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PROCEEDINGS OF THE
25TH INTERNATIONAL PLANETARIUM SOCIETY CONFERENCE
(2020 VIRTUAL CONFERENCE)

Contributed Papers

UNISPHERE Tomáš Gráf	1
PLANETARIUM OR ASTRONOMY MUSEUM? WORLD’S BIGGEST ASTRONOMY MUSEUM WILL OPEN IN SHANGHAI IN 2021 Lin Qing	4
THE SOUTHERNMOST PLANETARIUM IN BRAZIL IS BORN Guilherme F. Marranghello, Cecília P. Irala and Rafael K. Kimura	8
THE MEXICAN CASE, THE STUDY WITH BLENDED LEARNING EXPERIENCES AND A PORTABLE DOME Alejandro Casales Navarrete	14
BEYOND THE DOME: AMATEUR TELESCOPE MAKING AND ASTRONOMICAL OBSERVATION AT THE ADLER PLANETARIUM Pedro M. P. Raposo	23
LSS DIGITAL PLANETARIUM SYSTEM Lionel Ruiz and Yves Lhoumeau	30
IN THE BLINK OF AN EAR Léon Snyman	32
<u>Panels</u>	
OUTREACH WITH A PORTABLE PLANETARIUM Susan Button, Marco Avalos Dittel, Tilo Hohenschläger, John Meader, Guilherme Marranghello and Dr. Ruth Grützbauch	37
PROFESSIONAL DEVELOPMENT AND CULTURAL EXCHANGE OPPORTUNITIES Susan Button, Dr. Ruth Grützbauch, Tilo Hohenschläger, Andy Kreyche, Guilherme Marranghello, John Meader and Michele Wistisen	43
MUSICAL MOMENTS OF WONDER Derek Demeter, Patty Seaton, Mike Smail and Michele Wistisen	50
VISION2020 AND IPS— THE ENDGAME (PANEL SESSION) Jon Elvert, Karrie Berglund, Ruth Coalson, Anna Green and Dr. Tom Kwasnitschka	53
ARE PLANETARIUMS STILL RELEVANT? Philip Groce, David Dundee and Benjamin Mendelsohn	56

CLIMATE CHANGE IN THE DOME – A PANEL DISCUSSION Shawn Laatsch, Jane Ashong, Jacob Ashong, Dr. Julieta Aguilera and Dr. Ka Chun Yu	60
BETTER STAFFING FOR BETTER PRESENTATIONS Nick Lake, Naomi Pequette and Angela Perez	66
INDIGENOUS ASTRONOMY –BEST PRACTICES AND PROTOCOLS FOR INCLUDING INDIGENOUS ASTRONOMY IN THE PLANETARIUM SETTING Annette S. Lee, Nancy C. Maryboy, David Begay, Wilfred Buck, Duane Hamacher, Jarita Holbrook, Ka’iu Kimura, Carola Knockwood, Te Kahuratai Painting and Milagros Varguez	69
THE EDUCATIONAL VALUE OF THE PLANETARIUM: INTERNATIONAL Sharon Shanks, Kaoru Kimura, Sally Macfarlane and Guilherme Frederico Marranghello	78
LET’S HAVE A CENTENNIAL! PROJECTS FOR THE 100TH ANNIVERSARY OF THE PLANETARIUM Björn Voss, Anna Green, Mike Smail, Martin George, Ryan Wyatt and Kaoru Kimura	80
AESTHETICS OF THE PLANETARIUM EXPERIENCE Ka Chun Yu, Alexander Sivitilli, Julieta Aguilera and Barry Perlus	82
SCIENCE STORYTELLING FOR THE PLANETARIUM Ka Chun Yu, Carolyn Collins Petersen, Dani LeBlanc and Ryan Wyatt	88

UNISPHERE
Science Popularisation Hub for Education, Research and Entertainment

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Abstract: For almost 10 years, the Faculty of Philosophy and Science, Silesian University in Opava, has been offering a Bachelor's degree programme in Multimedia Technology. It focuses on making documentary films popularizing science. The students of this programme can benefit from several well-equipped facilities such as a video studio, editing rooms etc. are provided in the renovated building (Hauerova 4), with addition of a digital fulldome (FD) projection system called Unisphere, which was opened last year (2019) in the Bezrucova 13 building. Unisphere will be also used by students of a new Master's degree programme in Multimedia Technology. The production team of Unisphere Studio is currently working on a series of 10 short tutorials on extreme astrophysical topics, which will be completed later this year.

Introduction

A project co-financed from EU funds enabled a renovation of the attic of the hundred-year-old university building housing the Institute of Physics and for a consequent construction of the new digital planetarium—*Unisphere*—in the newly created space.

This spherical projection (fulldome) has a diameter of 8 meters and a capacity of 50 seats. It is equipped with the cutting-edge Digistar 6 system allowing also for a stereoscopic projection.

However, the nature of operation of the planetarium as well as the new shows to be developed in the planned student FD studio will differ from similar institutions. We would like to focus on using FD projection as an immersive medium. We are looking for experts to help us to achieve this goal.



Fig. 1 *Unisphere* is located in attic space of this building.

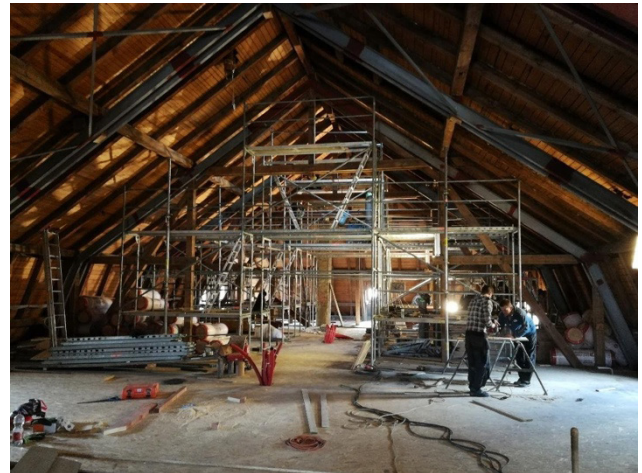


Fig. 2 Construction work in the attic space, summer 2019.

Operation of the Unisphere

Unisphere is primarily intended for university students. However, from September 2020, it will also start serving high school students and the general public. Several purchased shows in both classic and stereoscopic versions are prepared for them. In addition, programs acquainting visitors with the night sky above Opava will be available.



Fig. 3 Hanging dome of Unisphere with auditorium for 50 people.

Unisphere studio

Unisphere incorporates also a studio designed for a production of our own full-dome shows. For that purpose it is equipped with a second full version of the Digistar 6 software and a small model of the projection dome. The Institute of Physics is a top scientific institution, so it is no wonder that the first full-dome shows will map the areas that local scientists are dealing with.

By the end of the year, 10 short (approximately 15 minutes each) educational shows will be created. Not only the employees of the Institute of Physics, but also students and teachers of the study program of Multimedia Technology participate in this process. Next year, we anticipate the production of the English versions of these shows and their worldwide distribution.

List of new educational shows:

Binary systems with neutron star
Binary systems with a black hole
Optical effects in extreme gravitational fields
Accretion structures near black holes and neutron stars
Radiation in strong gravity
Life under the black suns - exoplanets at black holes
Cosmic microwave background
X-ray observation space missions
Accretion disk at black holes up close
Astrophysics full of extremes

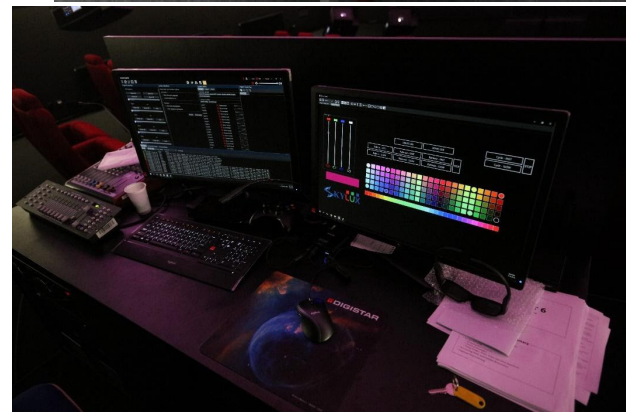


Fig. 4 Studio Unisphere with small projection dome.

Conclusions

Unisphere is like a small child—so far it is learning to walk. If you want to be there, as it develops and grows, let us know!

System Specifications

The Unisphere dome is an 8-meter Spitz NanoSeam® dome with a custom perforation pattern, 170 degrees of elevation and 0.38 screen gain. The screen is suspended, in the old building of the Opava Silesian University, with a seating capacity of 50.

The Digistar 6 projection system with eight WQXGA DLP Laser Phosphor projectors provides a 5K full dome resolution, reaching 13.8 fL brightness (47.4 cd/m²) with only a 2.4mm pixel size.

The 5.1 audio system, from Skypoint Planetariums, delivers more than 4,500W with Bose speakers and JBL subwoofers. The audio system includes a 3-language ALS system.

The cove lighting is based on Skylux from Skypoint

Planetariums, and uses 64 bits, RGBW fixture every 30 cm. The total amount of light is 25,000 lumens and is easily controlled and fully integrated into the Digistar 6 UI.

Acknowledgment

The author would like to thank colleagues from the institute, faculty and university leadership for the fact that he could contribute to the project.

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PLANETARIUM OR ASTRONOMY MUSEUM? WORLD'S BIGGEST ASTRONOMY MUSEUM WILL OPEN IN SHANGHAI IN 2021

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Abstract: Shanghai Planetarium (SHP) Project, later changing name to Shanghai Astronomy Museum (SAM), was been approved by Shanghai Municipal Government in 2014. Shanghai Science & Technology Museum was entrusted by the government to take charge of such a big project. This museum now has completed its architecture construction and the exhibition construction is in progress. SAM is scheduled to open next summer. With a building area of 38,000 square meters, it will be one of the biggest and most advanced planetariums in the world. This talk will report the background of such an exciting project, its ambitious goal, creative designing concept and newest information of construction progress.

