz, and Bob Bonadurer.

Today's panel discussion builds on my survey of experienced planetarians who use and adapt full-dome shows. The results of the survey can be found in the March, 2018 issue of *Planetarian,* in my IPS Education committee column, "Seeking What Works."

Some suggestions given by the 1918 survey respondents are:

- *- Have pre-discussion of aspects of the show that are relevant to the particular audience.*
- *- Conduct an extensive after-program question-and-answer session.*
- *- Select a pre-recorded show carefully for content matched with particular grades.*
- *- Select a pre-recorded show carefully for good educational format.*
- *- Select a pre-recorded show carefully for program*

characters appropriate to the age level.

- *- Before the pre-recorded show, start with live sky talk tied to the program content.*
- *- Stop the program and give needed explanation for the group before continuing.*
- *- Show important relevant words on the dome, which encourages school emphasis in reading.*
- *- Keep a pre-recorded show current by comments before and after show.*
- *- If very important, stop the show to give an update.*

Robin Gill

The Wilderness Center (TWC) is a non-profit nature center located in Wilmot, Ohio. Our Planetarium is part of our Astronomy Education Building which also houses a roll-off-roof observatory. We have been providing astronomy education programs for the schools we serve and the general public for 20 years. In October 2017 we installed a Digitalis Epsilon Digital Theater system giving us the capability to do fulldome shows.

The Wilderness Center is a field trip for the children we serve. We offer programs for pre-school through high school. The children we serve are mainly from pre-school to seventh grade. Unfortunately, we do not have many high school teachers taking advantage of the programming that we have developed for them; this includes the astronomy programming. Teachers select the activities they want their students to experience from our "School and Youth Group Program Guide". The short description in the Guide consisting of a description of the program and the educational standard met is the only information teachers receive about the planetarium programs prior to their visit. We see these kids only once and at best, they are in the planetarium for 50 minutes.

We decided to add fulldome astronomy shows with a short live-presenter portion to our live-presenter-only planetarium outreach offerings in the spring of 2018. The fulldome shows added to our program include "Moles: What is Out There," "Chronicle of a Journey to Earth," "The Cowboy Astronomer," "COS" (Cosmic Origins Spectrograph), and "Musica." The Program Guide recommends "Moles" for our preschool and kindergartners, "Chronicle of a Journey to Earth" for fifth and sixth graders, and "The Cowboy Astronomer," "COS" (Cosmic Origins Spectrograph), and "Musica" for middle and high school students. However, teachers can select any of the offered programs.

"Moles" is quite popular with our preschool through third grade teachers. We had also offered "One World, One Sky: Big Bird's Adventure" for this age group until it became unavailable. The kids are so engaged with these shows. It's fun to sit back and watch and listen to them. The kids chatter softly throughout the entire show about what they are seeing, doing, and learning. The teachers love how engaged their kids are.

"The Cowboy Astronomer" and "Chronicle of a Journey to Earth" have also been big hits with our fourth, fifth, and sixth grade teachers. We have had some second and third grade teachers select "Cowboy" for their students. We hear chuckles and "oh, I see it" throughout the show. The kids love the stories. The teachers love the emphasis on staying in school, reading and learning, continuous learning, topics covered, and of course the stories.

After each of these shows a short, live presentation is made that emphasizes the important learning points of the show, whether it be the Moon, Moon phases, star color or distance, constellations, seasons, or eclipses.

We have also found that these programs engage our developmentally disabled children in a very positive way. They tend to more verbal about what they are seeing during the show and interact more with the live presenter.

In the two years I have been doing this job only one high school has come to the planetarium and they came only for the planetarium. Their fulldome show was "Phantom of the Universe," selected because they were starting a unit on dark matter the following week.

The fulldome shows selected give us another tool to present material that helps our teachers meet the state educational standards and/or their classroom curriculum. The shows educate and entertain, providing a fulldome immersive experience that the majority of our students have never experienced.

We have found that teachers want their kids to have this type of learning experience. In our first year of offering fulldome shows 67% of the children coming to the planetarium saw a fulldome show. Word got around, teachers talk, and in our second year 88% of the children coming to the planetarium saw a fulldome show. Teacher feedback indicates that the planetarium is meeting and most times exceeding their expectations.

Based on our results so far we will continue to offer fulldome shows as a part of our educational outreach offerings.

Katy Downing

The Lake Erie Nature & Science Center (The Center) celebrates 75 years as an organization in 2020. Our planetarium turned 50 in 2018, and we are still going strong. We are located in Bay Village, Ohio and serve children, families, school groups, and scout groups year round and just about every one of the 165,000 people served last year set foot in our planetarium. We encourage children and families to "Discover the universe in their own backyard" and do that with our live animal exhibits, our wildlife rehabilitation program, preschool classes, and planetarium.

While most of our planetarium programming is live, we do use fulldome videos in a variety of ways. We include our age appropriate fulldome offerings within our field trip guide and schools and groups choose from there. Some school groups come in and just want something fun and aren't here to "learn anything specific". These groups usually visit during the summer months and are day-care groups. Our two most popular shows for these groups are "The Little Star that Could" and "Rusty Rocket's Last Blast". Some groups come for a 30-minute show, where we just show the film. Other groups come for a 60-minute program, where we show the film and then have a small discussion and a night sky presentation.

During the school year, we have a few schools that love coming to the dome to see AVI's "The Moon" for grades K-2. We have turned this three part "mini movie" into an hour (45-minute) interactive program. Our planetarium walls are all carpet, so we have the freedom to put manipulatives on the wall and interact with them along with the shows. I created a rough image of the Moon along with the three basic features, and a set of different moon phases discussed in "The Moon" program. After showing a segment of the film, we put the Moon up on the wall and have the kids come up and add to it the features. After part two, we have the kids stand up and repeat the motion of pointing out the motion of the Moon and Sun and have them move their bodies from planetarium east to planetarium west. Lastly, after part three where the film discusses the different phases of the Moon and puts them in order, we put up our moon phases and have the kids come up and move the moon pieces to put them back in order. This program isn't as popular as our live presentations, but the groups that come, always come back year after year.

Our public shows offer a weekly rotating fulldome show on Saturdays and Sundays. We have gone through our limited library of shows and show a different one every weekend. Sometimes these are popular, other times we receive comments of "I have already seen that one".

Our audiences and school groups seem to enjoy the fulldome films that we have, even if some are getting tired of the same ones over and over. Our biggest issue is finding the funding to purchase new full dome content, and the price we charge for our programs. Currently our full dome show that is just the film and nothing else, we are charging $5 and we are starting to receive complaints on the price point. My question to the (panel) audience is what do you charge for your fulldome shows?

All in all, we will continue to use fulldome content in our programs as a way to enhance our live shows and to present to the public and school groups as a fun "edutainment" program. I would love to see more interactive "mini movies" like "The Moon" that we can use with the younger crowds.

Sara Schultz

The MSUM Planetarium is located on the campus of Minnesota State University Moorhead. We serve our MSUM students in various courses including astronomy, earth sciences, and education. Though we are a part of the university, our largest use is for k-12 school and public shows. We use a digital projector for fulldome movies as well as live presentation. We do not typically have repeat visits from classes, so their visits are one-time field trips.

Our programing for all audiences is comprised of either all live or half live and half fulldome movie. Our shows run 50 minutes so we always have time to do at least some live before or after a fulldome movie. We typically use fulldome movies most for younger audiences, like "One World, One Sky," because it holds their attention longer with its bright colors and familiar characters.

Much of what we do for k-12 is live presentation in order to customize our offerings to meet the needs of the teachers. Standards and benchmarks are a big concern for the teachers who visit us, and being able to address those is important to them. However, in a few cases, particularly the younger grades, a fulldome show partnered with live presentation is beneficial.

"One World, One Sky" is one of our most used fulldome shows. We typically show it to pre-K, Kindergarten, and sometimes 1st grade. It is a great introduction to the sky. Another reason it is so strong is the educator and teacher resources that it has with it. Using those tools, we dig deeper into the content covered during the show in the time we have afterwards. It gives us a great opportunity to see what they have retained and keep them thinking about it. For our programs, we focus mostly on the Moon. We have the students think about differences and similarities between the Moon and the Earth and how that might affect them if they were to travel there. The idea is to keep them thinking critically about what they have seen and help them notice these aspects of the Moon in relation to what they are already familiar with, the Earth.

Another show we use parts of is AVI's "The Moon." This show is typically given at the 1st-2nd grade level to help them understand Moon phases and motions. We use the modules to help the students understand the cycles and patterns that can be observed. For slightly older groups, we use the time afterward to investigate Moon phases deeper and actually look into the causes by flying out into space and looking at the Sun, Moon, Earth system from a different point of view. Being able to take imagery they are more familiar with and connect it with a view they cannot have is very beneficial to help them understand the connections.

We were fortunate to be able to purchase NSC Creative's "CAPCOM GO!" to help celebrate the 50th Anniversary of Apollo 11. Because CAPCOM covers all aspects of the space race, it has a lot of different things we can focus on in our live programming afterwards. With one group we focused on humans in space and space travel. We visited the ISS, took a look at the distances and sizes of the earth and Moon, and talked about living or working on the Moon and on to Mars. It was a great opportunity to get them thinking about the challenges we face as humans to explore other worlds from atmosphere, fuel/propulsion, terrain, life sustaining systems, etc.

Regardless of the fulldome show presented, we always find nuggets to tie into our live portion at the end. For some we have more polished content, but there is always at least something to take away. The nice thing about having the flexibility of using fulldome shows is that they can often visualize things I cannot in my dome software, which opens up opportunities for further conversations.

Bob Bonadurer

We make planetarium shows here in Milwaukee. We sell about 40 programs per year. They are quality shows—or so we think. We try to make them affordable to smaller planetariums that have little or no budget. We make 1 to 2 shows a year.

We make shows with two questions in mind:

Will they be popular with the public?
Do they align with a future exhibit here at the Milwaukee Museum?

Our style—for lack of a better word—is edutainment. Most are family shows—suitable for kids and adults. We try to engage, inspire and then educate. All shows include a wealth of solid astronomy topics. When we obtain shows from other vendors, we typically look for similar type shows—ones that are family-oriented and will be popular with the general public.

We do not survey other planetariums to see what type of show to produce. I would like to know:

What types of shows should producers make more of—adult, school/student or family?
Name one show you would like to see made?
What is the biggest issue with current show production?
Should a planetarium be able to edit a show they bought?
How would you make your best planetarium show? (Using scale below)

Production Quality		*Scale*			*Production Quality*
No Story	1	2	3	4	Tells a Story
Little Science Standards	1	2	3	4	Lots of Science Standards
Little or No Humor	1	2	3	4	More Humor
Real Video or Photography	1	2	3	4	Animation
Recognizable Narrator	1	2	3	4	Basic Narrator
Powerful Music	1	2	3	4	Simple Music
Entertaining	1	2	3	4	Educational

Further Audience Interaction following Panel Presentations

Robin asked the questions: If you use fulldome shows in your educational outreach, what has been your experience? Has it been positive? There were a couple of responses. One was to consider using shows for other than initially-recommended age groups. Peggy Hernandez noted that she has been successful using "One World, One, Sky, Big Bird's Adventure" for cognitively delayed high school students She cautioned that it must be presented so that the higher-functioning students are not insulted by the show while making it interesting and fun for all. Another shared that that teachers have selected fulldome shows over presentations that are entirely live. Everyone seemed to agree that having a live interactive presentation at the end of the fulldome show is important.

Discussion from the audience noted:

- We have underserved communities, and we need to find ways to best accommodate them with both fulldome shows and other offerings. We need to adapt the way we give any shows for the disabled of all kinds.

- A challenge for reaching different ages with the same pre-recorded show is science content. The appropriate vocabulary and depth of explanation is different for different audiences.

- An interactive activity about scale to supplement a fulldome show can be performed using the dome size as a benchmark for measurement.

- Time to give a pre-recorded show and provide extra explanations and activities only is a problem if the group arrives late.

- Exhibits that accompany a widely-used fulldome show can go far to help audiences better understand and appreciate the show. Examples are shows and exhibits featuring Galileo, Cleopatra, and neutrinos.

- It would be useful to have mini-programs that feature single concepts or "nuggets."

Both Sara and Bob asked, What new fulldome shows would you like produced and that you think would lend themselves to the fulldome format? Everyone responded and these topics were mentioned: Archaeoastronomy, Mars, Weather, Geology (with Earthquakes, Impact Craters, Glaciations, and changes with time), Radio Astronomy, Moon phases (phases concept only), Climate change, Distances and how we know, Underwater World, Small Worlds, LIGO and Gravitational Waves, Retrospective on Voyage, Electromagnetism, programs that meet NGSS standards, and a Pre-K show.

PANEL: THE VALUE OF EDUCATION IN THE PLANETARIUM, AN IPS WHITE PAPER

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Abstract: The International Planetarium Society (IPS) has recently produced two new documents both titled "The Value of the Planetarium in Education." How the two versions of the document, now available for use, were prepared, elaboration of the individual points made in the document sections, and where to access the document will discussed by the panel. Attendees will receive a copy of the one-page version. Sharon Shanks will describe how planetarium/astronomy research in recent years has added substance to statements about the educational value of planetariums.

Jeanne Bishop:

Two new documents have been produced by the International Planetarium Society (IPS) that should be helpful to many planetariums in diverse facilities. Both have the title of "The Value of the Planetarium in Education." One is a full white paper, while the second is a one-page summary presented in attractive form. This topic has been addressed previously by GLPA and others, but not recently and not as thoroughly. The following are seen as major reasons for this document:

1. A rationale for building or purchasing a planetarium.
2. A rationale for funding an existing planetarium and keeping it in operation.
3. A continuing rationale for all who work in planetariums to disseminate positive information about planetariums.
4. A document for referral by everyone involved in planetarium work with ideas that can be shared with administrators, teachers, planetarium attendees, and the voting community.
5. A document for use by planetarium educators that touches on some best practices for their work.

IPS President Mark SubbaRao asked Jeanne Bishop, Chair of the IPS Education Committee, to prepare the document. Dayna Thompson and Sharon Shanks gave major help. How the two versions of the document, now available for use, were prepared, elaboration of the individual points made in the document sections, and where to access the document will discussed by the panel. Attendees will receive a copy of the one-page version. Sharon Shanks will describe how planetarium/astronomy research in recent years has added substance to statements about the educational value of planetariums.

Last January I wrote all IPS Representatives, Committee Chairs and officers, and a large number of other professionals requesting their views relating to the goals of this document. When I received a limited number of responses, I studied 1) an enormous number of articles relating to this topic in back issues of *Planetarian*, 2) organization and planetarium facility website and published statements, including several from GLPA, and 3) related literature, especially research, in planetarium and astronomy education.