Shanghai planetarium dream will come true next year

In China, the first and the only comprehensive planetarium till now is Beijing Planetarium which is a successful planetarium and inspired many astronomy fans' dream of becoming a scientist. As the biggest and another important metropolis in China, Shanghai also desires a big planetarium to serve for the most populated area in China.

The dream began as early as 1974; Shanghai Planetarium project has been discussed and approved by the National government. But the project has finally been canceled because of some political reason. In the early 1990s, the Shanghai Planetarium project was on the agenda, but postponed again.

In 2010, with the success of Shanghai EXPO, Professor Ye Shuhua, former director of Shanghai Astronomical Observatory (SHAO) and academician of CAS suggested a new Shanghai Planetarium project again to the government. The advocacy got the strong support from the city governments. In February 2012, the government asked Shanghai Science & Technology Museum (SSTM) to take charge of the task to construct a world-class Shanghai Planetarium. Based on the intensive and carefully analysis and evaluation, The Shanghai government gave final approval to the construction project of SHP in January 29th, 2014.

The Shanghai Planetarium (later changing name to Shanghai Astronomy Museum, or SAM) will be the second branch of SSTM after the Shanghai Natural Museum to be its first branch and opened in 2015. As to the approved plan, The Shanghai Planetarium will occupy a total area of 58,600 square meters; the area of the building will be 38,000 square meters, which will put it as the biggest planetarium in China, and also one of the biggest in the world. The Shanghai government also proposes a high demand for the object, that is to construct a top level planetarium or museum in the world of planetariums.



Figure 1. Project site.

The Project site (Fig 1) is located in the Lingang Special Area of Pudong District, which is in the southeast of Shanghai. The Lingang Special Area is designated as a pilot free trade zone by Chinese government in 2019 and is undoubtedly the most active new economic zone in China today. The Shanghai Planetarium is at the meeting point of the Lingang Avenue and Huanghu Road W-3. And the terminal station of metro Line 16 is very near the site.

We endowed the vision of SHP as “To form a complete cosmic view” and the mission is “To inspire everyone’s curiosity and encouraging people to enjoy the starry sky, understand the universe and ponder the future.” With the effective leading of SSTM and strong support of SHAO. The Shanghai Astronomy Museum has now completed its architecture construction and the exhibition construction is also on the progress. SAM is scheduled to open next summer.

Change name from Shanghai Planetarium to Shanghai Astronomy Museum

From the first modern planetarium in Germany, thousands of planetariums have appeared all around the world. Most of them follow the traditional mode that put the optical planetarium or digital dome theater as the center, surrounded by some exhibition to show our exploring achievement about the universe. But in these 20 years, things changed a lot, we have seen the great renovation of some famous planetariums, like Griffith Observatory, Adler

Planetarium, and others. These renovation projects all greatly enlarge the exhibition area, so they can more easily reflect the modern understanding of our universe. The traditional planetarium is still the most important role, but no longer the center of the exhibition system.

The Shanghai Planetarium project is also using the traditional name of Shanghai Planetarium, but as the exhibition design process, we realize that we are on the road that Griffith and Adler pioneered. We have a really big exhibition area (totally about 15 thousand square meters) and the dome theater with 23 meters diameter is no longer the center of our museum. The designing idea of the exhibition will be introduced as part 4 of this report. In order to reflect this idea, we think it is necessary to give this planetarium a new name. Now we call it as Shanghai Astronomy Museum, we think we should use the standard of modern museum to design and construct our exhibition architecture.

Here I also want to say something about my thinking of the role about optical planetarium and digital dome theater. As a trend, I have seen more and more planetariums are using a digital projecting system to replace the optical system, and call it digital planetarium. I don't think it is a good choice. Of course the digital system has a great deal of advantages which I don't need to describe more. But I don't think we should abandon the optical one, for at least two reasons: 1. Even in today's best resolution digital system, the effect of starry sky still can't exceed the optical system, no matter how excellent the resolution or contrast is. 2. Dome Theater is only fit for some of the visitors, because you have to buy tickets to see the film, but optical sky show can fit for every visitor. More and more people are losing their chance to see the real starry sky, so the planetarium will have a duty to reproduce the starry sky as really as possible for the public. That's what I appeal to every planetarium to notice the import role of traditional optical system. In the Shanghai Astronomy Museum, we have designed both the 23-meter digital dome theatre and also the optical planetarium with 17 meters diameter. We even put the optical planetarium as our first exhibition item. I hope every visitor will say "wow" when they first enter our exhibition and have a really different feeling of other museum.

Excellent Architecture has pushed SAM as a new landmark

The architecture design began from the summer in 2014. The Ennead Architecture LLP from USA has finally won the international bidding and become the principal designer. A local architecture also joined as the designing partner.

The Ennead Company has designed an excellent architecture. Many astronomical ideas have been applied to this beautiful building. The subject of the design is the gravity and celestial orbits. So the main building is looking like a celestial orbit. And the surrounding garden is also like a spiral or orbit. (Fig 2)



Figure 2. Main building.



Figure 3. Dome theater.

The whole building has three distinct structures to represent "three body problems", reminding both for the classical astronomical problem and the famous Chinese scientific fiction with the same name. First body is the dome theater (Fig 3), which is a whole sphere looking like the earth floating in the space. That's a great design that you can't see the supporting columns from the front because of the ingenious design, and you also can see a huge light circle in the ground at noon of some days, just like the annular solar eclipse.

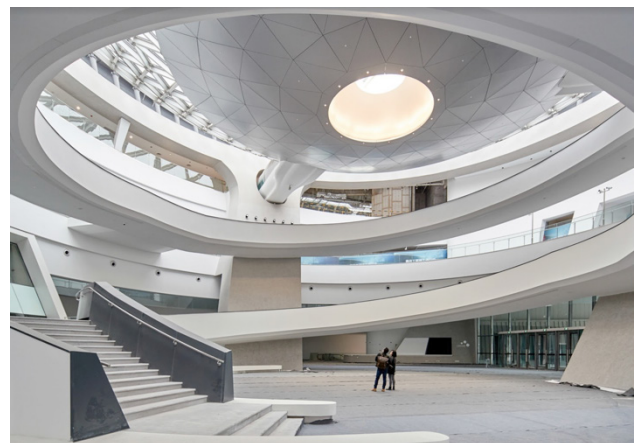


Figure 4. Inverted dome.

The second body is called the inverted dome (Fig 4). The designer using this special design to let down the sunshine to the central atrium, and the inverted dome idea is similar to a valley which can avoid the city light from around, the pure observational site called by the designer as the place to talk to the heaven.



Figure 5. *Occulent*.

The last one of the “three body” is just at the main entrance of the building, called the oculus (Fig 5). The Sun cast a big light spot on the ground, the spot will move as the time pass and will sit under the oculus in summer. If we trace the spot movement, we can use the building as a great time machine, that’s the idea of the designer.

These specially-designed structures have been perfectly realized after the architecture was finished in the autumn of 2019. Many good photos of the whole building from air and from inside, have been captured by journalists and astronomy fans. More and more people like this building and see it as a new internet celebrity even it has not opened to the public. Now the tourist agency of Ningang Special Area has chosen it as the trump card of their tourist propaganda.

Great Exhibition is alluring your visiting

The exhibition space is really big relative to traditional planetariums. So it’s a big challenge for us to design a leading exhibition on the subject of astronomy.

The Exhibition them of the Project will be “*Connecting man to the universe*”. With that theme, we wish to send visitors on the road to systematically explore the laws of nature, to understand the correlation between human and the universe, to cause them to think about in which way and how will we go in the future, and thus to affect their attitude and behavior towards the nature.

We have a logically coherent main exhibition area and several complementary exhibitions, two observatories, and a multi-functional education area as well.



Figure 6. *Bit Earth*.

The main exhibition consists of three parts. We will take a journey from our familiar “*Home*”, from the awesome optical planetarium to experience the night of starry sky. We guide visitors to go through the huge earth (the outer shell of the planetarium dome, Fig 6), a very big model moon (with the same proportional relation as the size of the earth and the moon), and the large screen showing the active sun. Everybody will appreciate the beauty and miracles in our own solar system, including many precious meteorites.

After going through a special designed immersive 4D Theater to quickly wondering our Galaxy, we arrive at the second main area named “*Cosmos*” where we organize the content with five topics (time-space, gravity, light, elements, and life) to reveal the structure and essence of our universe. This area is really a great challenge to designer because the difficulty to elaborate the essential scientific principle, from the big bang to the search of exoplanet and life in the universe. (Fig 7)



Figure 7. Space-Time.

After the splendid show of dazzled kinds of celestial body and painstaking understanding of the scientific principle, we will walk into the third area named “Odyssey” where we want to show how the development of astronomy will improve the progress of human civilization, pushing visitors to journey to space. Visitors will encounter many big scenes about the space exploration, especially Chinese Chang’e project (Fig 8) and Tiangong Space lab.



Figure 8. Chang’e Project.

In this wonderful cosmos wandering course, we will encounter the Earth three times, first is when we enter the exhibition zone, the second is in the end of “Cosmos” zone and before the searching for life outside the Earth. And the last one is when we walk out of the Tiangong Space lab, a long overpass appeared, go through it is just like to wander in the space, then you can see the Earth again. In this passage, you can even encounter a story of “Pale Blue Dot” and contemplate the special meaning of the Earth.

At the end of this area, we will organize a special zone named “Enigma World” to show as many as cutting-edge theories and weird guesses about our universe, guiding the visitor to think openly about the modern astronomy: We have acquired a huge amount of knowledge about our universe from generation and generation’s exploration, but we still have more and more puzzles about the deep space, which need every person to concern the seeming irrelevant but actually closely related cosmic event, helping the development of astronomy, that’s the essential purpose of a planetarium.

Besides the main exhibition area, we will also set up some special zones, one for astronomy in China; from the ancient to modern astronomy, one for children playing, and a special area for future Mars exploring which will use most advanced technology to

give visitors a dramatic experience in space.

Outside the main building, we also set up a public observatory with a 1-meter advanced telescope and a specially designed professional solar tower that can provide the chance to observe the Sun, the Moon, planets, and many other interesting celestial phenomena. Besides that, we still have an exploring camp which has many classroom and laboratories to form a multi-functional education center. (Fig 9)



Figure 9. Observatories and Exploring Camp.

Welcome to visit us one year later

The SAM construction team has the ambitious and also pays their great effort to set up a most advanced and best favored planetarium for everyone in the world.

Everything is going smoothly now; the architecture has been finished in September 2019. The exhibition design has also been finished. The decorating and exhibition construction, as well as the manufacture of many exhibition items, are all in progress. Although the Covid19 pandemic has influenced a lot and postponed some plans, but we still have the confidence to finish the whole exhibition project in the spring of next year. (Fig 10)



Figure 10. SAM at night

We hope our brand-new astronomy museum will open before July 2021. We hope you can come to be the first batch of visitors of our museum. Welcome! If you want to visit, please don’t hesitate to contact with me directly: linq@sstm.org.cn.

THE SOUTHERNMOST PLANETARIUM IN BRAZIL IS BORN

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Abstract: A new planetarium was born in the very south of Brazil, closer to the Uruguayan border than any other planetarium in Brazil. We present a brief description about the birth of the planetarium as well as some activities and educational research we have done in the past three years, including the pandemic. We briefly describe the structure, from staff to live presentations, activities in the schools, with elderly groups, kindergarten kids' activities, teacher-training programs, the travelling mobile dome and virtual school trips. After the first year of activities, we started to develop educational research in the planetarium.

The Birth

Brazil is a huge country, the fifth in size and population. Planetário da Unipampa is located just 60 km from Uruguayan border, in a region called Campanha that follows the Uruguayan border from the Atlantic Ocean to the Argentinean border. This region has gone through a hard period of economic, social, and cultural decline in the last decades of the 20th century. In 2006, the Brazilian government started a program to build new universities all over the country. The Campanha Region was selected to host a new university with the perspective to help the region in its rebuilding process.

In this context, we can date the planetarium birth in 2009, when our astronomy outreach program started celebrating the International Year of Astronomy. This program lasts until now. In 2013 we bought our first portable dome and the fixed dome started to be built in 2015. Inaugurated in the southern spring equinox of 2017, in the city of Bagé, it is located in a region with no science centers. The closest planetarium is 240 km to the north and the state main city is 370 km, where one can find another planetarium and a science museum.

Today, the outreach program created in 2009 has received more than 70.000 kids in our activities: lectures, night sky observations, planetarium sessions and, now, virtual school trips. Only in 2019, we have traveled 15.000 km traversing 25 cities spread all over the state which is similar in size to Uruguay, United Kingdom, Burkina Faso, New Zealand or the state of Nevada in US. Our location, 60 km from Uruguay is shown in Figure 1. A little more about the planetarium birth can be found in ref. [1, 2].



Figure 1: Bagé is shown, a Brazilian city close to Uruguayan border.

The Planetarium

The planetarium consists of a building with an 80 m² where we do all our work and, during the visits, we transform to a small science museum. Nowadays, we have a holographic pyramid showing some planets; a wind tunnel where the kids may test their beliefs about air resistance; an optical set, where we explain how telescopes work and, again, they can test their theories about the light by moving mirrors and lenses; an interactive screen about the Solar System; a lunar box to explain the phases of the Moon in a 3D perspective and a stage, where we perform little sketches on ethnoastronomy. We also have cards displayed all around with augmented reality space shuttles, ISS, Solar System and a 3D Southern Cross.

The 8 m dome is on the second floor, with 52 concentric seats and with a Digitarium Kappa from Digitalis running live programs and pre-recorded shows. We decided to keep the concentric configuration design because we believed it would contribute to the children's imagination. The planetarium is shown in Figure 2.

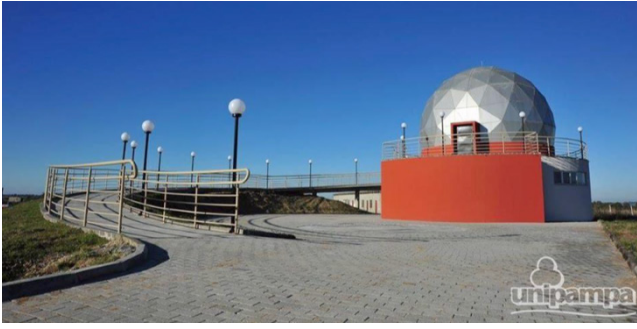


Figure 2: The planetarium.

Teachers Training Program

Since the first year, we have been working with in service teachers because we believe they shall be in the core of planetarium actions. One of the purposes of the installation of the Federal University was to increase the number of graduate courses, especially those to form physics and science teachers [3].

We proposed, during the first years, the topics the course would cover and its duration. Now, everything is organized with the teachers and the municipal Secretary of Education. Those courses have ranged from kindergarten teachers to high school professionals, covering science education topics, seasons, moon phases, solar system and much more. We have from afternoon courses to 30 hours courses on which we invite teachers with great experience in astronomy teaching to discuss about their experiences using, for example, games, active learning strategies, experiments etc. Figure 3 shows a meeting with school teachers to arrange a training program.



Figure 3: School meeting.

From Young Kids to Elderly Groups

The planetarium works mainly receiving pre-scheduled school groups, but we also schedule some other special groups. One of our special projects is focused on elderly public and, besides our regular attendance, we spend most of our time listening to them. They bring us their knowledge and stories related to the sky in monthly visits (Figure 4).

During the planetarium sessions, we talk about cultural astronomy and instigate them to talk about their experiences.

Some stories that have appeared in these sessions are related to: a star that guides the *gauchos* (which are like “Brazilian cowboys”); to the birth of children when the mothers have seven days to point the kid to the Moon and ask its help to raise the kid in health; to the 1966 total solar eclipse that was seen in Bagé.



Figure 4: Elderly group visiting the planetarium.

When we receive kindergarten kids, we propose a different approach to the topics of astronomy: through storytelling. Using figures and more theatrical language, we were able to work with children on themes such as lunar eclipse and light scattering for example. You can see some of these moments in the figure 5.



Figure 5: Planetarium team telling a story about the indigenous legend of the lunar eclipse.



Inside and outside the planetarium

Just as it is important for the school to go to the Planetarium, it is also important to bring astronomy activities to the school. After school visits, some teachers seek the help of the planetarium team to promote other activities related to Astronomy with their classes. The children's joy in receiving "the planetarium people" in the school space of which they are part creates a greater interconnection of students and teachers with the subjects related to Astronomy and with the other activities of the Planetarium. Some activities promoted are: workshop for the construction and launch of PET rockets, workshop for the construction of the Rose of the Winds, conversation about the 50th anniversary of the Man's journey to the Moon, from Earth to the Universe: Astronomy for children and how they are discovered the chemical elements of the Planets. Some registers Some records can be seen in Figure 6.



Figure 6: Activities in schools.



Equity, Diversity and Inclusion

As a university planetarium, a diverse group of professionals surrounds us. During the years that preceded the planetarium inauguration, we have worked, among others, with professors and researchers on Equity, Diversity and Inclusion. This experience has led our group to bear in mind that our activities must always take into account people with any kind of special needs.

We can think Equity, Diversity and Inclusion in many different aspects related to the planetarium. Here, we are going to highlight only some of those related to the public:

We took care to include black girls in our first productions;

We have produced a show that present some indigenous knowledge about the sky;

We travel with our mobile dome to places with higher rates of poverty;

We have included sign language translations in our shows (Figure 7a);

We have had help of blind students to develop consistent materials for our public (Figure 7b);

We have had some special groups visiting the planetarium;



Figure 7: (a) Sign language translations and (b) Moon phase prototype.

Productions

As most international planetarium shows do not have the Brazilian-Portuguese narration, we work on translations and narrations. We also have counted on Brazilian productions and on our own productions. In this section, we briefly describe our planetarium live presentations, three productions, and plans.

As students arrive at the planetarium, they are received in front of the dome, around a compass rose, where we talk about the sunrise and sunset, seasons, or the Southern Cross. We go inside the dome, which shows the panorama exactly the way the students saw outside the dome and resume the previous talk. We then talk about the night sky, including few constellations, the Moon, and the visible planets. This first part of the in-dome activities takes about 20-30 minutes and, after that, we present a pre-recorded show, previously selected by the teacher.

As we work with Digitalis, our first two productions were totally made with Nightshade. The first one, Life Island, is not an original production. We converted an old opto-mechanical show into a full-dome show. The second one was produced for a special public of kindergarten kids, Zito Adventures and the Colors of the Universe. The story of Zito, who lives in another world, with a pink atmosphere, pink grass and different trees is fulfilled with the color theme. Zito leaves his planet to look for another kid to play with, but his spaceship falls on Earth, where he finds Daniela (Figure 8a).

During the show, Zito can realize the differences between his atmosphere, grass, plants and even the star that his planet orbits, which is a red dwarf, from Earth biosphere and the Sun. He also travels through brown and blue planets, which are covered with dust or water. On Earth, Daniela is trying to help him to find his way back home among the stars.

The third show was produced to talk about the Moon. It has its beginning and the end filmed with a fisheye lens camera. A little girl, who dreams to be an astronaut, asks her mother about the Moon (Figure 8b). The show is filled with some cultural aspects related to the Moon phases, and the eclipses and goes back in time to visit the city of Sobral, in the northeast of Brazil, where Eddington led the observations of the 1909 Solar Eclipse. We also travel with astronauts of Apollo 11 to land on the Moon in 1969. The launch and landing on the Moon were created with the

software Blender.

We have shows being prepared about the southern sky and also about Mars. The Mars show is meant to be a traditional full-dome show while the southern sky show will be split into small contents to be presented live.



Figure 8: (a) Scripting the Zito show and (b) filming A Small Step.