The sections of the longer white paper, in carefully-worded brief paragraphs are:

- *What is a Planetarium?*
- *A Brief History*
- *A Unique, Inspirational Environment*
- *Educational Standards*
- *A Superior Learning Environment*
- *A Place for Inquiry-based learning*
- *Reinforcement of Classroom learning and Retention*
- *Help for the Difficult Learner*
- *Unique Capabilities of Current Planetariums*
- *Multi-Discipline Presentations*
- *Unlimited Possibilities with Digital Fulldome*
- *A Positive Social Environment*
- *Impacting Communities*
- *Inspiration to Follow STEM and non-STEM Career Paths*

There are three other parts of the longer white paper. The first is a group of statements in support of the educational value of the planetarium from individuals and organizations (United Nations, GLPA, MAPS). The second is a list for further reading, and the third is a list of 27 endnotes which support the statements in the paper sections.

Please copy and use the long and short versions of the document. You can access them 1) on the IPS website: https://ww.ips-planetarium.org within Publications, White Papers and 2) in *Planetarian*, June 2019, pp.8-11. Also, a number of suggestions for using the documents are in *Planetarian*, September, 2019, "Seeking What Works", p. 50.

Mark SubbaRao

As IPS President, I get requests to attend meetings in which they are considering closure. One meeting that I described in my President's message in *Planetarian*, was for a school planetarium in my area. I discussed the value of education in the planetarium. Fortunately, following my presentation, the school board decided to keep that district's planetarium open. I realized the need for a document that I could use and others could use to convince others about the value of planetarium education. So I asked Jeanne, as Chair of the IPS Education Committee, to prepare such a document, one that was updated from older statements to include the digital/fulldome planetarium and which identified supporting research. I appreciate Jeanne, Dayna, and Sharon's work in preparing the two versions of the Value of Education in the Planetarium. I have been invited to attend international sites where planetariums will be constructed, and it is valuable to have the documents for these occasions. A copy of the short summary version on the document to give to each person at all meetings where planetariums are considering closure or new planetariums are planned is very helpful. I would like to know from you, would like to see other IPS white papers on other subjects, ones that would be helpful to you in your situation?

Dayna Thompson

I was involved chiefly with the design and contents of the 1-page summary. As Mark says, I hope this summary will be helpful in many instances where you are working to convey the value of what you are doing. Newspapers and other media may appreciate having a copy of the summary to help them with their publications. I suggest that the longer version and its list of resources can be used for grant writing. Almost all the verbiage I contributed to the project was taken from grant proposals I have worked on over the years. Questions I have for you are 1) How do you envision using the two versions of the document? Have you used either of them already? 2) Are there instances in which a planetarium program you have seen that provided inspiration, education, or community outreach in ways one does not normally see outside the dome? I hope our work will help you in your particular facility.

Sharon Shanks

I have worked on a project that supports the documents. In 2019 I gave a paper at the Notre Dame GLPA conference titled "Where's the Data?" I recently reviewed this paper and the research and happily found that there is now a great deal of data to support the effectiveness of planetariums. My detailed article, "Where's the Data? Why, Here it is!" appears on pp. 12-15 of the June, 2019 issue of *Planetarian* and in these proceedings. The educational value of the planetarium usually is a moot point if the planetarium is closed. Yes, it is true that the Educational Value document can be used to gather support to keep a planetarium open, and perhaps it can be used to get a closed facility re-opened. The document is, however, just one tool we can use. We need additional tools, information about facilities in jeopardy. That will take participation from everyone. You know your area. You watch the news, you read the newspapers, and you hear the rumors. You need to let others know what you know. An established line of communication is required. We need letters of support from IPS leadership. We need case study examples of successful projects. We need to know what methods worked and did not work. What are your ideas on what is needed? Would you be willing to be part of a planetarium-resource effort to share information with IPS? Is anyone interested in being the point person?

AUTHOR'S NOTE

This panel presentation was scheduled at the end of the day. The time schedule was running very late. We were requested to cut our panel time in half, so there was no time for the interactive question period we had planned. We hope readers of the Proceedings will consider the embedded questions and contact us with their thoughts.

APPENDIX A.

The Value of Education in the Planetarium
April 2019

Prepared for The International Planetarium Society, a nonprofit organization comprised of planetarium professionals from around the globe, by Dr. Jeanne Bishop, Chair of the IPS Education Committee.

What is a Planetarium? A planetarium is a specially-designed theater with a domed ceiling that is able to project a realistic image of the night sky indoors. First used to educate about stars, planets, and constellations, planetariums today are unique immersive facilities often used to support Science, Technology, Engineering, and Mathematics (STEM) learning and to cross learning disciplines into art, culture, and history.

A Brief History: The first optical-mechanical planetarium was introduced in Germany in 1923. Now thousands of planetariums of many types and sizes exist worldwide in schools, museums, science centers, and other locations. Portable planetariums are also used and expand educational possibilities to far-flung audiences. It is estimated that over 1 billion people have been served by planetariums since their introduction.1 The Soviet cosmonaut who first flew in space and the Apollo astronauts who walked on the Moon 50 years ago were trained in planetariums.

Value of Astronomy: Astronomy is an integral part of human history. Cultural constellation stories reflect how past societies viewed their world. Hunters, farmers, sailors, and other explorers all studied the sky to learn the rhythms of nature for survival and commerce. Understanding modern astronomy helps people comprehend their place in space and time. Astronomical understandings regulate many parts of our lives today: daylight savings time, seasons, the calendar, and also some holidays are determined by sky events. Additionally, the scientific method is demonstrated in a concrete way when we learn about sky objects such as galaxies and black holes.

Unique, Inspirational Environment: Every planetarium immerses visitors in a 3-D environment that evokes realism. The sight of stars appearing in a dark sky, now being lost to light pollution in many areas, immediately captures attention and evokes awe. As cities expand, the lack of personal contact with nature is producing negative psychological effects.2, 3 A planetarium's night sky is a powerful, memorable, and soothing image which encourages learning. Immersion sparks a viewer's creativity, interest, and engagement, aspects of education's affective domain

.

Educational Standards: Earth and Space Science and the scientific method are major themes in national and state pre-college educational standards. For example, countries require teaching the fact that patterns of the motion of the Sun, Moon, and stars in the sky can be observed, described, and predicted, and that seasonal patterns of sunrise and sunset be observed, described, and predicted. Both topics are best taught in a planetarium because of their ability to speed up time and show unobservable phenomena

.

A Superior Learning Environment: The immersive planetarium shows learners our universe in ways that flat screen films do not.4,5 For example, Moon phases is a projective spatial concept, one that requires a person to mentally switch back and forth between Earth and space views and relate the two perspectives for better understanding. Earlier research had found that most students were unable to reach this coordinated level of understanding of Moon phases. However, it was found to be possible in the fulldome planetarium.6

Place for Inquiry-based Learning: Inquiry-based learning is a teaching strategy and learning method that prioritizes student questions, ideas, and analyses. The planetarium environment triggers learner curiosity in ways that normal classrooms cannot. Students are able to discover sky changes that are parts of important long-term cycles, including day and night as a result of Earth's rotation, differences in the daytime paths of the Sun during different seasons, lunar phase and position changes during a month, and planet movement among the fixed stars. Acceleration of these sky changes, so that they occur in a convenient student-visit time period, provides exceptional opportunities for learning astronomy with inquiry procedures.

Reinforcement of Classroom Learning and Retention: Students who attend a planetarium presentation in conjunction with classroom learning,7 have the opportunity to resolve misconceptions introduced by 2-D textbook illustrations and computer diagrams. Research is showing that classroom learning coordinated with planetarium lessons show the most gains in knowledge and retention.8,9,10,11,12,13 In addition, since many elementary classroom teachers receive limited training in science, the planetarium integration provides them an opportunity to improve their own knowledge and teaching methods.

Help for the Difficult Learner: The planetarium experience can be an important gateway to learning for children who dislike learning in formal environments.14 Additionally, live planetarium programs benefit learners with short attention spans.15

Unique Capabilities of Current Planetariums: Increasingly, planetariums employ digital projectors that can zoom the learner from Earth to the Moon, other planets, stars, and distant galaxies. The ability to see objects from different perspectives offers the opportunity to understand our true place in space. Basic spatial understanding, like the Earth's rotation, seasons, and Moon phases can be visualized both from Earth and space.16 Cutting-edge science research, whose data is normally shown only in spreadsheets, can now be visualized and understood by the general public. Observatories can stream images directly to planetarium audiences, showing real-time views of the cosmos. Additionally, planetariums stream astronomy lectures and multi-discipline programs live to other planetariums in small schools, museums, and even in remote locations.

Multi-Discipline Presentations: Planetariums are natural multi-discipline facilities. Thousands of planetarium programs are offered across the globe and range from live artistic performances to programs that take the audience underwater to learn about topics beyond astronomy. Even foreign language lessons, creative writing sessions, and reenactments of historical events take place in planetariums. Current and future artists, musicians, writers, animators, and many other non-STEM professionals are inspired by planetariums.

Unlimited Possibilities with Digital Fulldome: The evolution of technology extends the possibilities of the multi-discipline planetarium learning environment. Structures and processes within atoms, cells, DNA, human anatomy, land forms, weather systems, and ocean currents can be illustrated at different scales and from different points of view. Simulated trips can take learners to a nuclear power plant, the Egyptian pyramids, the terra cotta warriors of Xian, Greek and Roman temples, the Grand Canyon, Stonehenge, and more. Recent archaeological discoveries at Mayan, Viking, Celtic, and other sites are visualized and shared. Visitors also can travel across geological time periods, historical timelines, and even the predicted futures of human civilization.

A Positive Social Environment: The planetarium is a place where diversity and equality can be promoted, particularly when facilitators use interactive techniques. Live programming provides the opportunity for participants to connect with each other and the presenter. Also, accommodations have been developed for people with disabilities: the visually and hearing impaired, those with autism spectrum disorder, people with intellectual disabilities, and more.

Impacting Communities: Planetariums are not just for young learners. They welcome everyone from the community to attend public events. Many community groups and professional organizations visit the planetarium for lifelong learning experiences. Many STEM-related issues affect our planet today. It is the public who must have the capacity to understand these issues to make informed decisions and encourage powerful, global impact. Planetariums inform the public on these matters.17

Inspiration to Follow STEM and non-STEM Career Paths: Astronomers, space scientists, and others working in STEM fields were influenced to follow their careers after planetarium visits.18 Currently, it is estimated that employment in the STEM field will increase by 1 million jobs by 202219. Also, the development of planetarium programming requires skills of computer programmers, writers, artists, animators, musicians, and others. These programs in turn inspire future writers, artists, and countless others.

Statements in Support of the Educational Value of the Planetarium

"Student comprehension of complex concepts is enhanced by the ability of the planetarium to compressing-term patterns and cycles into shorter segments which in result in powerful learning experiences."—*The Middle Atlantic Planetarium Society* (www.mapsplanetarium.org)

"The planetarium can motivate students with its stimulating learning situation. Surveys have shown that students like astronomy more than other sciences, and the stimulating environment can build on initial interest and help it develop into a lifelong interest."—*The Great Lakes Planetarium Society* (www.glpa.org)

"Space science makes an important contribution to social, cultural, and intellectual development, which are inseparable from economic development in the long run...planetariums can make an important contribution to the Universe around us."—*Office for Outer Space Affairs, United Nations*[20]

"The President of the United States, Barack Obama, and his wife and two young daughters attended a planetarium show in a portable dome set up on the South Lawn of the White House on October 7, 2009 at a NASA star party...The President asked a question that had come up during their dinner earlier that evening about the cause of the seasons. I gave a short demo on DigitalSky showing the changing Sun illumination at the North Pole over a six-month period...Later I learned that the family normally spends much less time at White House lawn events than the hour they did that evening--we made an impact."—*Martin Ratcliffe*[21]

"The (immersive planetarium) medium is well suited for productions that combine art and science...While the specific missions of museums vary, it has been argued that imparting a sense of social responsibility is a universal imperative. The capability to deliver powerful media experiences ought to translate into the capability to more deeply influence the visitor's core beliefs and worldviews. This focus on transformation is an emerging trend in fulldome programming."—*Ed Lantz*[22]

"The immersive dome experience itself can be an outstanding source of inspiration that will encourage guests to engage in a lifetime process of learning."—*Michael Daut*[23]

"Information from research institutions often is a vital part of many planetarium presentations. In this sense, planetariums can function as a media outlet for education and public outreach offices at research facilities. These theatres are an effective magnet for the 'motivated, interested public' that education and public outreach offices seek to reach."—*Carolyn Collins Petersen*[24]

"Planetariums have a way of attracting people's attention and their imagination, ushering learners into a deeper understanding of scientific concepts."—*Dayna Thompson*[25]

"The environment of a planetarium provides a family and community gathering place where children and parents can have shared experiences in the learning process."—*Astronomy Literacy, Great Lakes Planetarium Association*[26]

"We currently are living in a time when truth, reality, and science are under constant fire from sources seeking to spread alt-truths, unsupported fantasies, and disinformation about scientific results...A planetarium can be a place in a school, museum, or science centre that can best present current science information to both students and the general public of all ages in a way that is accurate, engaging, and inspirational. Regardless of whether the facility is analogue or digital, the planetarium can go a long way in helping teach STE(A)M topics and instill the spirit of the scientific method, something people likely will not get in other places."—*Tom Callen*[27]

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Further Reading

"The Educational Value of the Planetarium." (1978). Editor: Jeanne E. Bishop. Approved by GLPA membership, annual meeting. www.glpa.org, pp. 1-4.

Jackson, F. (2019) "Why Stargaze?" *Sky & Telescope* 137(5), p. 84.

Manning, J. G. (1995) "The Role of Planetariums in Astronomy Education." An Address to the Education Symposium of the Astronomical Society of the Pacific, June 24, 1995. Retrieved from www.ips-planetarium.org/page/a_manning 1995.

Perhoniemi, T. (2006). "Essence of Planetarium Use of Pedagogy." *Planetarian* 35(1). pp 16-19.

Reed, G. (1994) "Who in the Hell Needs a Planetarium? *Planetarian* 23(1). Retrieved from https://www.ips-planetarium.org/page/a_reed1994.

Sweitzer, J. (2005). "Feeding the Beast and Other Responsibilities of Digital All-Dome Planetarium Owners." *Planetarian* 34(3). pp 12-14.

Tips for the New Planetarian. GLPA tips booklet No. 1 (1990 Edition). Editors: DeRemer, D.A. & Sampson, G.E. Retrieved from https://glpa.org.

Watt, R. (2005)."Planetarium Paradigm Shift." *Planetarian* 34(3). pp. 15-10.

Yu, K.D. (2005). "Digital Fulldomes: The Future of Virtual Astronomy Education." *Planetarian* 34(3). pp. 6-11.

Endnotes

1 International Planetarium Society Official Statement on the Role of Planetariums in Education, www.ips-planetarium.org/page/edstatement

2 Moore, C.A. and Richman, A.M. and Chamberlain, V.D. (2011) "Finding Inspiration in the Face of Endangered Starry Skies." *The Inspiration of Astronomical Phenomena*, ASP Conference Series, Vol. 441. San Francisco: Astronomical Society of the Pacific, p. 451

3 *The Week,* Health and Science News. "Green Spaces and Mental Health." March 15, 2019, p. 22.