Mobile Dome

The mobile dome has an amazing relevance in our work as it travels all over the state, going to cities that are hundreds of kilometers away from a science center or a planetarium. We have visited more than 40 cities all over the state that range from 2,000 to 100,000 inhabitants.

We have offered teachers training courses during the travels and we usually stay two or three days in each city. When it is possible, we arrange to visit two cities in the same week. The van and dome can be seen in figure 9.



Figure 9: The mobile dome visiting a city.

Educational Research

As part of our work at the university, we develop research focused on educational research, mainly devoted to the work in the planetarium. The research has been crucial to better comprehend our work, as we intend to evaluate our productions, our routines, our projects, and all the material that is part of the planetarium and we truly believe a planetarium is obligated to do some research on its routines.

Before developing our researches, we have looked for previous works and researches about planetarium as an educational tool [2, 3]. We emphasize the value of research about planetarium work, be the evaluation of students learning during school visits or about general public interests and behavior during the visits.

Virtual School Trips

During the pandemic, we decided to go live on Facebook, however, due to internet instabilities, we moved to produce content for our social media. As the web situation stabilizes, we started to schedule virtual school trips to the planetarium [4, 5].

Brazil is a huge country, but it still has a small number of planetariums and some of them still work with old opto-mechanical instruments, unassisted by a full-dome projection system. The planetariums are also badly distributed in the national territory. It means most of cities are hundreds, or even thousands, of kilometers away from a planetarium. We didn't find, until the day this article was submitted, another Brazilian planetarium scheduling virtual school trips. This means that we schedule visits for school 4.000 km away from us.

During the virtual school trips, we offered a mix of a planetarium visit and a small lecture, talking about the sky differences (visible constellations, sun height, etc) on each city, flying through the planets and talking about recent science achievements. Some pics can be found in figure 10.

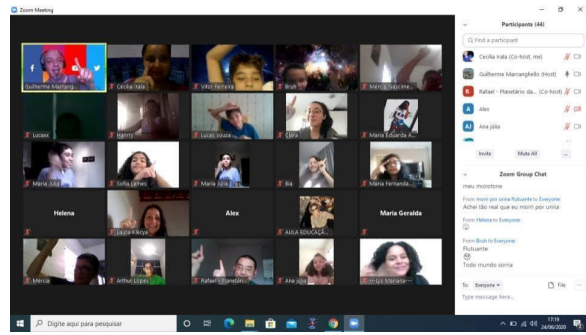
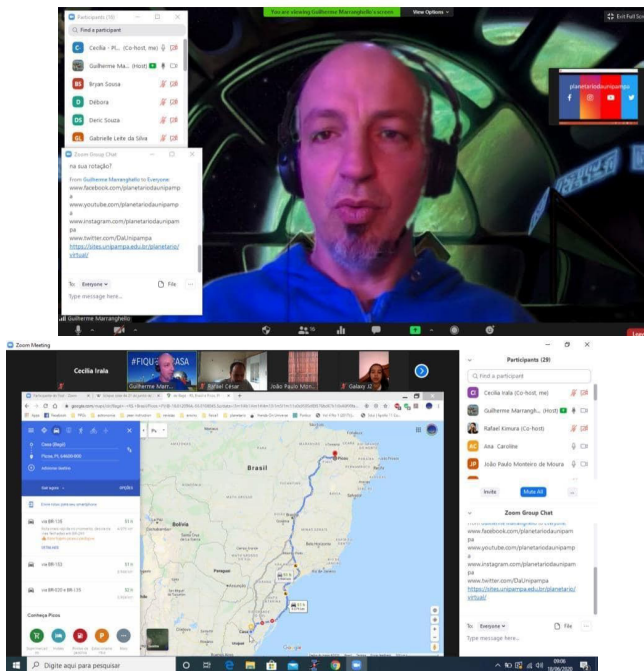


Figure 10: Virtual school trip. The middle panel shows the route from Bagé-RS to Pico-PI which takes 4.000km.

Final Remarks

Every year, we celebrate the planetarium activities with a great party, the Starry Night, before going on vacations. Starry Night party starts with planetarium shows, theater (Figure 11), hands-on activities for kids, school competition, AstroArt contest, music and telescope observations. So, we conclude this paper with some images of this Starry Night Party that better reflects our work, developed with competence, dedication, and passion.

During these years, we have tried to follow what is done national and internationally to better understand the power contained in a planetarium to educate people in science literacy, social commitment and development, raising awareness not only about space, but about our Earth. We know a deep change on educational structures, social organizations, cultural understanding of science are hard to achieve and a long time of work is necessary, but we truly believe we are on the right path and we hope to see, in the next few decades, all these changes in our city, region, and state.



Figure 11: Starry Night Party in two moments (a) the end of the

theater Multiverse played by the planetarium team as Dungeons & Dragons and (b) the musical show by the sunset.

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THE MEXICAN CASE, THE STUDY WITH BLENDED LEARNING EXPERIENCES AND A PORTABLE DOME

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Abstract: The purpose of this article is to inform the reader about the progress of a case that revolves around the implementation of a curriculum design with blended learnings and a polyangular dome. It was held in Villahermosa city and Victoria de Durango city in Mexico. Its origin comes from the social inequalities that mark the country and its education, as well the urgency to incorporate digital technologies into education at a particular time of global transition, which forces us to recover the valuables of previous experiences and from there to enhance the pedagogical work of the future.

Introduction

The objective of this article is to publicize the experiences of implementation of an organized curriculum design and a set of educational practices, considering a virtual teaching approach that combined technology with the presence of the teacher. Its justification comes from this particular moment of global transition that is lived with technologies for education, where are a need to equip teachers with technological tools among which is the polyangular immersion, its multimodal instruments, and repertoires to implement for the different disciplines of knowledge.

On the basis of the empirical approaches of research, the educational situation focused on the benefits acquired by implementing a blended learning curriculum and an immersion dome will be exposed.

Approaching the problem

In recent years, the educational offer underpinned by information and communication technologies has grown and with it the need for educational spaces with technological support (Díaz, 2008:1). Recognizing the social and educational inequalities that mark Latin America, and at the same time, the need to incorporate digital technologies into the future of education, it's important recover the previous experiences and from there to enhance pedagogical work. However, in Mexico teachers do not have adequate training or experience in immersive technology, nor is it possible to offer a meaningful use of this technology for teaching and building new knowledge (Rojano, 2017:29). Despite this, Mexicans should not limit themselves to the lack of teacher experiences and training, and this is something that can be fostered with a curriculum modeled on blended learnings that includes an immersive dome of self-construction.

The immersion dome is a place where you can make light projections, its 180° dome-shaped screen allows one to present a wide range of panoramic films, its realism and detail produce the feeling of being within a simulated visual environment (Hartweg, 2018; Sumners, Reiff and Weber, 2008; Yu and Sahami, 2007). Its

contents are generated by an optical projector or a computer. Much of his research comes from its origin in planetariums who have focused their ability to be used as a tool to promote conceptual changes in various areas of knowledge (Brazell and Espinoza, 2009; Hartweg, 2018; Yu, 2001). This place comes as excellent learning scenarios, as well as opening a research pathway to explore the qualitative nature of educational experiences in order to generate new knowledge.

Theoretical referents

This case has three components and different theoretical references. The first component is a workshop with its curriculum design based on the blended learning model, including a web application and previously prepared teaching materials. The second component is curriculum to implementation, through educational interventions that occurred at two practice sites. The third component is the perception comments from workshop participants about their learning experience.

The theoretical references of the *first component* were based on existing models of blended learning, basically meaning that students learn online, allowing them to have some elements of control over the time and place of learning. According to Greenberg *et al*, the most successful definition is divided into four parts:

- a) The first part says that it should be personalized and with it, means that it focuses on the needs of each student, not of the class as a whole.
- b) The second part is that it is based on dominance and basically means that students move forward and are recognized when they master a basic concept.
- c) The third point focuses on students' expectations, which means that each student defines the goals that drive his career and success.
- d) The fourth and final point of this definition is that the

intellectual property of the student exists. This is critical, because the intellectual property of the student means that they are trained with the skills they need to manage their own learning.

In this sense, a curriculum for blended learning with specific knowledge was planned and different models were previously revised such as Tyler’s four-step model (1973), Taba’s model that considers the needs of society and culture (Meza, 2012:42), and the Fonseca and Gamboa model, identified as a teaching-learning process that has to be carried out scientifically (Fonseca and Gamboa, 2017:84).

All revisions took into account the ancient forms of teaching that come from artistic actions, where knowledge has specific purposes of teaching production and theory is given to the aspirant circumstantially as problems arise (Siqueiros, 2020). In this way the artist Siqueiros (1896-1974) contributes with his vision from the methodology of collective work and from his visual theory of “polyangular” composition, dedicated to the viewer in motion (Gómez, 2013). The following table shows the curriculum design.

Table 1. Curriculum design

1. Conceptualization of the model.	The development of educational tools and materials specifically designed for teaching in an immersive dome allow to explore complex knowledge that can now be useful for students from the age of 8. As an example, the virtual study of astronomy to understand and solve three-dimensional problems with different variables (Yu, 2001), and to teach the different types of knowledge that allow the development of problem-solving skills, where the intervention of reasoning and certain mental mechanisms is required (Meza and Perrenoud, 2012: 52).
2.- Curriculum type.	Multimodal for an active student.
3.- Approach.	Blended learning
4.- Determination of the output profile.	Gain skills to conduct an immersive production study, identifying the characteristics that allow to consolidate its function and self-construction (Cruzvillegas, 2014).
5.- Identification of the graduate’s future.	A graduate capable of designing multimodal content in immersive spaces.
6.- Determination of the necessary contents to achieve the terminal objectives.	Stimulating creativity, through the tools and exercises that allow to acquire the necessary knowledge for the creation of narratives for its presentation in an immersive dome of self-construction (Cruzvillegas, 2014).

7.- Content.	<p>Theme: Introduction.</p> <ul style="list-style-type: none"> 0. The astronomical scenario. a. Technologies applied in planetariums. <p>Theme: Applied sciences.</p> <ul style="list-style-type: none"> c. Notes on vision. 0. From continuous space to the fourth dimension. 0. Aesthetic aspects and plastic integration. <p>Theme: Immersion.</p> <ul style="list-style-type: none"> f. Polyangular dome (Siqueiros, 2020). 0. Technical aspects of an envelope and its integration. 0. Immersive language.
8.- Instruments.	<p>A web application is the tool that responds to the needs of the curriculum and serves to investigate the implications of education with blended learnings.</p> <p>The application manages the virtual teaching environment, is based on hypertext markup (HTML), java script (JS), and style sheets (CSS) languages. To achieve active communication between the user and the information, the application makes use of the following elements: image (JPEG), video (MP4), graphics (GIF), audio (MP3) and portable documents (PDF).</p> <p>It contains a blueprint to assemble a dome, geodesic calculator, open source planetarium software and its guide to use in Spanish, digital effects, digital production files, video editing software, 3D modeling software and photo editing software. You can visit in: https://www.visualmusic.info</p>
9.- Methodology.	<p>The working method is collective, the learning time is programmed for six days of self-learning with the web application and 15 hours of classroom learning.</p> <p>In the first part of seven days students receive the app by email. They interact from their computers, tablets or cell phones. Personal lessons are then integrated with production projects for five days lasting 180 minutes per session.</p> <p>Throughout the process the student is endowed with theoretical information that helps him discover concepts related to science, arts and visibility such as anchoring, objectivating, classification, fragmentation, variability of representations (Moscovici, 2000), and polyangular concept (Siqueiros, 2020).</p>

10.- Requirements.	<p>Technical requirements for participants: portable computer and skills of higher or middle education.</p> <p>The technical requirements to carry out the activity in the educational spaces were adapted to a classroom equipped with internet.</p>
Source: Own, 2020.	

The theoretical references of the *second component* are established as a planned educational intervention determined in its educational limits. Its references come from Spallanzani *et al*, where the authors propose that the intervention is a practice that integrates action, practice and critical reflection; it is the relationship between didactic dimensions (relationship with knowledge/ knowledge), psycho-pedagogical dimensions (relationship with students/ students) and organizational dimensions, all anchored in a social relationship of a given temporal space. In another perspective, educational intervention projects aim to introduce changes in the structure and dynamics of a context (operation), positively affecting their functioning (Barbosa & Moura, 2013).

The theoretical references of the *third component* try to determine what will be the object of evaluation and its instruments. According to the approach, its social construct framework is constituted with comments from students to identify the level of agreement or disagreement of the implemented methodology.

Research question

The case study attempts to contribute to the current state of knowledge of virtual education, through an inductive stance to describe two field experiences that implemented a curriculum design with a blended learning approach. Issues related to the problem look for answers to the following question:

What benefits come from comparing different blended learning processes?

Methodology

About the case of study

Among the various definitions there is an agreement on the term “case of study”; its origin comes from medical and

psychological research, where it is used to call the thorough analysis of an individual process that explains the dynamics and pathology of a disease. This method assumes that it is possible to know a phenomenon based on the intensive explanation of a single case (Arzaluz, 2005:109). Other perspectives propose that cases are often individuals. This means that to generalize about the prevalence of some phenomenon we need a large population of individuals. However, if we are studying social processes, our focus will be on interactive units (Silverman, 2013:233). In this way, the case of study is the method of analysis to understand the effects of educational intervention with blended learnings, implemented in two sites that formed the analysis units.

Sites and subjects

The study is divided into two units of analysis: the first is the “Planetario Tabasco 2000” from Villahermosa in Tabasco, Mexico (PT2000), the activity happened as invitation of the Secretariat of Culture of Tabasco and was held from October 14 to 23 in 2019; the second was an educational intervention at the Durango Center of Knowledge and Arts in Durango, Mexico (CEKART), originated from the lack of immersive infrastructure and occurred from February 3 to 14 in 2020.

Procedures for data construction

A variety of information collection media was used for obtaining data. The following route expresses graphically the strategy of work.

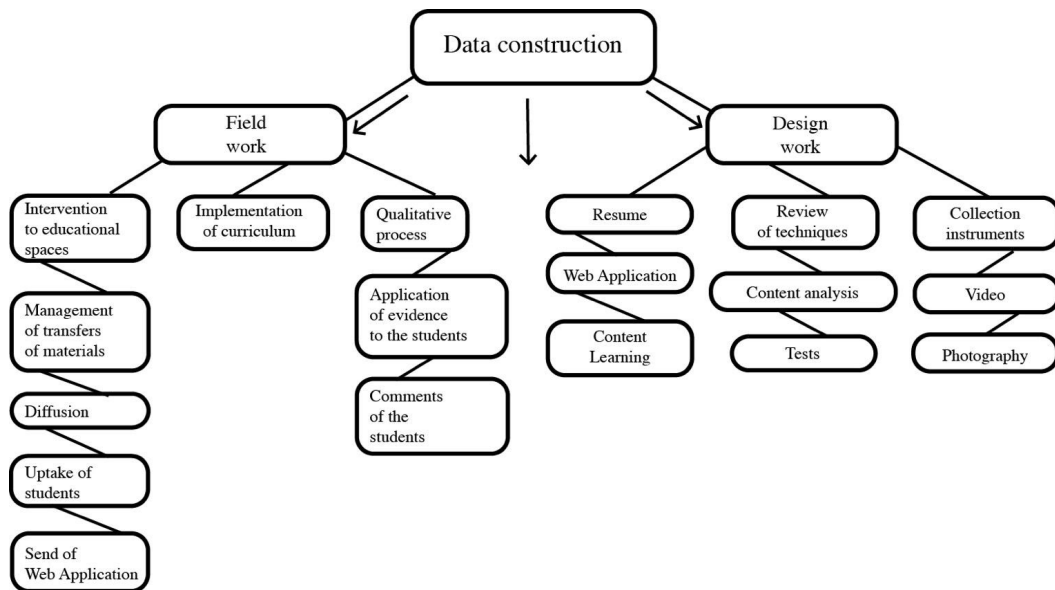


Image 1. Route for data construction

Results

The results are intended to show the overview of the field of study, as well as that of each unit, the results of the selection of comments and their organization related to the implications and recommendations.

Overall results

Fieldwork encompasses two artistic and cultural spaces in Mexico, each with a different audience and with different educational experiences. The particularity of the whole was the absence of education programs dedicated to the dissemination of science and arts, especially for polyangular concept. As well for the lack of immersive infrastructure and lack to use of blended learnings for teaching. The following table shows the information of the population studied.

Analysis Unit	Place	Dependence	Calendar	Interested*	Attendees**	Gender	Ranges
1	Tabasco PT2000	Tabasco Culture Secretariat	October 14-23, 2019.	14	10	4 Women 6 Men	68 to 21 years old
2	Durango CEKART	Durango Institute of Culture	February 3-14, 2020.	16	10	4 Women 6 Men	
			Total	30	20	8 Women 12 Men	68 to 21 years old
<p>* People who requested reports for course. **Final assistants. Source: Own, 2020.</p>							

Table 2. Population

Planetary Tabasco 2000 (PT2000)

Opened in 1981 and located within the Tabasco 2000 urban project, it is one of the most significant buildings of its kind. It has capacity for 300 spectators, a large semicircular stage, reclining seats and excellent acoustic camera; its concave screen is specially designed to project immersive films, but it doesn't work in some parts. In this place, ten people with different levels of education and ages agreed to participate. Industrial engineers, graduates in education, an engineering technician, a high school student, and natural science graduates were received. Intervals in the age range were 68 to 21 years, attended by four women and six men. The ten participants had been in the state's immersive dome, which served to share their experiences and compare their skills during the learning process. All people collaborated with collective work to construct the dome and write comments. In the end, three students presented astronomical exhibits and six artistic works.

Center for Knowledge and Arts in Durango (CEKART)

The place is a school for filmmakers, dancers, and painting courses are taught. The educational intervention happened due to the lack of educational means and technical facilities for the development for an immersive activity. The dissemination of the activity was in charge of the management of the place, 10 people from different professions attended such as architecture, art crafts, painters, engineering and a teacher. Nine participants had never been physically in an immersive dome and one went to the Medellin Planetarium in Colombia. All attendees collaborated on construction and developed their creative process and write comments, but only eight presented a final piece. Students' skills were limited to technology equipment and three of them did not have the right technical requirements.

Conclusions

Before presenting answers to research question, it is important to consider that the activity to construct an immersive dome with blended learnings is complex by the purposes and means to search for explore. Despite this, the curriculum scopes were completed in the analysis units outlined in this document.

Benefits that are gained by comparing different blended learning processes

Experiences were explored in students guided by blended learning, allowing them to have "individualized learning plans" created for them (Greenberg *et al*, 2020). The learning was streamlined using a variety of interactive teaching methods, collective work, dialogue and questions (Small & Plummer, 2010). At the end of each practice, participants publicly presented their work and a thoughtful response about their experience. Reflections are recommended as a useful form of data collection in astronomy education research (Stroud, Groome, Connolly, and Sheppard, 2006). In addition, the reflections on the participants encouraged thought about their experiences and their subsequent action was based on them (Clarke, 2004:11).

The samples provided an opportunity to examine them in detail, in their results no disinterest in the work of the practice,

nor dissertations. Entries were limited and final submissions were outstanding and others incomplete due to technological reasons in each student's computer equipment, which did not discourage students' interest in sharing their results. This is confirmed by the thesis of other research showing the potential effects of mobile planetariums on distant communities (Sumners, Reiff, Weber, 2008). Other authors suggest that the true value of the planetarium may be in the affective part, as a result in stimulating students, by taking them to visit a planetarium (Reed, 1970).

In addition, the evidence of fieldwork confirmed the educational benefits of the immersive dome and blended learning that were perceived by students. Some participants mentioned that they needed more time of learning, others mentioned their willingness to assemble their own planetarium at home, and others mentioned the simplicity and effectiveness of the materials. A selection of comments from three PT2000 participants is shown below.