4 Yu, Ka Chun and Sahami, Kamran and Sahami, Victoria and Sessions, Larry C. (2015) "*Using A Digital Planetarium For Teaching Seasons To Undergraduates*." Journal of Astronomy & Earth Sciences Education (JAESE), 2 (1). pp. 33-50. Retrieved from https://istardb.org/1288/

5 Thornburgh, W.R. (2017) *The Role of the Planetarium in Students' Attitudes, Learning, and Thinking About Astronomical Concepts*. Ph.D. dissertation, University of Louisville, Louisville, KY. Retrieved from https://istardb.org/1895/

6 Chastenay, P. (2016) "From Geocentrism to Allocentrism: Teaching the Phases of the Moon in a Digital Fulldome Planetarium." *Research in Science Education,* 46(1), pp. 43-77. See also https://link.springer.com/article/10.1007/s11165-015-9460-3

7 Schmoll, Shannon Elizabeth (2013) *A Comparison Of The Effectiveness Of Two Instructional Techniques In A Planetarium Setting*. Doctoral dissertation, University of Michigan Ann Arbor. Retrieved from https://istardb.org/168/

8 Larsen, Kristine and Bednarski, Marsha (2011) "*Assessing the Effect of a Digital Planetarium Show on the Astronomical Understanding of Fifth Graders*." In *Earth and Space Science: Making Connections in Education and Public Outreach*. Astronomical Society of the Pacific Conference Series, pp. 183-186.

9 Plummer, Julia D. and Small, Kim J. (2014) "*Integrating Planetarium and Classroom Instruction to Engage Children in the Practices of Science*." In *Ensuring STEM Literacy: A National Conference on STEM Education and Public Outreach*. Astronomical Society of the Pacific Conference Series, pp. 407-410.

10 Thornburgh, ibid.

11 Brandt, K. (2018) Personal communication of analysis of Robeson County, NC standardized testing report. Results retrieved from www.robeson k12.nc.us/Page/67130.

12 Plummer, J.D. (2009) "Early Elementary Students Development of Astronomy concepts in the Planetarium." *Journal of Research in Science Teaching,* 46(2), pp. 192-209.

13 Yu, K.C and Sahami, K. and Dem, G. and Sahami, V. and Sessions, L.C. (2016) "Immersive Planetarium Visualizations for Teaching Solar System Moon Concepts to Undergraduates." *Journal of Astronomy & Earth Sciences Education,"* 3(2).

14 Renninger, K.A. (2007) "Interest and Motivation in Informal Science Learning. *IEEE Computer Society Press*. Retrieved from www.informalscience.com/researches/Renninger_Commissioned_Paper.pdf

15 Plummer, (2009), ibid, pp. 192-209

16 Rubin, Judith. (2015) "Visualizing the Data: Solar Superstorms: How big data feeds a big movie." *Planetarian* 44(1), pp. 12-16

17 Gutwill, J.P., & Allen, S. (2012). Deepening students' scientific inquiry skills during a science museum field trip. *Journal of the Learning Sciences*, 21(1), 130-181.

18 Dietz, T. and Lund, L. and Rosendhal, J. (1989) *On the Origins of Scientists and Engineers*. The Space Policy Institute, George Washington University, Washington, DC.

19 Vilorio, D. (2014) "STEM 101: Intro to tomorrow's jobs" in *Occupational Outlook Quarterly*, Spring 2014, www.bls.gov/ooq,

3-12. Accessed from https://www.bls.gov/careeroutlook/2014/spring/art01.pdf.

20 *Planetarium: A Challenge for Educators*. (1992) Department of Political Affairs, Office for Outer Space Affairs, United Nations, New York. Forward, p. v.

21 Ratcliffe, Martin. (2009) "Star Party at the White House. *Planetarian* 38(4), pp. and personal communication, March 27, 2019.

22 Lantz, E. (2011) "Planetarium of the Future." Retrieved from https://www.researchgate.net/publication/230546875_Planetarium_of_the_Future.

23 Daut, Michael. (2019) "Planetariums Need to Build and Engage

Audiences to Survive." *Planetarian* 48(1). pp. 8-10.

24 Petersen, Carolyn Collins. (2005) "The Unique Role of the Planetarium Science Center in Science Communication." The *ESO/ESA/IAU Conference: Communicating Astronomy with the Public*.

25 Thompson, Dayna. Charles W. Brown Planetarium, Ball State University, Muncie, Indiana; personal communication, March 11 2019.

26 The Great Lakes Planetarium Association. "Astronomy Literacy: Essential Concepts for a K-12 Curriculum." First developed 2011. Most recent version 2019.

27 Personal communication, March 2019.

WHERE'S THE DATA? WHY, HERE IT IS!

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Citation:
Shanks, Sharon. "Where's the data? Why, here it is." *Planetarian*, Vol 48 No 2, June 2019. Pp. 12-15.

Abstract: The interest in astronomy education research is growing, and has transformed over the past decade (or basically since the turn of the century) to include more qualitative studies. The questions being asked have gone from "is the planetarium an effective teaching tool" to "why is the planetarium an effective teaching tool." In addition, a move to include grey literature as acceptable research sources has opened up a way for planetarians who are not astronomy education researchers to share their observations and insights. We planetarians need to take advantage of this open door and pro-actively contribute to the field.

Introduction

Nearly 10 years ago I gave a paper at the Great Lakes Planetarium Association conference (2010, Notre Dame) in which I asked "Where's the Data? (The need to survey planetariums for educational efficacy)." I reviewed recent publications on planetarium efficacy and mourned its scarcity. The paper wasn't noticed by many, and was duly included in the conference proceedings,[1] where it also wasn't noticed and became just another unfindable piece of grey literature.[2]

I am happy to revisit this question in 2019 with the observation that astronomy education research has come of age in the past decade and the question of "are planetariums effective" is being answered as "yes." Moreover, the adoption of fulldome and its immersive ability have changed the question, from "are planetariums effective" to "why are planetariums effective," opening new lines of research.

This is wonderful news, but for planetarians who have worked "in the trenches," so to speak, for years, there is something even better: our intuitions are being validated. Many veteran planetarians, myself included, have shared thoughts and observations over the years with each other about how and why a planetarium is an effective teaching tool, and our unquantifiable gut intuitions are right. Planetariums are the best tool to teach:

Movement over time, such as daily motion, celestial motion, and other periodic motions that cannot be easily observed;

Concepts that require or benefit from spatial and three-dimensional understanding, such as the sun-earth-moon system, moon phases, and seasons; and

Concepts that benefit from allocentric and geocentric observation, again such as moon phases and seasons, and a sense of scale, distance, and time.

In addition, we planetarians have known in our hearts that our facilities—both fixed dome and portable—make an impact on the affective realm of student experience and that positive experiences can improve learning; that teachers need to be active participants to make the best use of the planetarium experience; and that the dome is just one tool that can be used to educate and cannot be expected to "teach everything my students need to know to pass the test in 45 minutes."

So what happened?

Several major changes in educational research, along with planetarium technology change and the much-needed debut of a research database, have taken place roughly since the turn of the decade. In his 2017 paper "Illuminating Learning in the Dome: Constructing the International Studies of Astronomy Education Research Database,[3]" Dr. Timothy Slater at the University of Wyoming provides an overview of the new iSTAR Database (more on this below). He also reviews discoveries in his 2017 book *Research on Teaching Astronomy in the Planetarium*, co-written with Coty B. Tatge.[4] Among his findings is the existence of a research gap in astronomy education, roughly from 1990 to 2005. This also is the approximate time frame of the adoption of digital fulldome by many planetariums, a technology change that transformed planetariums from "theater of the stars" to immersive learning environments. Although beloved analog projectors (many still in use because of their superior star quality) had always provided an immersive environment, the ability to move more than just the stars opened the dome to clearer explanations of daily motion, the seasons, and other non-observable concepts. Taken together, this divided astronomy research into two eras: the analog era and the digital era.

Research following the digital evolution also benefited from what he calls "paradigm wars,[5]" a time roughly between 1980 and 2000 that saw less insistence on quantitative studies and the acceptance of qualitative and mixed methods research, especially in astronomy education research.

Slater also has championed the use of grey literature while conducting research in astronomy, arguing that theses and dissertations undergo as much, if not more, review as papers appearing in refereed journals. In "Undiscovered Value of Grey Astronomy Education Research Results[6]," Slater notes that "Grey literature is the scholarly work that has been done and presented at conferences or exhaustively written up in dissertations, but never formally published in refereed journals." He continues to an example of the best-known example of grey literature: Philip Sadler's *A Private Universe*.[7]

"Many authors publishing reviews of research rarely include graduate theses and dissertations, despite the fact that most have been more thoroughly reviewed by a larger number of scholars—those four, five, or six scholars who sit on graduate review committees—than those two or three who review manuscripts for journals.[8]"

Other changes Slater points out include a switch from live presentations by an astronomy educator with the analog projector to pre-recorded programs,[9] and a change of focus from star and constellation identification to cutting-edge research and explaining high-interest concepts (black holes, for example). Other factors impacting change: the slowdown in the US economy starting in 2008, the push to adopt national education standards, and growing diversity among students.

Some notable conclusions from ***Research on Teaching Astronomy in the Planetarium***:

"Taken together, there are tremendous forces shaping the way planetariums serve as a critical component of the larger US education portfolio. As a result, the future research questions pursued by planetarium education researchers will evolve as well." (page 25)

"Moreover, planetarium education researchers will have to engage in shedding the one-size fits all education approach and find innovative ways to individualize the planetarium learning experience." (page 25)

"What we now have come to better appreciate is that the planetarium in and of itself in isolation is not a magical silver-bullet for solving all of astronomy education's challenges for improving learning and attitudes. Instead, planetarium education programs need to use the same educational theory-driven, research-confirmed best practices in science education to help enhance learners' cognition and affect. The planetarium is unarguably able to capture attendees' innate interest, but planetarium education research confirms that lasting change requires purposeful educational decisions in order to be relevant and effective." (page 123)

What do researchers need?

In "A Community Discussion about Sharing and Publishing Space Science Education Research and Evaluation,[10]" Buxner et al reported that a Special Interest Group at the Astronomical Society of the Pacific's 2011 annual meeting expressed several specific concerns, including

The lack of a central place to publish and to read studies specifically in space science education.

The increasing need for a place to share evaluation results related to space science programs.

The need to make available a synthesis of research for non-education experts who work in space science education and public outreach.

The lack of access to relevant articles for individuals without institutional subscriptions.

At that point in time, concern 1 was being helped by *Astronomy Education Review* (AER), which provided the central place to publish. Unfortunately it operated only from October 2001 until December 2013.[11] The *Journal of Astronomy & Earth Science Education*[12] (JAESE) debuted a year later as an online, free-access publication under the editorship of Slater. It now fills the need for a central place to publish.[13]

Concerns 2 and 3 are outside of the scope of this paper,[14] but concern 4 is now being answered by iSTAR, the International Studies of Astronomy Education Research Database,[15] which launched in 2017. It is an international collaboration of astronomy education researchers who maintain and continually populate a growing database that can be searched in an almost endless combinations. In addition, it has collected hard-to-find theses and other grey literature and made them freely available for download by anyone doing research, a boon to those without access to institutional subscriptions (with the exception of some journal articles held by copyright behind paywalls, for which abstracts are available).

The iSTAR project is led by Dr. Stephanie J. Slater, director of the International CAPER Center for Astronomy & Physics Education Research, in collaboration with Australia's Michael T. Fitzgerald and graduate student Saeed Salimpour of Edith Cowen University's Institute for Education Research, Brazil's Paulo S. Bretones of the International Astronomical Union's Working Group on Astronomy Education, among many others, along with JAESE's Slater and University of Wyoming Ph.D. candidate Tatge.

Thanks to iSTAR, doing a literature search about planetarium efficacy suddenly became much easier and yielded more results, primarily because the database includes access to master's and doctoral theses not normally available and also shares research from grey literature.

Results of my iSTAR research: Highlights of the papers I chose to look at further

A doctoral dissertation titled *The Role of the Planetarium in Students' Attitudes, Learning, and Thinking About Astronomical Concepts* by William R. Thornburgh, 2017[16] was the most exciting find. Dr. Thornburgh, now a postdoc at the University of Louisville, examined "... the role of the planetarium on students while learning astronomy. The main goals of this study were to evaluate changes in students' attitudes towards astronomy, whether students learned and retained more knowledge due to planetarium-enriched instruction, and how the planetarium helped students think about astronomical concepts."[17]

His results: "... the immersive environment and unique capabilities of a digital planetarium positively influenced students' attitudes, learning, retention, and thinking." In addition, he clearly outlines the contributions of his research for planetariums, informal science education researchers, and schools. Because I consider his section on contributions to planetariums and planetarium educators to be so important, I am including the entire statement (page 126):

The first contribution of this study would be to planetariums and the educators they employ. The findings of this study have added to the existing data about planetariums, revealing a positive influence on students' attitudes toward science and confirming that students learn more from studying astronomy in a planetarium.

The measurement of learning included additional components that varied from previous research (i.e. retention quiz) and should encourage new studies to evaluate the retention of knowledge over time and to measure learning beyond test performance. This study found that students receiving an embedded planetarium program while learning astronomy outperformed others on a test by a statistically significant margin and exhibited an increased gap by 3.5% on the two assessments, meaning that the treatment group retained knowledge at a higher rate. Planetariums may have an increased interest in working with school groups to measure knowledge, which may lead to the redesign and improvement of field trip offerings.

In regards to capturing the process of learning, rather than learning as a product, the findings of this study indicated that each of the three contexts influenced students' thinking of astronomical concepts. Students were positively affected by the physical space of the planetarium, the activities conducted within the planetarium setting, and with the visualizations projected onto the dome. In order for planetariums to shape student thinking in a positive direction, more experiences (e.g. field trips, exhibits) that will touch each context of the CML[18] should be considered.[19]

Another positive report for planetariums is found in "The concept of spatial scale in astronomy addressed by an informal learning environment" by Anthony Lelliott[20] in Johannesburg, South Africa. He studied how grade 7 and 8 students engaged with the concept of spatial scale before, during, and after visits to both an astronomy science center and a planetarium.

He concludes that "results indicate that, despite contrary suggestions in the literature, students aged 13- to 15-years are able to improve their conceptions of size and distance from naïve and conflicting knowledge to a more scientific understanding after their visit.... The paper argues that a combination of related, themed experiences related to spatial scale can account for the improvement, and recommends that these and even more innovative activities should be explicitly promoted at science centres and in out-of-classroom activities."

Cumhur Turk and Huseyin Kalkan[21] in Turkey in 2014 wrote "The Effect of Planetariums on Teaching Specific Astronomy Concepts" with the goal of determining students' knowledge levels on certain astronomy concepts and the effect of the planetarium environment on teaching. They found "The study results showed that teaching astronomical concepts in a planetarium environment was more effective than in a classroom environment. The study also revealed that students in the planetarium-assisted group were more successful in comprehending subjects that require 3D thinking, a reference system, changing the time and observation of periodic motion than those in control group."

What do planetarians need?