"I had very good expectations of the course, it exceeded them by a lot. I take very good things, tools that will be extremely useful to me and I am very excited to put into practice everything learned and share it with my team. I congratulate you, he's a person from whom you can learn a lot, thank you"

"I finished the workshop very motivated and eager to go deeper into scientific dissemination, on the other hand, I am a little sad because I would have liked the workshop to last longer, I would also have liked to see a little projection inside the dome. Come back soon, Professor. I'll keep an eye on your work, thank you"

"The material used, despite being simple was very effective, I did not think that this could be achieved this way, the instructor shared very well, his knowledge is noticeable that he loves what he does. Many congratulations"

Selection of comments from three CEKART participants.

"It's great that workshops like this exist, two areas that people think are totally different, they're the closest thing to what we think. He knows how to work together with people of different knowledge and merge them"

"I am very happy and grateful to give me the opportunity to attend this program, it is very useful, and I will soon create my own planetarium"

"The course I liked, gave me the foundation to start creating with this style of creation. If the course were longer, though, it would be more enriching"

Comparatively, from an emic assessment (Rosa & Orey, 2012: 867), PT2000 students showed extensive discursive capabilities, corresponding to the use of the technologies that were leveraged by the group and the knowledge acquired in previous experiences, which allowed to develop complex presentations that are shown in the following image.

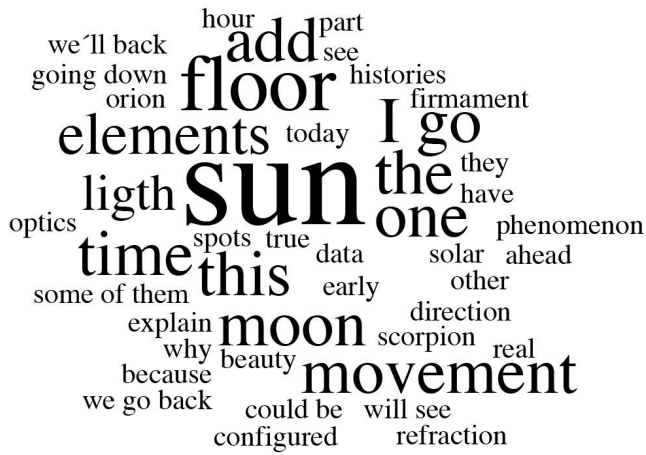


Image 2. PT2000 students' emic appreciation

On the other hand, CEKART students used the information of the web application until the face-to-face part of the curriculum arrived. This was due to the lack of experiences with blended learning and the no relationship with the immersive dome. In addition, the final production work ended with different types of achievement, from work with excellent invoices to limitations for digital skills. The following image illustrates the final works in both parts.



Image 3. Final samples in CEKART and PT2000

In relation to the study tests, an orthogonal anchorage grid based on the Whitt model (Reynolds, 2002:13) was first used, then a radial reticle of objection. With them, the concepts of anchoring, objectifying, classification, fragmentation and variability of social representations (Moscovici, 2000), showed comparatively unique results that are presented below.

A CEKART student took her camera through the streets of Durango, recorded the representation of a staircase to be radio-transformed. Meanwhile, a PT2000 student used the image of a snake to transform it into a new radial image.

The set of images, exhibit fragments that complement the anchors and the polyangular development of a snake and a ladder, in some parts distinguish abstractly the skin of the ophidia and on the other side the levels of the ladder. The objectivity is clearly abstract, but it becomes almost concrete when defining its existing parts in the nature of the ophidia and the civilized world that represents a ladder.

Its variability occupies a curious position among the concepts, since they show an abstraction of the world and at the same time, are the introduction to the order of its whole that is reproduced in a significant way. Its two facets equate each image to an idea, and each idea to an image. Thus, the stroke of an ophidia skin becomes snake and the abstraction of lines and semicircles become ladder (Image 4).



Image 4. Snake and ladder

Implications and recommendations

In general, the lack of educational technical means and facilities for the development of immersive proposals and blended learnings in Tabasco and Durango requires that its educational areas promote the general development of new technologies and the acquisition of their instruments.

In other words, the administrative management of educational implementation in PT2000 and CEKART, were carried without any setbacks. However, there is a complexity that is exacerbated by the broader government structure, as educational plans and teaching development programs have not expanded curriculum knowledge to immersive education. Likewise, stakeholders in the dissemination of scientific knowledge in Tabasco and especially in Durango actually seem to be far from the direct relationship with the educational system and its communities. This is interpreted as a negative fact, as it reveals the consequences of the disinterest directed to science in basic education students (PISA, 2018), and their impact on women with its multiple undesirable effects it generates in all orders of individual and social development (Abell and Lederman, 2006).

This is amplified by the goals proposed during the 2015 Summit for Sustainable Development, where UN Member States approved the 2030 Agenda for Sustainable Development, including a set of 17 Goals to end poverty, combat inequality and injustice, and tackle climate change through education. In the 17 objectives, the fourth refers to Quality Education.

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BEYOND THE DOME: AMATEUR TELESCOPE MAKING AND ASTRONOMICAL OBSERVATION AT THE ADLER PLANETARIUM

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Abstract: This paper uses the Adler Planetarium in Chicago as a case study in order to address the historical interplay between the ability to recreate astronomical phenomena indoors, which is central to the very concept of the modern planetarium, and the potential of planetaria to promote public engagement with the actual sky. It is shown that a solar telescope installed in the Adler Planetarium's building, a longstanding liaison with local amateur telescope makers, programs and exhibits promoting the making of telescopes, and eventually the creation of a standalone public observatory all played an important role in crafting the Planetarium's identity, and in firming its place in Chicago and among planetaria and science museums in general.

Introduction

In his guide to the Adler Planetarium and Astronomical Museum, astronomer Philip Fox (1878-1944), the Planetarium's first director, wrote: "visitors come to see a stirring spectacle, the heavens brought within the confines of museum walls".¹ Though it was not Chicago's first public planetarium,² the Adler Planetarium—thus named in honor of its benefactor, Chicago businessman Max Adler (1866-1952) was the first institution of its kind in the Western hemisphere, in the sense of a domed planetarium relying on an optical-mechanical projector.

The Planetarium opened to the public in May 1930. Its building originally stood on an island that was later merged into an artificial peninsula known as Northerly Island. To those arriving from Chicago's downtown, Adler is the furthestmost of three museums located in the area, the other two being the Field Museum, whose current premises opened to the public in 1921, and the Shedd Aquarium, inaugurated just two weeks after the Adler. For obvious reasons, this area is also

known as Museum Campus. In the words of Philip Fox, its three museums form a "trinity dedicated to the study of 'the heavens above, the Earth beneath, and the waters under the Earth'".³

While the Field Museum boasted extensive natural history and anthropological collections originating with the Columbian Exposition of 1893, the Shedd Aquarium presented a living spectacle of aquatic life. The Adler, in its turn, featured a novel technological marvel, the first of its kind to operate in the Western Hemisphere: the Zeiss Mk II projector. But would the machine itself and "the heavens brought within the confines of museum walls" suffice to firm the Adler Planetarium as an attractive and culturally credible neighbor to the two other members of the "trinity" mentioned by Fox?

When the Adler first opened its doors to the public in 1930, it already had more to offer than just artificial heavens. It sported a noteworthy collection of historical scientific instruments,⁴ and in the ensuing years several exhibits would be added, to a great extent due to the fact that the Planetarium was intended to feature as a major attraction in the Century of Progress Exposition of 1933-34, as it came to happen.⁵ The name Adler Planetarium and Astronomical Museum⁶ was tactfully chosen to stress that the new institution was not just some kind of astronomical movie theater, but in fact a serious cultural enterprise—according to Philip Fox, "an Astronomical Museum of which the Planetarium instrument is the principal exhibit".⁷

While the interplay between recreating the sky indoors and actually peering into it comes as evident in an institution like the Griffith Observatory, which was originally conceived to fulfill the triple function of observatory, star theater, and museum,⁸ in the case of the Adler Planetarium its own emphasis on the concept of an integrated planetarium-museum might lead to overlook the role played by telescope making and observation in shaping and reinventing the Planetarium over the decades. In what follows I will address some aspects of the Adler's history that evince the importance of those activities.

The Planetarium as Observatory

The original building of the Adler Planetarium was designed by the architect Ernest A. Grunsfeld, Jr. (1897-1970). The art-deco building, which garnered Grunsfeld an award, was meant to strike the viewer as an astronomical monument. It has the shape of a dodecagon, an allusion to the twelve signs of the zodiac. The dodecagon is embellished with sculptures of the zodiac signs by Alfonso Iannelli (1888-1965). The clockwise sequence of zodiac signs corresponds to the annual path of the Sun in the celestial sphere.⁹ To this day, the predominant element of the building (now partially encased by a structure of glass and metal, the Sky Pavilion) is the copper dome containing the dome theater originally used for planetarium demonstrations with the Zeiss Mk II projector. The

external dome reinforces the astronomical character of the whole construction, given its resonance with the idea of “sphere” that was fundamental to the identity and scope of classical astronomy.

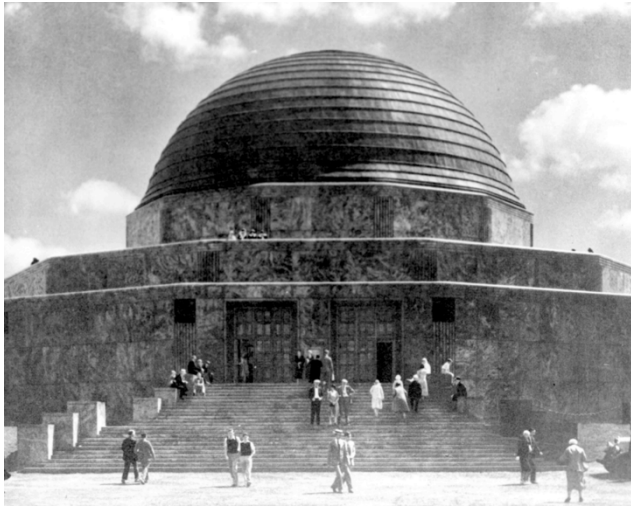


Fig. 1 - The building of the Adler Planetarium by the time of its opening in 1930. Note the presence of people on the deck and balcony (intermediate level) that was used to set up small telescopes for observing activities (photograph by Kaufman & Fabry, Adler Planetarium archives).