The paper that I personally gained the most knowledge from was "Elementary Student Knowledge Gains in the Digital Portable Planetarium[22]" by Laura D. Carsten-Conner, et. al. In addition to positive results, specifically "Our results suggest that the portable planetarium may be a useful strategy in supporting learners as they struggle with reconciling observed patterns with underlying, non-observable motions of the Earth, and with visualizing concepts such as the speed of planetary orbits relative to their position with respect to the sun," the paper was the only one I found that included a detailed description of the planetarium program itself.

The authors described the setting (a 6-meter dome), the projection system (a digital STARLAB), and the software (Starry Night). The program was interactive and 25 minutes long. A detailed description of the program provided the major points, the sequence it was presented, and the reasoning for the order of topic.

Other research papers describe using the dome in presenting a general topic or in analyzing a specific program, but not the actual presentation itself. For example, teaching seasons is described in "Using a Digital Planetarium for Teaching Seasons to Undergraduates,[23]" but the paper did not describe how the topic was presented under the dome. Another example, "Comparison of Student Learning About Space in Immersive and Computer Environments[24]" looks specifically at one program, *We Choose Space*, and how presenting the program in a dome and on a computer affected retention.

Drilling down to the basics of the presentation, in my opinion, is the best help for most planetarian presenters.

Shannon Schmoll, in her doctoral dissertation "A Comparison of the Effectiveness of Two Instructional Techniques in a Planetarium Setting,[25]" does not study planetarium efficacy as much as she does two teaching method frameworks. She does, however, conclude that students need adequate preparation and classroom support to get the most from their informal education experience. In suggesting revisions to the SMILES (School-Museum Integrated Learning Experiences in Science) framework, one of the two she studies, she says "These revisions included addressing choice and control normally seen in museum settings in the classroom, preparing students for language in addition to concepts seen while on a field trip by providing teachers with a script or list of vocabulary to be addressed in context, have students collect data from the show and explicitly use it with scientific practices the classroom afterward to support multiple exposures to ideas and help them avoid using authority of facts gathered at the planetarium as a sole means of justifying answers, model specifically those scientific practices in the classroom, and address a single overarching topic in planetarium show[s] or delineate changes between topics to avoid confusing students.[26]"

The points noted in this sentence are all usable suggestions that planetarians can take advantage of, especially the need to address a single topic, and, if more than one topic is included, to clearly let the students know when a topic change is taking place.

Planetarians need to contribute

Despite often being forgotten in planetarium education research, we under-the-dome planetarians have made many contributions to the field and continue to do so at each of our conferences. We do this by giving papers, which are then collected in conference proceedings. Until just recently, conference proceedings were not considered as appropriate sites for research because of the lack of peer review.

Returning to Slater and Tatge's *Research on Teaching Astronomy in the Planetarium*:

Due to the surprising lack of empirical research reports in scholarly peer-reviewed journals related to planetarium education research, much of the research is found within grey literature (Slater 2015[27]). Additionally, one of the journals central to planetarium education research, the *Planetarian*, publishes both peer-reviewed and grey literature mixed together without a clear distinction between the two[28]. In order for a work to qualify as "peer-reviewed," reports reviewed required an abstract, a listed accepted/published date, and one or more sections considered a methodology, literature review, or program evaluation with empirical results. For a research report to be classified as "grey literature," it needs to fulfill one or all of the following criteria: no abstract, no bibliographic citations, a conference proceeding, poster, or presentation. Since a large portion of publications relating to planetarium education research usually describe the subject in a general manner, they were categorized within the program/curriculum report or description domain as long as they were not considered formal reviews of the literature. Also classified within this category were any works that described a new activity or planetarium. (page 11)

Even though the adjective "empirical" means something based on or verifiable by observation or experience rather than theory or pure logic, in educational research empirical research relies not only on the observable, but also on the measurable. This translates to methodologies: quantitative, qualitative/interpretive, and mixed-methods.[29]

The subset of people who work under the dome who are able to conduct empirical research at the peer review level, especially within the requirement listed above, is fairly small; most (but not certainly all) of their names have been mentioned in this paper or in the endnotes. This leaves a large number of people making daily observations that are valuable to their peers, some of whom then share their observations, best practices, novel ideas, and other insights at conferences and in planetarium affiliate newsletters.

Here are research resources just waiting to be mined for data to share. There is *Planetarian*, of course, but also IPS conference proceedings and affiliate proceedings from around the world. Our resources are primarily grey literature, and iSTAR is willing to accept our contributions. As it states on the iSTAR website: "We challenge all communities of astronomy education researchers to use the iSTAR database to develop and extend collaborations; inform policy, funding and educational decisions; and share in the voice, perspective and experience of astronomy education research. Please join us by uploading any and all works related to astronomy education research[30]!"

Sources ready to be mined for data

Our job is to scour our publications for papers that deserve to be shared with wider audiences, instead of being hidden on our websites or shelves. Perhaps seek an astronomy education researcher from within your ranks to assist in deciding the suitability of the wider dissemination. Use the "iSTAR Database Document Categorization Scheme" that appears on page 12 of Slater's article in the December 2017 *Planetarian*, or on pages 8-11 in the *Astronomy Education Research in the Planetarium* book. Although the upload section of the iSTAR database website might appear daunting, do not let it stop you. The categories most applicable to planetarium grey literature are fairly clear, and you do not need to fill in every line:

Document source: grey literature

- *Type of resource: curriculum or program evaluation, curriculum description or report, position paper or editorial, and historical*
- *Empirical methodology: applies only to empirical studies*
- *Learning environment: informal*
- *Research setting: nearly all of the settings listed, with the probable exception of research facility*
- *Study participants: all apply*
- *Construct: your decision, but probably general teaching strategies and perhaps nature of science*
- *Scientific content focus area: all apply*
- *Demographic focus: all apply*

The final two categories, language of publication and location study conducted, are self explanatory.

Summary

There is a tremendous amount of valuable information in the planetarium community's conference proceedings. Although it might not be possible for planetarians to perform empirical research, we certainly can add to the literature to help astronomy education researchers by taking advantage of the iSTAR Database.

(Endnotes)

1 Shanks, Sharon. "Where's the Data? The Need to Survey Planetariums for Educational Efficacy," *Proceedings of the Great Lakes Planetarium Association*, Oct 20-23, 2010, Notre Dame University, pp 68-70.

2 Gray Literature: "That which is produced on all levels of government, academics, business and industry in print and electronic formats, but which is not controlled by commercial publishers." http://www.greylit.org/about

3 Slater, Timothy F. "Illuminating Learning in the Dome: Constructing the international Studies of Astronomy education Research Data Base." *Planetarian*, 56 (4), December 2017, p 11.

4 Slater, Timothy F. and Tatge, Coty B. (2017) *Research on Teaching Astronomy in the Planetarium*. Springer Briefs in Astronomy. ISBN 978-3-319-57200-0

5 ibid, p 15

6 Slater, Timothy F. (2016) "*Undiscovered value of grey astronomy education research results." The Grey Journal*, 12 (3).

7 *A Private Universe* was created and produced by Matthew H. Schneps and Philip M. Sadler, Harvard Smithsonian Center for Astrophysics, in 1988. An excellent article about the program appears at https://www.scienceinschool.org/2010/issue17/privateuniverse

8 Slater, 2016

9 This trend now appears to be moderating as the practice of Live Interactive Planetarium programs spreads; although never quantified officially, it seems the majority of planetariums include both live/interactive and recorded components. The "wow factor" and existence of pre-recorded fulldome content aided many stakeholders to approve funding for planetarium upgrades.

10 Buxner, Sanlyn R. and Bartolone, Lindsay and Fraknoi, Andrew and Plummer, Julia D. and Brinkworth, Carolyn and Schultz, Greg (2015) A Community Discussion about Sharing and Publishing Space Science Education Research and Evaluation. In: *Celebrating Science: Putting Education Best Practices to Work*. Astronomical Society of the Pacific Conference Series, pp 143-147.

11 Learn more about the story of AER in Fraknoi, Andrew (2014) "*A Brief History Of Publishing Papers On Astronomy Education Research." Journal of Astronomy & Earth Sciences Education* (JAESE), 1 (1) pp 37-40.

12 https://clutejournals.com/index.php/JAESE

13 See Fraknoi 2014 article in JAESE and also the 2017 Slater-Tatge book for additional publications.

14 Although Concern 3, the synthesis of research for non-education experts, would be a major benefit to planetarium educators.

15 https://istardb.org/information.html

16 Thornburgh, William R. (2017) *The Role of the Planetarium in Students' Attitudes, Learning, and Thinking About Astronomical Concepts*. Doctoral thesis, University of Louisville.

17 Ibid, p v (abstract)

18 Contextual Model of Learning (CML)

19 Go to https://ir.library.louisville.edu/etd/2684/ and read the thesis for yourself, or search for it on iStar.

20 Lelliott, Anthony D. (2010) "*The concept of spatial scale in astronomy addressed by an informal learning environment." African Journal of Research in Mathematics, Science and Technology Education*, 14 (3). pp. 20-33.

21 Turk, Cumhur and Kalkan, Huseyin (2014) "*The Effect of Planetariums on Teaching Specific Astronomy Concepts." Journal of Science Education and Technology*, 24 (1) pp 1-15.

22 Carsten-Conner, Laura D. and Larson, Angela M. and Arseneau, Jennifer and Herrick, Robert R. (2015) "*Elementary Student Knowledge Gains In The Digital Portable Planetarium. Journal of Astronomy & Earth Sciences Education* (JAESE), 2 (2) pp 65-76.

23 Yu, Ka Chun and Sahami, Kamran and Sahami, Victoria and Sessions, Larry C. (2015) "*Using A Digital Planetarium For Teaching Seasons To Undergraduates*." Journal of Astronomy & Earth Sciences Education (JAESE), 2 (1) pp 33-50.

24 Zimmerman, Laurie and Spillane, Stacia and Reiff, Patricia and Summers, Carolyn (2014) "*Comparison of student learning about space in immersive and computer environments*." Journal and Review of Astronomy Education and Outreach, 1 (1) A5-A20.

25 Schmoll, Shannon Elizabeth (2013) *A Comparison Of The Effectiveness Of Two Instructional Techniques In A Planetarium Setting*. Doctoral thesis, University of Michigan Ann Arbor.

26 Ibid, abstract

27 Slater, T. F. (2015). Is the best astronomy education research 'grey'? Retrieved from the AstroLrner blog at: https://astronomyfacultylounge.wordpress.com/2015/09/24/is-the-bestastronomy-education-research-grey/ https://astronomyfacultylounge.wordpress.com/2015/09/24/is-the-best-astronomy-education-research-grey/

28 This lack of distinction has changed over the past several years to make it clear which articles are reviewed, according to the editor.

29 Slater-Tatage (2017) p 12.

30 https://istardb.org/information.html

STARRY NIGHT FAVOURITES
FOR THE STARS, SUN, MOON, AND PLANETS

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Abstract: This short course demonstrates many of the favourites I have developed using Starry Night in Spitz SciDome. These cover applications to stars and the solar system and can be useful in a wide range of teaching and show modes. Besides common topics such as the stars and Sun at different latitudes, some less common topics include the sky in the far past or future, the analemma, a circumpolar moon, Phobos and Deimos in the Martian sky, the Sun seen from Uranus and Pluto, Venus in the Mayan sky, and more. SciDome users can get a complete set of these favourites.

Since we installed Spitz SciDome in 2014, I have developed an extensive set of favourites in Starry Night. I have developed an extensive set of favourites to demonstrate sky phenomena both familiar and unfamiliar. Some were developed for use in my BGSU astronomy classes meeting in the Planetarium. Many reflect my own sky interests. Others were developed while I was giving an independent study on sky phenomena to the son of one of my colleagues. They focus primarily on the solar system rather than deep space.

Since the Ritter Planetarium also has SciDome and is close to the BGSU Planetarium, the conference provided a unique opportunity to demonstrate a selection of these favourites in a short course format. SciDome users can get a complete set of the favourites by lending me a thumb drive. Users of other fulldome systems may also find ideas for creating demonstration in their own systems. Naturally, I would welcome suggestions for improvements to any of these favourites.

Two obvious sets of favourites show the starfield a variety of latitudes ranging from pole to pole and various sets of constellation graphics. Others show the effects of proper motion: how the Big Dipper changes over time and the appearance of the sky and constellations in the distant future and distant past. Coordinates favourites define the alt-az grid, the RA-dec grid, and the ecliptic. Another set shows the sky at dates used in David Bradstreet's history vignettes.

An extensive set of Sun favourites shows the Sun's diurnal path at a wide range of latitudes. Analemma favourites show the analemma from Earth at different dates or variations of orbit parameters, as well as analemmas from the Moon and all of the planets from Mercury to Pluto.

Lunar favourites includes ones to show the difference between the sidereal and synodic months, regression of the nodes, and synchronous rotation, the sky at each of the Apollo landing sites, the major and minor standstills, a circumpolar full moon at Ny Alesund, Norway, the geocentric parallax of the Moon, the changes with latitude of the setting crescent and full moon, and the Moon's diurnal path at different phases and months.

Planet favourites show orbits and rotations. Mercury favourites show the Sun's diurnal path and retrograde motion from different longitudes and greatest elongations seen from Earth. Venus favourites include showing the Sun's diurnal motion on Venus and the circumstances of Venus transiting the Sun as seen from Earth. Other Venus favourites show the complex paths observed by the ancient Maya over the planet's 8-year-5-synodic period cycle and the extreme azimuths of rising and setting encoded in Mayan architecture.

A spectacular Martian favourite shows Phobos and Deimos moving in Mars' sky.

The ecliptic and retrograde motion of Jupiter and Saturn are shown in other favourites, as is the changing aspect of Saturn's rings. The diurnal motions of the Sun on Uranus are shown for equator and poles for 1987, 2014, and 2029, and a related set shows the Sun from Pluto and Charon as seen from equator and poles are various dates.

Several favourites illustrate precession; others are designed to accompany my Venus, Jupiter, and Moon sky motion workshops and my Kepler's 2^{nd} and 3^{rd} law workshops for advanced students.

These favourites are designed for use in an instructional setting rather than as elements in a show.

The remainder of this text is an annotated list of all the favourites.

SKY MOTIONS, ORBITS, & ROTATIONS

STARS

STARFIELD VS LATITUDE

North Pole all (summer & winter)

Starfield at North Pole, including stars, stick figure constellations, north celestial pole, and celestial equator in summer (which we cannot see) and winter (which we can see). Summer constellations include Dippers, Summer Triangle, and Orion. Winter constellations include Dippers, Leo, Auriga, and Orion. Run forward to show motions.

BG all (summer & winter)

Starfield at Bowling Green, including stars, stick figure constellations, north celestial pole, circumpolar circle, and celestial equator in summer and winter. Summer constellations include Dippers, Summer Triangle, and Scorpius. Winter constellations include Dippers, Leo, Auriga, and Orion. Run forward to show motions, including circumpolar stars and stars that rise and set.

BG circumpolar

Starfield at BG, including stars, stick figure constellations, north celestial pole, and circumpolar circle for Bowling Green, showing Dippers as circumpolar constellations. Run forward to show motion.

BG rise-set

Starfield at BG, including stars, north celestial pole, and stick figure for Summer Triangle as example of stars that rise and set. Run forward to show motion.

BG near occluded

Starfield at BG, including stars, north celestial pole, and stick figure for Scorpius as example of a constellation that barely rises in the BG sky. Run forward to show motion.

Equator all (northern summer and winter)

Starfield at Equator, including stars, north and south celestial poles, celestial equator, and stick figure constellations for northern summer and winter. Summer constellations include Dippers, Summer Triangle, Scorpius, and Southern Cross. Winter constellations include Dippers, Leo, Auriga, Orion, and Southern Cross. Run forward to show motions of stars rising and setting perpendicular to horizon.

Australia all

Starfield from southern hemisphere, including stars, south celestial pole, and circumpolar circle. Stick figure constellations include Southern Cross, Scorpius, and Summer Triangle. Run forward to show motions.

Tasmania just stars

Just the stars as seen from Tasmania.

Launceston S const

Starfield from Launceston, Tasmania, including stars, circumpolar circle, and stick figures for all visible constellations.

McMurdo all

Starfield from McMurdo, Antarctica (latitude 78°S), including stars, south celestial pole, circumpolar circle, and stick figure for Scorpius to illustrate that most of the visible sky is circumpolar. Run forward to show motion.

South Pole all

Starfield from South Pole, including stars, south celestial pole, and stick figures for Scorpius and Southern Cross, to show circular motion of stars at the pole. Run forward to show motion.

STARS IN CLASS

A201-fall sky just stars

The early fall sky from BG with just stars and no other graphics.

A201-fall sky w- lines

The early fall sky from BG with stick figures for several constellations.

OBAFGKM

The late winter sky from BG with just stars and no other graphics, but oriented so you can point out examples of the *spectral types: O (Alnitak), B (Rigel), A (Sirius), F (Polaris), G (Sun), K (Arcturus), M (Betelgeuse).*

Planets activity 8/28

The planets and Sun in the sky of August 28, 2018 for use in an activity measuring the angular separation of the planets from the Sun and using those angles to locate the planets in their orbits in a worksheet with a top-on view.

Sheri's talk

The midwinter sky for use in a talk by Dr. Sheri Wells-Jensen in BGSU's English Department.

CONSTELLATION GROUPS

North sky

Stars and stick figures for north circumpolar constellations.

Big Dipper points

Stars, stick figures, and lines to show the Big Dipper pointing to Polaris, Leo, and Arcturus.

Pegasus

Stars and stick figures for Cepheus, Cassiopeia, Perseus, Pegasus, and Andromeda to aid in telling the famous story.

Summer Triangle

Stars and stick figures for part of the summer sky: Hercules, Delphinus, and the Summer Triangle (Cygnus, Lyra, and Aquila).

Orion area

Stars and stick figures for part of the winter sky: Orion, Lepus, Canis Major, Canis Minor, Gemini, Auriga, and Taurus.

Ecliptic & zodiac

Stars and the ecliptic with stick figures for the zodiac constellations. Run forward to move around the ecliptic.

South sky

Stars and stick figures for the southern sky: Centaurus, Crux, Carina, Dorado, Octans, Tucana, Fornax, Scorpius, Corvus, Leo, Orion, and Canis Major.

PROPER MOTION RESULTS

Big Dipper in the future

Run forward to show the changing shape of the Big Dipper from 2352 BC to 99999 AD.

50000 AD N & Orion

Stick figures to show the shape of the Dippers, Cassiopeia, & Orion in 50000 AD.

50000 AD N Peg Sco

Stick figures to show Dippers, Cassiopeia, Pegasus, Sagittarius, and Scorpius in 50000 AD.

50000 BC N & Orion

Stick figures to show Dippers, Cassiopeia, and Orion in 50000 BC.

50000 BC N Peg Sco

Stick figures to show Dippers, Cassiopeia, Pegasus, Sagittarius, and Scorpius in 50000 BC.

99999 AD N & Orion

Stick figures to show the shape of the Dippers, Cassiopeia, & Orion in 99999 AD.

99999 AD N Peg Sco

Stick figures to show Dippers, Cassiopeia, Pegasus, Sagittarius, and Scorpius in 50000 AD.

99999 BC N & Orion

Stick figures to show the shape of the Dippers, Cassiopeia, & Orion in 99999 BC.

99999 BC N Peg Sco

Stick figures to show Dippers, Cassiopeia, Pegasus, Sagittarius, and Scorpius in 50000 BC.

SIDEREAL TIMES

Static displays with key constellations shown.

Sidereal 0 BG

The stars at sidereal time 0 hr, with stick figure to show Pegasus on meridian.

Sidereal 6 BG

The stars at sidereal time 6 hr, with stick figure to show Orion on meridian.

Sidereal 12 BG

The stars at sidereal time 12 hr, with stick figure to show Leo on meridian.

Sidereal 18 BG

The stars at sidereal time 18 hr, with stick figure to show Summer Triangle on meridian.

COORDINATES

<u>Star field no grid</u>

Spring starfield with graphics only for horizon and directions

<u>Alt az grid</u>

Starfield showing alt-azimuth grid.

<u>BG NCP & cel eq</u>

Winter star field showing north celestial pole and celestial equator.

<u>BG NCP & cel eq & ecl</u>

Winter starfield showing north celestial pole, celestial equator, and ecliptic.

<u>BG RA dec grid</u>

Winter starfield showing right ascension-declination grid

Define vernal equinox

Starfield with celestial equator and sun on ecliptic. Run (or step) forward to show Sun crossing the equator going north on the March equinox.

HISTORY

<u>Lincoln</u>

Sky with stars and Jupiter at 11:30 p.m. on August 29, 1857, night of murder in a trial with Lincoln successfully defending the accused.

<u>Boston Massacre</u>

Sky with stars, Saturn, and the Moon on March 5, 1770, date of the Boston Massacre.

<u>Boston Tea Party</u>

Sky with stars and Jupiter in evening of December 16, 1773, time of the Boston Tea Party.

<u>Paul Revere</u>

Sky with stars, Moon, Saturn, and Mars on April 18-19, 1775, night of Paul Revere's ride.

SUN

<u>sun on ecliptic</u>

Shows sun on ecliptic. Run or step the sun forward to show its motion along the ecliptic.

<u>sun ecliptic equator</u>

Shows sun on ecliptic with celestial equator also shown. Run or step the Sun forward to show its motion along the ecliptic and across the equator.

<u>sun N of equator</u>

Shows sun on ecliptic with celestial equator also shown. Run or step run the Sun forward to show its motion along the ecliptic and across the equator. Sun starts at March equinox, so motion will show the June half of the year when Sun is north of the equator.

<u>sun S of equator</u>

Shows sun on ecliptic with celestial equator also shown. Run or step the Sun forward to show its motion along the ecliptic and across the equator. Sun starts at September equinox, so motion will show the December half of the year when sun is south of the equator.

SUN PATH VS LATITUDE

These favourites, arranged from north to south, can show the Sun's diurnal path for different dates and latitudes. Most include the azimuth ring, the meridian, and an alt-azimuth grid. Some also show ecliptic and celestial equator. Run forward to show the Sun's diurnal motion.

<u>sun North Pole March</u>

Sun is on horizon. Run forward ≥2 days to show corkscrew effect.

<u>sun North Pole June</u>

Sun is at altitude 23½ degrees.

<u>sun Ny Alesund June</u>

Ny Alesund is a research village in Spitsbergen at latitude 78°N. 24-hour sun in June. Only graphics are meridian and horizon.

<u>sun Ny Alesund Feb</u>

Sun returns along southern horizon after winter absence.

<u>sun Barrow June</u>

Barrow is on the north coast of Alaska at latitude 71°N. 24-hour sun in June. Only graphics are meridian and horizon. Sun starts in east.

<u>sun Barrow June simple</u>

Sun starts low in northeast

<u>sun Arctic Circle June</u>

24-hour sun. Starts in northeast.

sun Fairbanks June

Fairbanks is at latitude 65°N, just below the Arctic Circle. Starts at sunrise just east of north point.

sun Fairbanks December

Starts at sunrise with just east of south.

sun Fairbanks Dec simple

As above, but only graphic is horizon. Suitable use with younger children.

sun Anchorage June

Anchorage is at latitude 61°N. Sun starts low in sky just east of north point.

sun Callanish June

Callanish is stone formation in UK at latitude 58°N. Starts at sunrise in NE. Long days.

sun Callanish Dec

Starts at sunrise near SE. Short days.

sun Edmonton June

Edmonton is at latitude 53°N. Starts at sunrise near NE. Long days

sun BG December

Starts at sunrise near SE to show winter path.

sun BG December simple

As above, but only graphic is cardinal points. Suitable use with younger children.

sun BG March

Starts at sunrise due east to show equinox path.

sun BG March simple

As above, but only graphic is cardinal points. Suitable use with younger children.

sun BG June

Starts at sunrise near NE to show summer path.

sun BG June simple

As above, but only graphic is cardinal points. Suitable use with younger children.

sun BG September

Starts at sunrise due east to show equinox path.

sun Tropic of Cancer June

Starts at sunrise and shows passage through zenith at midday.

Monte Alban Cap hel rise

Monte Alban is Zapotec site in Mexico from ~300BC. Only graphics are zenith and horizon. Shows heliacal rise of Capella on day the Sun reaches the zenith at midday.

Sun Equator June

Starts at sunrise and shows that sun transits north of zenith.

Sun Australia June

Shows that sun's rising and setting azimuths are similar to here, but that it transits in the north. Shows that June is southern winter.

Sun Antarctic Circle June

Shows that sun just barely skims the northern horizon at noon.

Sun South Pole June

Shows that sun is not visible. Opposite of North Pole.

ANALEMMA FROM EARTH

Each shows analemma of sun. To draw analemma, run forward. Step time is one solar day.

Analemma now

Analemma now for present orbit of Earth.

Analemma now no tilt

Analemma if Earth's axis were not tilted.

Analemma now no ecc

Analemma if Earth's orbit were circular.

Analemma now no tilt no ecc

Analemma if axis were not tilted and orbit were circular.

Analemma now 3% ecc

Analemma if Earth's orbit were 3% eccentric

Analemma now 4% ecc

Analemma if Earth's orbit were 4% eccentric

Analemma 1248 AD

Perihelion at winter solstice

Analemma 6489 AD

Perihelion at vernal equinox

Analemma 11732 AD

perihelion at summer solstice

Analemma 16974 AD

Perihelion at autumnal equinox

ANALEMMA FROM PLANETS

Analemma from each of the planets. Run forward to draw analemma. Step size is one solar day of the planet, or an appropriate multiple to make reasonable drawing speed. (Note that these are analemmas of the Sun seen from each planet, not motions of the planet relative to the Sun seen from Earth.)

Analemma Mercury
Analemma Venus
Analemma Moon
Analemma Mars
Analemma Jupiter
Analemma Saturn
Analemma Uranus
Analemma Neptune
Analemma Pluto

MOON

Moon sidereal vs synodic

Designed to show difference between sidereal and synodic months, using sun, moon, ecliptic, and equator. Moon starts at waning crescent. Step forward one sidereal month (back to same place in starfield), then 2 more days for synodic month (same phase).

Full moon BG Sept 26 rise

Full moon rises opposite setting Sun, Sept 26, 2015

Moon on ecliptic

Uses ecliptic, equator, and moon to show that moon's path is close to the ecliptic. Step moon forward on day at a time.

Moon at sunset N→F

Place of Moon in sky at sunset from new to full, showing eastward progress of moon over two weeks.

Regression of nodes

Designed to show regression of the nodes using ecliptic and moon's path. Run forward to show regression (westward motion 1½° per month) of point where moon's path crosses the ecliptic.

Moon synch rotation

Top-on view shows synchronous rotation of moon, using Sun, Earth, and Moon globe with grid. Run or step forward. Prime meridian on globe stays aligned with Earth.

MOON SKY

Moon north pole

Sky seen from the Moon's north pole, including sun and rotating Earth. Run forward to show sun in lunar sky.

Earth phase in moon sky

Sun and Earth in lunar sky. Run forward to see Earth phase, sun rise and set, Earth move in lunar sky.

Apollo 11 sky
Apollo 12 sky
Apollo 14 sky
Apollo 15 sky
Apollo 16 sky
Apollo 17 sky

static displays at Apollo landing sites on date of landing, but can run forward

STANDSTILLS

Major standstill BG 2025

Full moonrise at major standstill (when moon is at maximum angle north of equator). Static display but can run forward.

Minor standstill BG 2015

Full moonrise at minor standstill (when moon is at maximum angle south of equator). Static display but can run forward.

Skaw moon max dec

Northernmost settlement in UK at 61°N. Moon is nearly circumpolar at major standstill. Shows moon path north of ecliptic. Run forward.

Ny Alesund moon max dec

Latitude 79°N in Spitsbergen. Shows moon path north of ecliptic.

Run forward to see circumpolar full moon

GEOCENTRIC PARALLAX

These show the geocentric parallax of the Moon.

Moon parallax Punta Arenas (latitude 53°S)

moon slightly above ecliptic

Moon parallax BG.

moon on ecliptic

Moon parallax Alert (latitude 82°N)

moon below ecliptic

ECLIPSES

Shows moon's sky path for these three eclipses, using sun, moon, and ecliptic. SciDome shows all these eclipses as total.

May 10 1994 ann eclipse
Aug 21 2017 partial eclipse
April 8 2024 total eclipse

EASTER & HARVEST MOON

Harvest full moon

Harvest full moon rising in BG. Step one day back (scroll on date display); small change in altitude because ecliptic is at shallow angle to horizon.

Easter full moon

Easter full moon rising in BG. Step one day back (scroll on date display); larger change in altitude because ecliptic is at steep angle to horizon.

SETTING CRESCENT TILT

Shows setting crescent moon at four latitudes to illustrate the changing of the tilt to the horizon at different latitudes. Fairbanks is 65°N; BG is 41°N; Quito is on the Equator; Santiago is 33°S.

Crescent Fairbanks
Crescent BG
Crescent Quito
Crescent Santiago

static; see crescent change angle with latitude

FULL MOON BG & FAR SOUTH

Shows that orientation of full moon is different in southern hemisphere. Punta Arenas is 53°S. Moon turns 90° between BG and PA.

Full moon BG
Full moon Punta Arenas

PHASES RISING

These show the diurnal paths of the Moon at 1st quarter, full, and 3rd quarter for each month of 2020.