The Adler’s building has been described as a sort of “a cenotaph for some forgotten astronomer” on the grounds of its somewhat somber appearance resulting from the combined effect of its design and the rock (gneiss) used in its construction.¹⁰ It has also been suggested that Grunsfeld might have derived inspiration from Mayan architecture.¹¹ An aspect that resonates with this suggestion but which is usually overlooked is how the building itself was also conceived and suited to work, at least to some extent, as an observing venue.



Fig. 2 - Philip Fox (first on the left) showing the Adler’s Planetarium’s coelostat and solar telescope to a group of delegates during the 44th meeting of the American Astronomical Society, hosted by the Planetarium in September 1930 (Adler Planetarium archives).

In the abovementioned guide Philip Fox remarks, “there is a broad upper promenade deck for view of the sky. Portable instruments are carried there on clear evenings”¹² (fig. 1). Additionally, Fox coordinated the installation of an apparatus for solar observing that comprised a coelostat located in the deck, and a vertical 20-foot telescope that extended from the Planetarium’s

lower gallery (fig. 2). Fox noted that, combined with a spectrohelioscope, this telescope formed the “one instrument of primary research of the institution”.¹³ Fox thus sought to reinforce the character of the Planetarium as a research institution, as well as his own scientific authority in the double role of planetarium director and working astronomer.¹⁴ However, Fox’s research ambitions were apparently never fulfilled, and the instrument, which remained active until the 1980s, was mainly used for its secondary function: to project the image of the sun and the solar spectrum before Planetarium visitors.

Fox left the Planetarium in 1937 to become the director of Chicago’s Museum of Science and Industry, but by then he had already secured a steady place for observing practice at the Planetarium. An additional feature in the Planetarium’s premises proved pivotal in that regard: an optical shop that was used to foster an enduring relationship between the Planetarium and the local amateur community.

The Amateur Telescope Movement (ATM) and the Adler Planetarium

In the late 1920s, a movement known as Amateur Telescope Making (ATM) started to take shape in the United States. Amateurs all over the country (and eventually, the world) formed groups and associations devoted to the making of telescopes.¹⁵ The leading figure in this movement was Albert G. Ingalls (1888- 1958), who edited a column in *Scientific American* titled ‘The Amateur Scientist’. Ingalls was also the author of *Amateur Telescope Making*, a work that went through several editions, and which was crucial in fostering amateur astronomy in the USA and other countries.

The ATM movement soon gained a footing in the Chicagoland area. The Amateur Telescope Makers of Chicago (ATMC) were led by Arthur Howe Carpenter (1877-1956), a professor of metallurgy at the Armour Institute in Chicago (now the Illinois Institute of Technology). Two other leading figures in Chicago’s amateur astronomy were Lois and William Buttles, a couple which formed a separate amateur society named Astrolab. The latter attracted members from all over the U.S. and other countries, and promoted the collaborative construction of standardized portable telescopes that were taken to schools, community groups, and several organizations for public observing events.¹⁶

Philip Fox recognized that engaging with Chicago’s vibrant amateur community would help build a civic basis of support and consolidate a regular audience for the Adler Planetarium, and invited this community to use the Planetarium’s premises and equipment, namely its optical shop and a Zeiss polishing machine available there.¹⁷ According to Thomas R. Williams, the Adler’s workshop became “a showplace and the envy of amateur telescope makers across the country”.¹⁸ Beginning in 1932, if not before, the ATMC held their monthly meetings at the Planetarium¹⁹ and continued to do so at least until 1936.²⁰ There was also a booth in the lower level of the Planetarium where ATMC members could make and display their telescopes.²¹



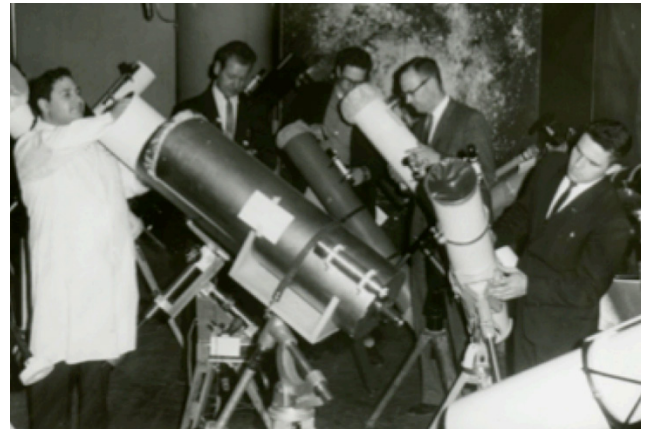
Figs. 3 and 4: Staff and amateur telescope makers at the Adler Planetarium's optical shop, c. 1960 (Adler Planetarium archives).

By the early 1950s the Adler's optical shop occupied an important role in the Adler's offerings, hosting telescope-making sessions during which amateurs and enthusiasts could use the available equipment to grind their own telescope mirrors and assemble their instruments under the guidance of Planetarium staff and fellow amateurs (figs. 3 and 4).

Around 1960 the optical shop became a "living" exhibition titled "Amateur Telescope Makers Optical Shop", likely with the goal of attracting more participants. Visitors walking by could watch staff and participants engaging in telescopic making operations, or at least get a glimpse of the shop's set up and equipment when it was not in use (figs. 5 and 6). The Planetarium further promoted its liaison with the ATM movement by hosting a Telescope Maker's Fair (figs. 7 and 8). The optical shop was dismantled in 1999, but the Planetarium continued to promote engagement with telescopes and astronomical observation through public observing programs and events, and with its own observatory (see section below "A Planetarium and an Observatory in an Astronomical Park").



Figs. 5 and 6: The Adler Planetarium's optical shop as an exhibition in the 1960s (Adler Planetarium archives).





Figs. 7 and 8: Homemade telescopes on display during a Telescope Maker's Fair hosted by the Adler Planetarium (data unknown, Adler Planetarium archives).

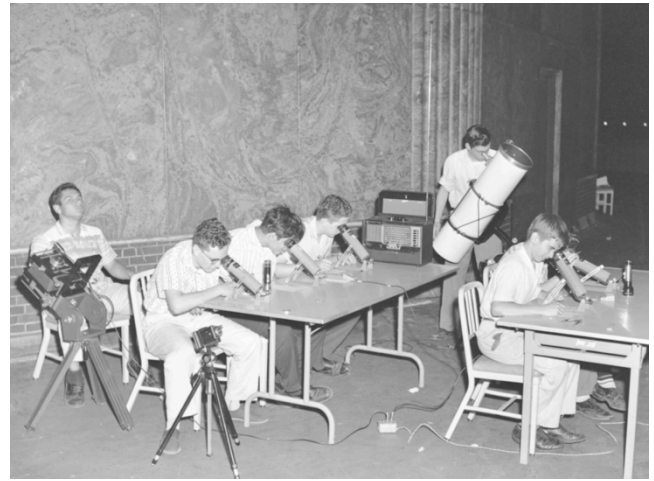


Fig. 9: Young Project Moonwatch observers from the Chicago Astronomical Society in action at the Planetarium's deck, c. 1957-58 (Adler Planetarium archives).

Space Age Stargazers: Project Moonwatch at the Adler Planetarium

In 1956 the Smithsonian Astrophysical Observatory launched Operation Moonwatch with the aim of tracking artificial satellites. The program was led by Fred L. Whipple (1906-2004). It gained momentum after the launch of Sputnik I by the Soviet Union in October 1957, becoming emblematic of the Cold War and the Space Race.²²

Moonwatch eventually counted on more than 200 teams spread across the United States and other countries. In a typical Moonwatch session a group of observers sat in a row along the north-south line with each individual covering a specific section of the sky. Observations were carried out using small telescopes specifically designed to rest on a table while the observer looked downwards through the eyepiece, which made the search for satellites more comfortable. When a satellite was spotted, the exact times it entered and left the field of view

were duly recorded and then submitted to the Smithsonian Astrophysical Observatory. Besides helping track and compute the orbits of satellites, the data compiled from the various participating teams was used to refine the understand of the Earth's shape and atmosphere, a type of knowledge that gained a particular relevance as the two major players in the Cold War were developing their ballistic missile arsenals.

The Adler Planetarium soon made its observing deck available to young Project Moonwatch observers from the Chicago Astronomical Society (fig. 9). It also hosted an exhibit where the project and its observing methods were explained to visitors (fig. 10). Besides making the Planetarium look more appealing to young astronomy and space enthusiasts, the Adler's support to local Project Moonwatch volunteers entailed an additional, twofold meaning.

First, it allowed to the Planetarium to reinforce its connection with the local amateur community after the latter had gone through several organizational changes. In 1941 the ATMC gave way to the Burnham Astronomical Society. The later become affiliated with the Chicago Academy of Sciences in 1945. In 1955, it merged with the Chicago Astronomical Society (CAS).²³

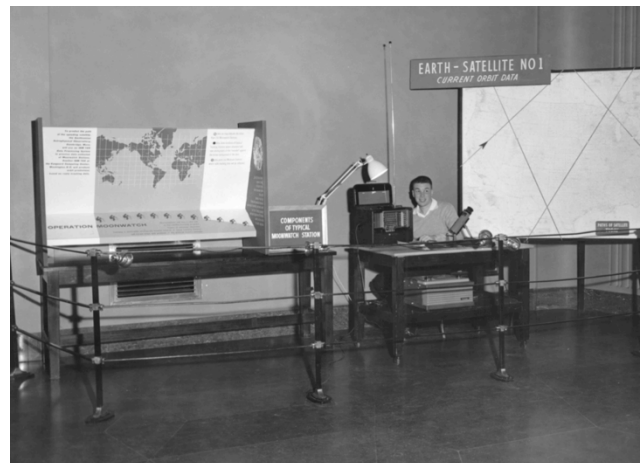


Fig. 10: Project Moonwatch exhibition at the Adler Planetarium, c. 1957-58 (Adler Planetarium archives).