Jan 2020

Moon 1st qtr

Moon full

Moon 3rd qtr

Feb 2020

Moon 1st qtr

Moon full

Moon 3rd qtr

Mar 2020

Moon 1st qtr

Moon full

Moon 3rd qtr

Apr 2020

Moon 1st qtr

Moon full

Moon 3rd qtr

May 2020

Moon 1st qtr

Moon full

Moon 3rd qtr

June 2020

Moon 1st qtr

Moon full

Moon 3rd qtr

July 2020

Moon 1st qtr

Moon full

Moon 3rd qtr

Aug 2020

Moon 1st qtr

Moon full

Moon 3rd qtr

Sept 2020

Moon 1st qtr

Moon full

Moon 3rd qtr

Oct#1 2020

Moon 1st qtr

Moon full

Moon 3rd qtr

Oct#2 2020

Moon 1st qtr

Moon full

Moon 3rd qtr

Nov 2020

Moon 1st qtr

Moon full

Moon 3rd qtr

Dec 2020

Moon 1st qtr

Moon full

Moon 3rd qtr

rising azimuths by month and phase

PLANETS

Orbits to Neptune

Top-on view. Static display to show scale of orbits

Inner planets circle sun

Earth-based view. Sun, Mercury, and Venus on ecliptic, with globes and orbit line. Run forward to show planets orbiting.

Inner planets no orbit

As above, but dots rather than orbit lines to show motion. Run forward to show planets orbiting.

Jovian planet rotation

Top-on view, with Jovian planets as globes. Run forward to see globes rotate and move in orbit.

Naked eye planets rotate

As above, but with all planets Mercury to Neptune as globes.

Outer planets retrograde

Earth-based view. Globes for outer planets move on ecliptic and rotate. Run forward to see motion in orbit and retrograde motion.

Planets activity 4 June 2019

Planet positions for Earth-view to God's-eye-view college class activity

MERCURY

Mercury globe around sun

Earth-based view. Run forward to see Mercury globe go around Sun and see dots trace Mercury's motion along ecliptic.

Mercury around sun

As above, but no globe.

Mercury along ecliptic

As above, but with Mercury as globe. Emphasizes motion along ecliptic.

Mercury transit 2016

Earth-based view. Step forward to show dot transiting.

Mercury in dark evening

Static display at southern latitude where Mercury can be seen in dark evening sky due to steep angle of ecliptic to horizon.

Mercury rotation in orbit

Top-on view. All planets orbit sun, but Mercury globe with grid shows locked-in rotation. Run forward.

Mercury configs

To show conjunctions and elongations of inner planets

MERCURY SKY

Mercury north pole

Sun and stars seen from north pole. Run forward to see retrograde motion of Sun along horizon.

Mercury noon sun bob

Sun's diurnal motion from Caloris longitude on equator. Run forward to see retrograde motion at noon.

Mercury sunrise bob

Sun's diurnal motion from 90° longitude on equator. Run forward to see retrograde motion at sunrise.

Mercury sunset bob

Sun's diurnal motion from 270° longitude on equator. Run forward to see retrograde motion at sunset.

Mercury 45N noon bob

Sun's diurnal motion from Caloris longitude at 45°N latitude. Run forward to see retrograde motion at noon.

MERCURY MAX ELONGATIONS

These Earth-based views show Mercury at its maximum elongations, using Mercury, sun, ecliptic, and ecliptic grid. Intended as static displays but can be run forward.

Mercury GWE 27

Greatest western elongation (27°)

Mercury GWE 27 rise

Greatest western elongation (27°) with Mercury visible before sunrise.

Mercury GEE 18

Greatest eastern elongation (18°).

Mercury GEE 18 set

Greatest eastern elongation (18°) with Mercury visible after sunset.

Mercury GEE 18 set & V

As above, with Venus near Mercury in sky.

VENUS

Venus around sun

Earth-based view, with sun, Venus, ecliptic, and orbit. Run forward to see Venus orbit, but need to turn sky twice with diurnal motion to keep Venus above horizon.

Venus set late

Earth-based view to show very late evening setting at max elongation in June.

Venus rise early

Earth-based view to show early pre-dawn rising at max elongation in June.

Venus along ecliptic

Earth-based view with Venus, sun, ecliptic, and grid. Run forward to see Venus circle sun. Dots trace Venus' path along ecliptic.

VENUS SKY

Venus equator

Run forward to show diurnal motion of sun in Venus's sky. Sun rises in west and moves east in cloud-free Venus sky.

Venus rotation

Top-on view. Run forward. All planets orbit sun, but Venus globe shows locked-in rotation.

VENUS TRANSITS

Earth view with ecliptic, grid, Sun, and Venus. Step forward to see Venus transit Sun. Dots show motion along ecliptic.

Venus transit 1639
Venus transit 1761
Venus transit 1769
Venus transit 1874
Venus transit 1882
Venus transit 2004
Venus transit 2012
Venus transit 2117
Venus transit 2125

VENUS MAYA BG

Analemma with Venus

Analemma of Sun with Venus added, showing complex path of Venus over 8 years. Run forward. Set at latitude of BG.

Venus max north set
Venus max south set

Venus max south rise
Venus max north rise

Static Earth-based views showing extreme azimuths of Venus rise and set at latitude of BG.

VENUS MAYA CHICHEN ITZA

Analemma with Venus

Analemma of Sun with Venus added, showing complex path of Venus over 8 years. Run forward. Set at latitude of Yucatan.

Venus max north set
Venus max south set
Venus max south rise
Venus max north rise

Static displays showing extreme azimuths of Venus rise and set at latitude of Yucatan.

Venus shows complex motions in the pre-dawn and evening skies, with five loops each that repeat every eight years. The analemma favourite shows all these loops. The favourites here show each of the five loops separately, starting at the beginning of each loop. The meridian acts as the horizon. Each loop is timed to start with Venus on the meridian/horizon. Run forward, but stop when Venus crosses meridian/horizon, i.e. sets.

Venus morning twilight 1
Venus morning twilight 2
Venus morning twilight 3
Venus morning twilight 4
Venus morning twilight 5

Run forward; paths of Venus (meridian acts as eastern horizon)

Venus evening twilight 1
Venus evening twilight 2
Venus evening twilight 3
Venus evening twilight 4
Venus evening twilight 5

Run forward; paths of Venus (meridian acts as western horizon)

Sun max south set
Sun max south rise
Sun max north rise
Sun max north set

Static Earth-based views showing extreme azimuths of sunrise and sunset at latitude of Yucatan.

EARTH

Earth rotates in space

[from Spitz]

Hover as Earth rot & rev

[from Spitz] Earth rotates, showing phase as Sun moves behind it

Pivotswing as E rot & rev

[from Spitz] Earth moves in space and pivots up and down

MARS

Mars moons orbits

Face-on view. Mars globe with grid shows planet's rotation. Run forward to show orbit speed & rotations.

Equator sky Phobos Deimos

Spectacular view of Phobos and Deimos moving in Martian sky. Run forward to see Phobos rising in west; see Deimos move slowly westward.

Mars south pole summer

Run forward to see circumpolar sun in Martian polar skies

Phobos sky
Deimos sky

Day and night sky seen from Phobos and Deimos. Other objects appear as names in sky. Run forward.

Mars along ecliptic

Earth-based view with ecliptic, grid, Sun, and Mars. Run forward to see retrograde motion of Mars with loops, Z, and S shapes.

JUPITER

Jupiter globe around sun

Earth-based view with ecliptic, grid, Sun, planet dots, and Jupiter globe. Run forward to see dots trace Jupiter's motion along ecliptic, especially retrograde.

Jupiter along ecliptic

Earth-based view with ecliptic, grid, Sun, and Jupiter. Run forward to see dots trace Jupiter's motion along ecliptic, especially retrograde.

Jupiter configs

To show conjunction, opposition, and retrograde motion of outer planets.

SATURN

Saturn along ecliptic

Earth view with ecliptic, grid, Sun, and Saturn. Dots show Saturn's motion along ecliptic. Run forward to see retrograde motion

Sat sat

Satellites in Saturn sky. Objects appear as names in sky. Run forward to show them move.

Enceladus sky

Sun and satellites of Saturn in Enceladus sky. Objects appear as names in sky. Run forward.

Titan sky

Sun and satellites of Saturn in Titan sky, orange and translucent by day, clear by night. Objects appear as names in sky. Run forward.

SATURN TILT

Saturn ring tilt

Step forward to show changing tilt as Saturn globe moves against stars.

Saturn tilt around orbit

Run or step forward to show changing tilt as Saturn globe with grid moves around its orbit.

URANUS

Uranus 1986

Face-on view of planet orbits, showing Uranus globe and grid. Static display of rotating Uranus south pole-on at time of Voyager flyby.

Uranus 2014

Face-on view of planet orbits, showing Uranus globe and grid. Static display of rotating Uranus side-on.

Uranus 2029

Face-on view of planet orbits, showing Uranus globe and grid. Static display of rotating Uranus north pole-on

Uranus sat

Objects appear as names in sky. Run forward to show satellites in Uranus' sky

SUN FROM URANUS

Diurnal motions of Sun in Uranus sky. Other objects appear as names in sky.

Uranus equator 1987
Uranus north pole 1987
Uranus south pole 1987

Run forward to show sun path; south pole faces sun; sun does small circle near zenith from south pole, small circle near south point from equator, invisible from north pole.

Uranus equator 2014
Uranus north pole 2014
Uranus south pole 2014

Run forward to show sun path; equator faces sun; sun rises in west from equator, circumpolar from north pole; invisible from south pole.

Uranus equator 2029
Uranus north pole 2029
Uranus south pole 2029

Run forward to show sun path; north pole faces sun; sun does small circle near north point from equator, small circle near zenith from north pole, invisible from south pole.

NEPTUNE

Triton & Nereid

Face-on orbits of Triton and Nereid, which are shown as globes with grids. Run forward to see grids rotate.

Neptune sat

Objects appear as names in sky. Run forward to show satellites in Neptune's sky

Nereid sky

Run forward to see sun and Neptune rise and set in Nereid sky. Objects appear as names in sky.

Triton sky

Run forward to see Neptune move near zenith in Triton sky and see sun rise in west & set in east. Objects appear as names in sky.

PLUTO

Pluto Charon tidal lock

Top-on view of orbits and globes with grids. Run forward to show lock of prime meridians.

Pluto July 4, 2015

Top-on view of satellite orbits. Globes and grids for Charon, Nix, & Hydra.

Static display for date of New Horizons flyby.

Pluto sat

Run forward to show satellites in Pluto's sky. Objects appear as names in sky.

Eris with Dysnomia

Run forward to show Dysnomia & Sun in Eris' sky

Pluto 1866 aphelion equator-on (approx.)
Pluto 1930 south pole-on (approx.)
Pluto 1990 perihelion equator-on (approx.)
Pluto 2015 New Horizons flyby
Pluto 2050 north-pole-on (approx.)

Top-on views of outer planet orbit at dates indicated. Pluto globes with grids in orbit showing rotation & tilt to Sun

SUN FROM PLUTO

Diurnal path of Sun in Pluto's sky. Other objects appear as names in sky.

Pluto equator 1866

Rises in west, sets in east.

Pluto north pole 1866

Barely visible along north horizon.

Pluto south pole 1866

Invisible. Pluto at aphelion.

Pluto equator 1930

Rises in west, sets in east.

Pluto north pole 1930

Invisible. Pluto south pole faces sun.

Pluto south pole 1930

Circumpolar circle high in sky.

Pluto equator 1990

Rises in west, sets in east.

Pluto north pole 1990

Invisible

Pluto south pole 1990

Circles horizon, barely visible. Pluto at perihelion.

Pluto equator 2050

Rises in west, sets in east.

Pluto north pole 2050

Circumpolar circle high in sky. Pluto north pole faces sun

Pluto south pole 2050

Invisible.

SUN FROM CHARON

Diurnal path of Sun in Charon's sky. Other objects appear as names in sky.

Charon equator 1866

Rises in west, sets in east; Pluto stationary near zenith & phasing.

Charon north pole 1866

Circles horizon, barely visible; Pluto on horizon

Charon south pole 1866

Circles horizon, barely visible; Pluto on horizon

Charon equator 1930

Rises in west, sets in east; Pluto stationary near zenith & phasing.

Charon north pole 1930

Invisible.

Charon south pole 1930

Circumpolar circle high in sky.

Charon equator 1990

Rises in west, sets in east, rises in west; Pluto stationary near zenith & phasing.

Charon north pole 1990

Circles horizon, barely visible; Pluto on horizon.

Charon south pole 1990

Invisible.

Charon equator 2050

Rises in west, sets in east; Pluto stationary near zenith & phasing.

Charon north pole 2050

Circumpolar circle high in sky.

Charon south pole 2050

Invisible.

PRECESSION

All of these are shown in the Earth's sky.

Precession Thuban

Static display shows Thuban as pole star in 3000 BC using precession circle, north celestial pole, Dippers, Draco.

Precession 100BC VE c bdy

Run forward to see NCP move round circle and see VE move along ecliptic starting in 100 BC. Uses ecliptic, equator, precession circle, pole; Aries, Pegasus, Aquarius.

Precession now

Static display showing Polaris as pole star in present. Uses north & south precession circles, north pole, Little Dipper.

Precession now + eq ecl

As above, adding ecliptic, equator, Pegasus, and Orion.

Precession age Aq start

Static display at start of Age of Aquarius in 2600 AD with VE at Pisces-Aquarius boundary. Shows ecliptic, equator, precession circle, pole; Aries, Pegasus, Aquarius.

Precession Vega

Static display showing Vega as pole star in 14000 AD using precession circle, pole, Summer Triangle.

Precession Vega & VE in E

As above, adding equator and ecliptic and placing Vega in east.

Precession Vega & VE in W

As above, with Vega in west. Add Aries, Pegasus, Pisces.

Precession Vega VE c bdy

As above, shows VE at descending node.

Precession south circle

South precession circle, pole; Southern Cross, Octans, Carina; time is present.

Precession north circle

North precession circle, pole; Dippers, Summer Triangle.

Precession of NCP and Eq

[from Spitz] Precession circle, Pole, equator, ecliptic; run forward to show movement of Pole around Circle.

Precession of NCP and Equinox

[from Spitz] as above with different appearance of graphics,

WORKSHOPS & SCHOOL SHOWS

Star Shapes

Static sky to use in Star Shapes preschool live program

Life cycles

Static sky to use in Life Cycles of Stars live program

VENUS WORKSHOP

Step forward through worksheet (available on request).

JUPITER WORKSHOP

Step forward through worksheet (available on request).

MOON WORKSHOP APRIL 2018
Alt-az grid
Sun BG April 25
Moon 1st qtr Apr 2018
Moon full Apr 2018
Moon 3rd qtr May 2018
Sun June
Moon full June 2018
Sun September
Moon full Sept 2018
Sun December
Moon full Dec 2018
Step forward through worksheet (available on request).

FIRST GRADE CONSTELLATIONS

For use with my first grade constellation program.

2a-Orion

2b-Leo
2c-Ursa Major
2d-Peg & Cyg
2e-daytime
2-first grade day planets

STORYBOOK SKY

For use with my Storybook Sky live interactive program

1-storybook Orion no art
2-storybook Orion
3-storybook Orion group
4-storybook Sco
5-storybook Leo
6-storybook Andromeda
7-storybook Dippers
8-storybook Bears
9-storybook all

STONEHENGE

Stonehenge sum sol noon
starts at noon

Stonehenge sum sol
run forward; starts at sunrise

Stonehenge win sol
run forward; starts at sunrise

KEPLER
K2-Mars
K2-Mercury 1st
K2-Mercury 2nd
K2-Mercury 3rd
K2-Mercury 4th
K3-Mercury 1st IC
K3-Mercury WE
K3-Mercury 2nd IC
K3-Mercury EE
K3-Venus 1st IC
K3-Venus WE
K3-Venus EE
K3-Venus 2nd IC
K3-Mars 1st conj
K3-Mars EQ
K3-Mars 2nd conj
K3-Mars WQ
K3-Jupiter 1st conj
K3-Jupiter EQ
K3-Jupiter 2nd conj
K3-Jupiter WQ
K3-Saturn 1st conj
K3-Saturn EQ
K3-Saturn 2nd conj
K3-Saturn WQ
step forward through worksheet (available on request).

DARK TWIST ON PLANETARIUM STORYTELLING PART II

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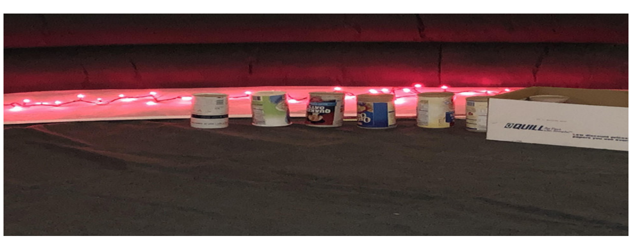
__Abstract:__ Sometimes technology challenges planetarians—hardware and software sometimes fail. We are in an awkward position—we have no stars! But, we are anxious to teach students. Last year we had a program set up with the elementary school's technology specialist (Librarian), putting third, fourth, and fifth graders into groups, and having them build constellation projectors from oatmeal boxes. Students wrote stories, told them in the planetarium dome, and then listened to several stories about the constellations. This is how it turned out.

Previously at GLPA Presentations:

> *I gave up my planetarium in a large high school and moved to the "country." I live so far out of town, even the people that live in the boonies say I live in the boonies.*
>
> *I was speaking to the local school librarian about my dome. Maybe we could just put up the dome and bring the kids inside and just tell stories.*
>
> *We eventually decided to give the students a chance to try out storytelling for themselves. We could let the kids make their own single constellation star projectors.*

Well, what happened?

We worked with our school librarian and the third, fourth, and fifth grade students. She grouped them so there were six groups in each class. Then she had the fifth graders make oatmeal box projectors.



The librarian took the students into a dark room at school and the kids projected their constellations on the wall. They made a drawing of their stars. Then they made up a story about the picture they saw.

When the stories were ready, Buck (my husband) and I brought the dome to school and we took each class into the portable dome. We lit the dome with strings of white Christmas mini lights. We secured them just below the springline of the dome which us about 5' off of the ground. We also had a string of red lights that lay on the ground in the "front" of the dome.

One person from each group would shine the constellation on the dome. It was a little difficult for the kids to maintain a focus with the projector, but my assistant would help the kids with that. Another student would draw the picture they saw with a laser pointer. This was really hard for them and the Librarian would often have to re-draw the picture. Most of the pictures were really imaginative and showed great creativity by the groups. Then a third person would hold a light while a fourth would read their three or four sentence story.

Here are sample stories written by the kids. Spelling has not been corrected as they were reading the stories themselves and we were featuring their creativity.

One day a duck was swimming. Then he fell and tried flying. It succeeded. After he got to space he never came back never ever.
Rachel Caldwell, Azlynn Jones, Brock Mileton, and Ethan Morgan

A squrill got kicked so hard it flew to space and it stayed there.
Sam, Bryce, Kali, Antoine

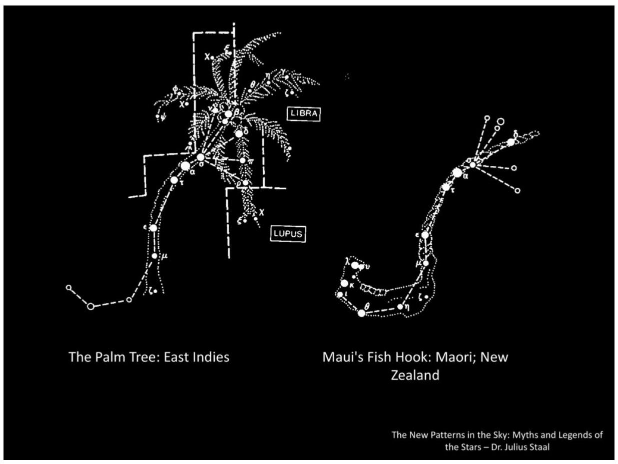
A girl named maddlen bet her fisrt letter of her name for a life supply of games. The game was called endless games, She loves it. She legally took the first letter in her name away. The mayor dousnt know what to do with the first letter. So he got a rocket and launched the letter M into space.
Joey, Maleah, Gabie, Cooper

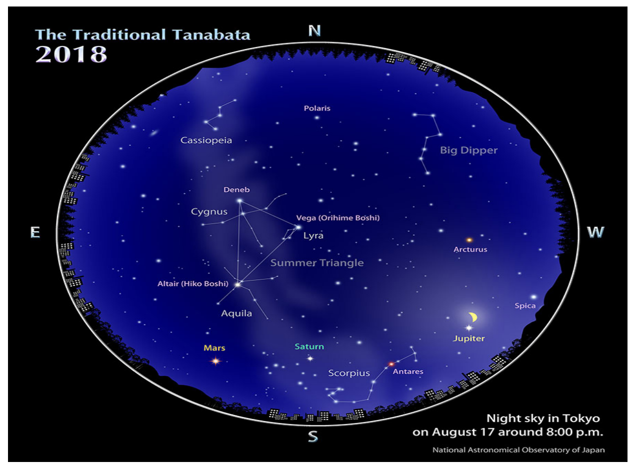
Bongo with a face
Once epon a time Africans made a bongo out of a bear and when people came along they made a sling shot and shot it up in space and now it in space.
Julie-Anne, Carlie, Andrew

Max's dad wanted to catch a mouse. He got mad and threw into the sky. Now its there.
Katelyn, Max, Autumn, Payne

The Bird went in the house and he was too FAT! He try to get out, but he could not so he flew to space.
Eli, Blake, Isabella, Becca

When they got done telling their story, I would tell them a story to go with the Greco-Roman picture for those stars and then another story from a different culture.





The constellations I have chosen to use are Ursa Major, Cygnus, Scorpius, Pegasus, Orion, Draco, Gemini, and Boötes. These had good stories to tell and I knew a second story for most of these areas in the sky. We emphasized that the sky map has been standardized with 88 constellations, most of which were traced back to the Romans and then the Greeks. We explained that everyone sees the same stars and that other cultures, whether Asian, Native American, Polynesian, Northern Europe, or African could have a story for that same group of stars. Some, like Maui's fish hook, used a very similar picture with a completely different story; some, like Iroquois bear hunt, used the same picture with similar story; and some, like the Asian Princess and Royal Herdsman, used a different part of the picture for a completely different story. We emphasized that their story was not wrong just because it didn't match any of the stories I told about those same stars.

The sky is much darker where my husband and I live now compared to the suburbs of Pittsburgh. The children have a much better chance of seeing stars and star patterns. We hoped that this experience would stimulate a curiosity about looking at the sky.

FOUR BIG ASTRONOMICAL EVENTS YOU SHOULDN'T MISS

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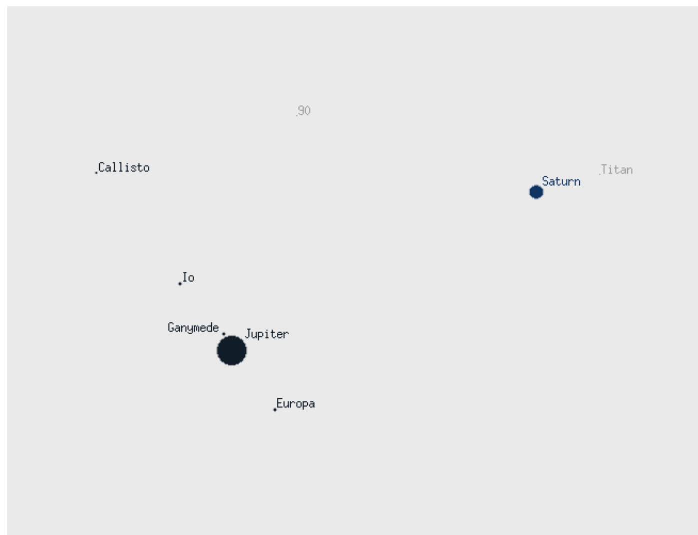
Abstract: This paper talks about four big astronomical observing events that are coming in the future. These are observing opportunities you should prepare for and teach your audiences about. The four are: The *Jupiter and Saturn conjunction* in 2020, the *Solar Eclipse* in 2024, the *Five Planet Gathering* in 2040, *Halley's Comet* in 2061.

There are four big astronomical observing events coming up in the next few decades. As planetarians, we should all be aware of them and start promoting them. The purpose of this poster is not to give you lots of details on how to observe—you know how to do that—but to let you know about these events so you can start to let your planetarium visitors know and start their anticipation. This list goes from the year 2020 to 2061. While 2061 might seem a long way off for some of us, it's only 42 years. Our school aged visitors will easily be able to witness it. A typical 3rd grader will just be turning 50 years old when Halley's Comet comes around. Imagine the thrill of seeing it after 42 years of anticipation. So, on with the list.

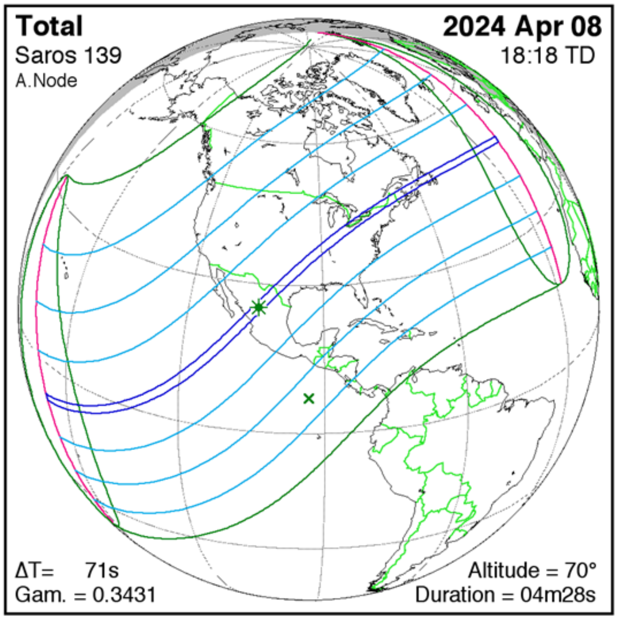
2020 The Great Jupiter Saturn Conjunction

Jupiter will pass Saturn December 21, 2020. The two planets will be within ***one tenth of a degree*** of each other. You will be able to see both the rings of Saturn and the Moons of Jupiter in the same field of view in a typical telescope. Jupiter passes Saturn every twenty years, but the last time this happened, we didn't get a good view. Jupiter and Saturn were on the other side of the solar system and the Sun blocked our view. So it's been 40 years since these two gas giants were easily visible together. But they usually don't get this close. Typical Jupiter Saturn conjunctions are a degree apart. The conjunction of 1961 was *two tenths of a degree* apart, the last one that was somewhat comparable.



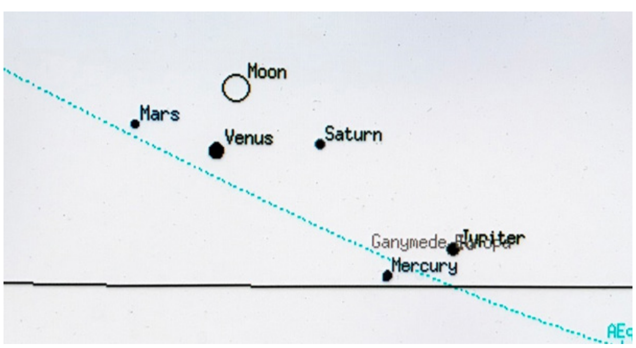
2024 The Great North American Solar Eclipse

The Solar Eclipse of **April 2024** goes from Mexico to Newfoundland. The eclipse path is wider than the 2017 eclipse, so expect the sky to be darker than 2017. The next North American Solar Eclipses after this will be August 23, 2044 and August 12, 2045.



2040 The Great Five Planet Gathering

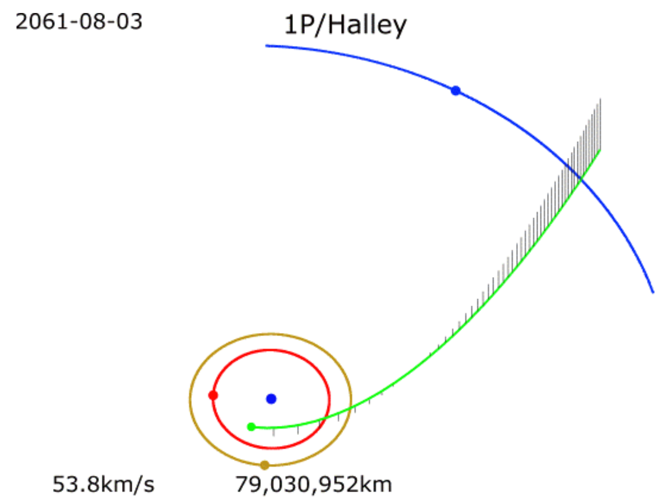
On September 8, 2040, all five naked eye planets and the crescent moon will be within a 10° field of view. This is the tightest grouping of all five planets for a long time. In the year 2000, all five were within 20°. You have to go back to the year 1186 for a more compact gathering. I don't know when they will be closer but it will be after the year 2735 since that is as far as the data goes in the paper *"Quintuple Planetary Groupings"* by Salvo De Meis and Jean Meeus.



2061 Halley's Comet

The return of Halley's Comet in 2061 will be ***spectacular!*** If your impression of Halley's Comet was the 1986 perihelion, get that idea out of your head. 1986 was about the worst view we've ever had of the comet. It pretty much stayed on the other side of the solar system the whole visit. The next time, it's going to be at perihelion around the same time as its closest approach to Earth. It will have a magnitude of -0.3 compared with +2.1 for 1986. In 2061,

To quote Bob Victor, *"Halley passes perihelion, inferior conjunction (nearly between Earth and Sun), and closest approach to Earth, all on July 28-29. In its inclined orbit, the Comet will then be north of, or "above" the plane or Earth's orbit and so will appear some 21° north of the Sun. On the nights of July 25-28, from latitude 40° N, the comet will even be seen twice each night, low in NW at dusk, and low in NE at dawn."*



So, get ready for these observing events. Let's all keep the visitors to our planetarium "in the know" about these celestial happenings. Let's foster a sense of awe and anticipation in the minds of the current elementary students. We may never know who we inspire in our theaters who will go on to do great things.

RECEPTION AND EVOLUTION OF NGSS SHOWS AT MORRISON PLANETARIUM

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Abstract: In 2017 Morrison Planetarium premiered two restructured school shows for third to eighth grade students focused on new NGSS national standards. This poster will explore how these shows have been received by students and teachers in the last two years. It will also aim to open up conversations with conference attendees assessing the ways they have utilized Morrison's shared school show scripts or assets, and explore potential methods to improve the shows in the coming years.

Two years ago, as a response to hardware and projection updates, changes in California's science standards to the Next Generation Science Standards (NGSS), and with the aid of a generous donation from Barry and Marie Lipman, Morrison Planetarium updated their existing planetarium shows for school groups. The process for developing the new school shows and our methods presenting them was shared by myself, Josh Roberts, and Dan Tell in the proceedings for the Pleiades conference in 2017 (Developing New NGSS-Aligned, Live, Interactive School Shows at the California Academy of Sciences). Since their launch the Morrison team has had the opportunity to share assets and scripts for the shows with other planetarians, conduct surveys with visiting teachers to evaluate how the shows were received, and adapt the shows slightly based on feedback from presenters, teachers, and Academy education staff. With this poster, I will share where planetarians can continue to access our shared assets and scripts, give an overview of feedback from the teacher surveys we conducted, and review some of the biggest changes that were made to the show since their launch.

Generally the presenter team at Morrison store any show scripts in a shared Google Drive folder, to allow for easy access and simple, trackable editing. We encourage our presenters to always make their own version of any show script, keeping all the same main talking points, topics, and goals for the show, but adapting it slightly to their particular presentation style. When we decided to share our process for developing our new NGSS-aligned shows back in 2017, we also wanted to share our scripts more widely so other planetarians could utilize them for their needs as well. Unfortunately, we didn't keep close track regarding who accessed these scripts and assets or how they might have improved or adapted them for their needs. To help make this sharing more transparent and helpful to us and others in the future, I will be creating a survey to see who has used the scripts already and who would like access to them, which I will share at GLPA.

Starting in spring 2018 we began surveying teachers who came to the new school shows to gauge reaction to, and effectiveness of, the new structure and content. We edited those surveys slightly for the 2018-2019 school year and sent them out to all 3rd-8th grade school show attendees. I will share some highlights from these surveys as well as give access to all survey questions from 2018-2019 for GLPA attendees to view as they like.

In spring 2019 we also invited staff from the Academy's education team to observe a few of our shows. A couple people from their team were very closely involved in the development of the NGSS-aligned shows, so we wanted to check in and make sure our shows were still hitting all of our education goals. I will share some of their feedback which they shared for my show and outline tweaks I made for my future shows based on their feedback.

The biggest thing I'd like to do with this poster is provide an avenue to share information. If any of the assets, scripts, survey questions are helpful for my fellow planetarians to use in their programs, or if anyone has suggestions, tips, or feedback based on how they do their school shows I would love to have a conversation at GLPA or afterwards! Come by my poster and we'll share our stories together!

POLLUTION SOLUTION

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Abstract: Fernbank Science Center offers outreach programs in local schools. This lesson for third graders incorporates science standards for their grade level with hands-on STEM skills. Students work with model street lights to design fully-shielded fixtures. The lesson has been very well received, both by students and teachers.

Fernbank Science Center offers outreach lessons to schools in DeKalb County. A lesson to introduce or review pollution, its causes, and effects, was offered during the 2018-19 school year.

I taught this lesson in third grade classes around the county during the last school year, and again this year, and it's been successful.

Students first list different types of pollution (land/soil, air, water) and identify them on a power point presentation. Near the beginning of the school year, this lesson may serve as an introduction, but so far, students could all name sources of pollution, whether they'd "already studied it" or not.

If time or student ability permitted, I adapted an activity from the Leave No Trace Center for Outdoor Ethics. Large cards showing the image of an item of "trash" or the item's decomposition time were distributed to several students in the class. Students matched the item to its decomposition time and formed a time-line to demonstrate how long items remain in the environment.

Next, students were divided into groups of four to work on light pollution. Each group worked with a "kit" of materials for constructing a fully-shielded fixture for a model street light.

Fernbank's staff artist designed a traffic intersection mat and 3D printed small plastic "pedestrians." Wooden discs with holes drilled in the center formed bases for the "street lights"—Mini MagliteLEDs that operate in candle mode.

With their pedestrians at a safe corner crossing, and their street lights on, students observed the effects of unshielded lights on the night sky, by looking at the ceiling. Then they worked with their group to design and build a shielded fixture.

Some of the materials they used came from the recycling bin—plastic yogurt cups, jar lids, or individual-portion fruit containers. Other materials in the kit were consumables—aluminum foil, chenille stems (pipe cleaners), a film canister (a total mystery object for today's—they keep calling it "the garbage can"), a small paper cup, and bendable plastic straws.

Students must follow two limitations in building their fixture. Whatever they build cannot touch the bulb of the Maglite. And their structure must support itself.

Listening to discussions reiterates the point that third graders are just beginning to work well in groups. Circulating among the students and asking about their fixtures elicits interesting information, and can help with misconceptions.

As the time limit approaches, a one-minute warning is given. At "time" all work stops, whether the fixture is complete or not, all students get seated, and the room lights are turned off once again.

Those groups with dark sky above, and streetlight directed onto their pedestrian, are elated. Time permitting, each group describes its structure, detailing what materials were used.

As a wrap-up, students dismantle their fixtures, return all materials to the kit boxes, and watch Loch Ness' Losing the Dark video. It's on YouTube at https://www.google.com/search?client=firefox-b-1-d&q=youtube+losing+the+dark

As Georgia's coastline contains sea turtle habitat, the presentation aligns well with other standards, too.

Student and teacher response to this lesson has been most positive. It's rated excellent on the survey sent after the class, and students have given me lists of ideas for decreasing light pollution. Please contact me if you want more details.

EXPANDED OUTREACH AT THE NEWHARD PLANETARIUM

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Abstract: **Upgrades in computer and sound to the Newhard Planetarium along with outreach partners have allowed for growth in visitors to the planetarium. We have partnered with Mazza's Children Museum, Hancock County Libraries, and a local American Chemical Society chapter. New events include Funday Sunday, story time under the stars, Harry Potter and the stars, how stars are the makers of elements/periodic table, and chemistry of space with NASA. We have also integrated student workers and added other volunteer faculty to help with the outreach.**

New Computer

specs:

- 2.5GHz 14-core Intel Xeon processor (turbo boost to 4.3 GHz
- 128GB 2666MHz DDR4 ECC memory
- Radeon Pro Vega 64 graphics processor with 16GB of HBM2 memory
- 27-inch (diagonal) Retina 5K display
- 5120by2880 resolution with support for one billion colors
- 1TB SSD

Increased Outreach

The planetarium experienced an increase in usage this past year. We welcomed over 1700 people during 74 events. Not only did we have more guests, but the planetarium was utilized for more than just talking about stars. Dr. Louden Hanes used the planetarium for her two Art History Classes. The planetarium was also part of two American Chemical Society public outreach events called "Chemistry in a Box". The planetarium participated in the two "Waste to Energy Workshops" hosted here at UF in the fall of 2018 and spring 2019. Hosted two Advancement outreach events. "One and done" and the "Mazza Moon event". The planetarium hosted "Science on the Rig" which is Biology's science talk series.

All the young visitors love Molecularium.

Reinforcements (new help)

One of the reasons for the increase in patronage was the incorporation of student workers and other faculty members to help out. Four students and three faculty members helped by presenting sixteen movies to various groups. The students include Morgan Stegemiller, Jane Swanton, Schylar McClure, and Taylor Cornett. The faculty were Dr. Bellavia, Instructor Grine, and Dr. Emmert.

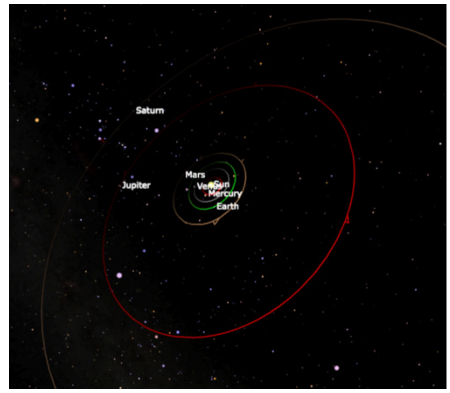
Morgan Stegmiller

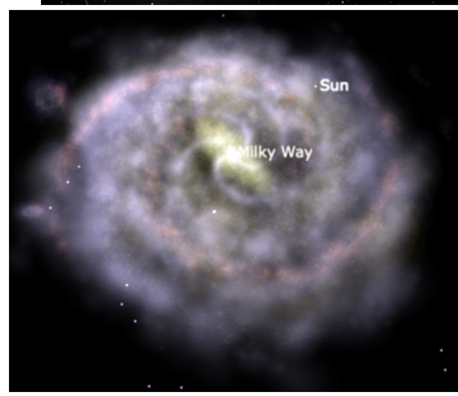
Professor Grine, Dr. Emmert

Dr. Bellavia

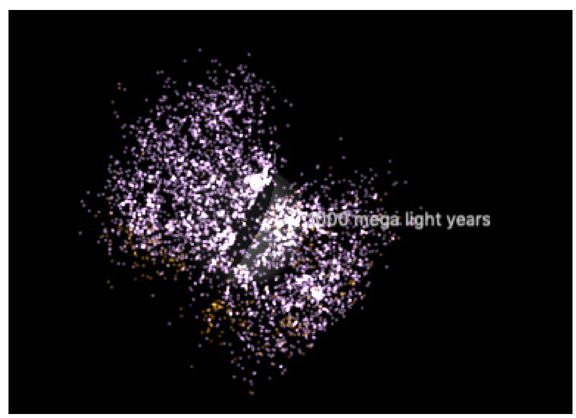
New Software

The addition of Starry Night Podium adds many new exciting ways to explore the solar system, galaxy, and universe. The content is updated to include new features as well. In addition to new visualization methods, Starry Night also comes with over 100 mini videos on space-science topics. Touring the universe is a big hit with visitors both young and old.





Screenshot of some visitor favorites, the inner solar system and our place in galaxy.

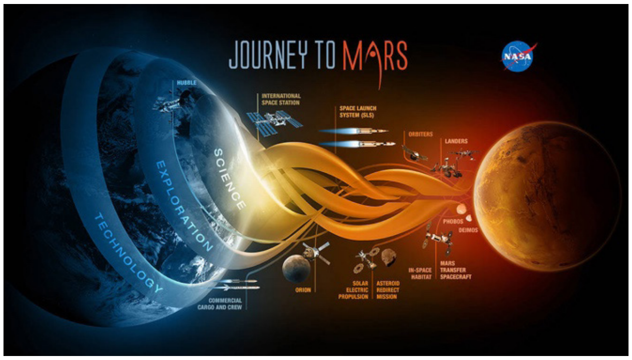


Screenshot of the Universe. Notice the blank-slice in the middle. This is the part we can't see because of the Milky Way.

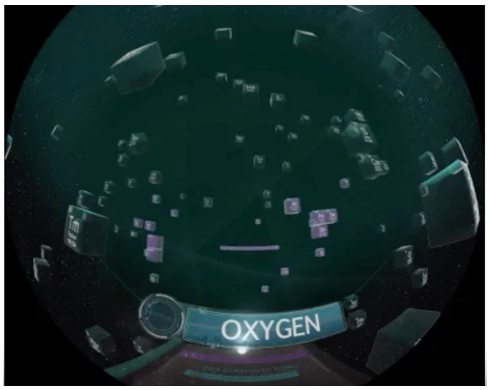
Another one that is always a crowd pleaser.

Chemistry in a Box Series

The planetarium helped participate with two Chemistry in a Box series. One featured the chemistry of space (NASA's Journey to Mars) and the other was on how stars made the elements of the period table (The Cosmic Recipe: Setting the Periodic Table).

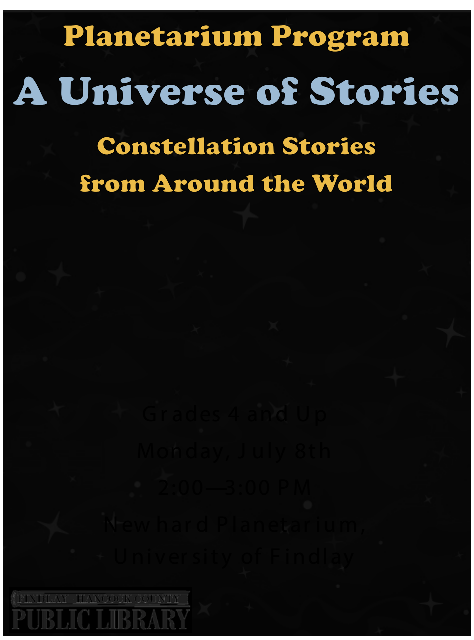


Poster image of NASA's Journey to Mars.

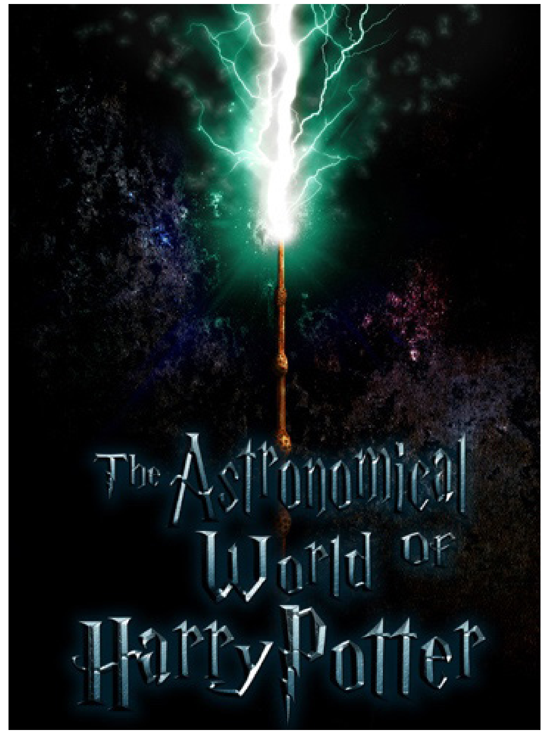


Screenshot from The Cosmic Recipe: Setting the Periodic Table.

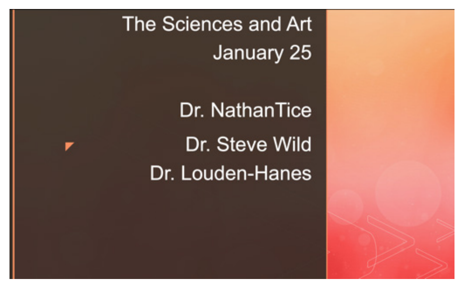
Hancock County Library



The Findlay Public Library did a series of events at the planetarium in Summer of 2019. These included story times for little kids, and incorporating the stars into stories about other cultures including Egyptian, Inuit, and Polynesian. We also did a Harry Potter Day on October 19 which was adapted from the Louisiana Arts and Science Museum.



Looking at Cave Art



Slide from the presentation on Cave art.

In the Spring of 2019. The planetarium was used for a "Cave Art" lecture. The dome was a natural fit for a looking into caves and cave art, like at Chauvet in France. In Spring of 2020 there may be a continued partnership when looking at the science and art of DaVinci.

Screenshot of the replica cave art of Chauvet in France.