CAS was founded in 1862 by a group of Chicago civic leaders interested in fostering astronomy in the city as a way of boosting its cultural status and prestige. As part of that effort CAS sponsored the acquisition of a large refracting telescope by Alvan Clark & Sons, which original tube and mount are now on display at the Adler Planetarium.²⁴ Fox was closely involved with CAS, having held the post of the Society's secretary. By the time the Adler Planetarium was founded, CAS was in need of revitalization, and Fox sought to give it a new lease of life, expecting it to become a strong civic advocate for the Planetarium. CAS was allowed to have it official headquarters at the Planetarium, and to hold its monthly meetings there. However, Fox's revitalizing efforts were not very successful, which led him to focus on cementing a strong liaison with the ATMC.

With the presence of Project Moonwatch at the Adler, all these efforts came full circle, since CAS had absorbed the local ATM movement. It must also be noted that Moonwatch had a strong resonance with ATM. Though a standard Moonwatch telescope was sold by the Edmond Scientific Corporation,²⁵ many volunteers made their own instruments in accordance with the project's guidelines.

By welcoming Project Moonwatch the Adler also showed to embrace the Space Age. This contrasted with the conservative attitude of Planetarium staff towards space flight in the years that preceded the launch of Sputnik I. In his recollections of the time he spent at the Adler around 1954, while still a high school student, physicist and space scientist George Carruthers notes that spaceflight and the possibility of doing astronomy from space (an idea that Carruthers got interested in after reading an article by Fred Whipple in *Collier's* magazine) were deemed nonsense by the Planetarium's scientists. ²⁶ By the late 1950s the Adler's approach to space exploration was inevitably changing and its keen support to local Project Moonwatch volunteers can be seen as an early effort towards refashioning the Adler as a planetarium for the Space Age.

A Planetarium and an Observatory in an Astronomical Park

By the late 1960s discussions were underway to permanently install a telescope in the Adler's deck for public observing activities. These discussions eventually led to the construction of a whole separate observatory by the lake just behind the Planetarium's building, opposite its main entrance (fig. 11). The new structure was completed in 1977 and named Doane Observatory in memory of Chicago businessman Ralph Doane and his wife Lillian Doane, with their family sponsoring the new facility.

The Doane Observatory's first instrument testified to the Adler's longstanding engagement with telescope making, sporting a 16-inch primary mirror made in the Adler's optical shop in 1961.²⁷ There was also a television camera system so that astronomical objects on view at the telescope could be shown on screens before groups of visitors.²⁸ The Observatory's equipment has gone through several upgrades over the years, more recently with the installation of a new 24-inch telescope in January 2020. In 2014 its building was also refigured in order to add a multi-purpose room for various educational activities and public programs.



Figs. 11 and 12: The Doane Observatory c. 1977 (Adler Planetarium archives) and the interior of the observatory during a lunar eclipse viewing event, July 16, 1981 (Adler Planetarium Archives).



Fig. 13: A Chicago Astronomical Society telescope in the grounds of the Adler Planetarium during a lunar eclipse viewing event, July 16, 1981 (Adler Planetarium Archives).

More than adding a permanent, purpose-built observatory to the Adler's offerings, the placement of the Doane Observatory in the immediate vicinities of the Planetarium's building contributed to turn the whole area into an open meeting point under the sky, with the Doane functioning as the main attraction in public observing programs (figs. 12 and 13). Observing parties hosted by the occasion of lunar and solar eclipses and other astronomical events such as the passage of Halley's Comet in 1985-6 have proved particularly successful in terms of attendance.

The character of the Adler's site as a sort of public astronomical park has been further reinforced with the addition of public art works since the early 1970s. These works include: a recast of the statue of Copernicus sitting in front of the Polish Academy of Sciences in Warsaw (1973); a sculpture titled "Spiral Galaxy" (1998), by John David Mooney; 'Man Enters the Cosmos' (1980), a sculpture by Henry Moore that is also a fully functional equatorial sundial; and 'America's Courtyard' (1998), an installation by Denise Milan and Ary Perez comprising sixty stone blocks in a layout that resembles an amphitheater, while evoking megalithic monuments such as Stonehenge. The stones are also arranged so as to form four pathways that mark the rising and setting points of the Sun in the summer and winter solstices. ²⁹ 'Man Enters the

Cosmos' and 'America's Courtyard' are particularly meaningful in that they embody direct connections with the sky above. Together with the Doane Observatory, they reinforce the notion that the Planetarium is not there to replace the real sky, but to connect its audiences with it.

Concluding remarks

Engagement with telescopes and astronomical observation has played an important role in the history of the Adler Planetarium since its early days, serving varied but complementary purposes over its nine decades of existence. Regardless of the extent to which it was used for actual research, the in-built solar telescope installed under the supervision of Philip Fox reinforced the scientific character of the institution while testifying to the Planetarium's commitment to astronomical observation. The longstanding liaison with the local amateur community helped cement a local basis of support and a faithful audience. By opening its observing deck and exhibit galleries to Project Moonwatch in the late 1950s, the Adler not only reinforced its ties with local amateurs as it also showed to embrace the emerging Space Age. The conversion of the Planetarium's optical shop into a living exhibit rendered the making of telescopes transparent, while offering an opportunity for hands-on engagement with science as opposed to the more passive experiences of attending a sky show or appreciating historical artifacts on display. The addition of a separate observatory building to a surrounding area increasingly embellished with astronomy-inspired public art sealed the Planetarium's commitment to engage its audiences and stakeholders with the actual sky. All of the above served for the Planetarium to carve a distinctive identity in the context of Chicago's Museum Campus, in the urban tapestry of the city as a whole, and in the broader panorama of planetaria and science museums. It thus affirmed itself as a community-friendly museum fostering state-of-the-art dome visualizations, world-class collections and museum displays, and astronomical observing, becoming Chicago's go-to place to witness a particular astronomical event or simply to catch a glimpse through a telescope in the company of Planetarium experts and volunteers, and other visitors.

Footnotes

- 1 Philip Fox, Adler Planetarium and Astronomical Museum. An Account of the Optical Planetarium and a Brief Guide to the Museum (Chicago: The Lakeside Press, R. R. Donnelley & Sons Co., 1935), p. 26.
- 2 That title goes to the Atwood Sphere, an immersive planetarium designed by the geographer Wallace Atwood and built in 1913 under the auspices of the Chicago Academy of Sciences. In the 1990s the Atwood Sphere was relocated to the Adler Planetarium, where it has been a major attraction. See: Pedro M. P. Raposo, "'Moving the Universe": the Atwood Sphere and the Adler Planetarium in Chicago', *Early Popular Visual Culture* 15 (2017): 268-272; Jean-Michel Faidit, Marvin Bolt, 'The Magic of the Atwood Sphere', *Planetarian - Journal of the International Planetarium Society* 42 (2013): 12-16.

- 3 Philip Fox, Adler Planetarium and Astronomical Museum, 1935, p. 6.
- 4 On the origins of the Adler's collections see Liba Taub, "'Canned astronomy'" versus cultural credibility: The acquisition of the Mensing Collection by the Adler Planetarium', *Journal for the History of Collections* 7 (2005): 243-250.
- 5 See Pedro M. P. Raposo, 'Astronomy Between Solemnity and Spectacle: The Adler Planetarium and the Century of Progress fair in Chicago, 1933-34', in Marco Beretta, Elena Canadelli, Laura Ronzon (eds.), *Behind the exhibit: displaying science and technology at world's fairs and museums in the twentieth century* (Smithsonian Institution Scholarly Press, 2019), pp. 89-107.
- 6 It was later renamed Adler Planetarium and Astronomy Museum, and is now simply Adler Planetarium.
- 7 Philip Fox, Adler Planetarium and Astronomical Museum, 1935, p. 6.
- 8 See Stuart W. Leslie, Emily A. Margolis, 'Griffith Observatory: Hollywood's celestial theater', *Early Popular Visual Culture* 15 (2017): 227-246.
- 9 The original intention was to have the opposite, so that the signs would be presented as on the surface of a celestial globe.
- 10 *Ibidem*, p. 229.
- 11 William Firebrace, *Star Theater: The Story of the Planetarium* (London: Reaktion Books, 2017).
- 12 Philip Fox, Adler Planetarium and Astronomical Museum, 1935, p. 8.
- 13 *Ibidem*, p. 58.
- 14 Fox negotiated with Max Adler to retain an affiliation with Northwestern University, on the premise that most of his scientific work would now be done at the Planetarium.
- 15 See Gary Leonard Cameron, "Public Skies: Telescopes and the Popularization of Astronomy in the Twentieth Century" (PhD thesis, Iowa State University, 2010).
- 16 L. I. Buttles, 'Amateur Telescope Makers in Chicago', *Popular Astronomy* 40 (1932): 586; 'Astrolab', William Buttles Papers WBPS1, Adler Planetarium archives.
- 17 Thomas R. Williams's, 'Getting Organized: A History of Amateur Astronomy in The United States' (PhD thesis, Rive University, 2000), p. 179.
- 18 *Ibidem*.
- 19 W. M. Callum, 'Amateur Telescope Makers of Chicago', *Popular Astronomy* 40 (1932): 652.

- 20 W. M. Callum, 'Amateur Telescope Makers of Chicago', *Popular Astronomy* 44 (1936): 103.
- 21 Philip Fox, Adler Planetarium and Astronomical Museum, 1935, p. 60.
- 22 Patrick McCray, *Keep Watching the Skies! The Story of Operation Moonwatch* (Princeton University Press, 2008).
- 23 'Chicago Academy of Sciences / Peggy Notebaert Nature Museum - Archives/Finding Aid - Collection Title: Burnham Astronomical Society Records', <https://www.naturemuseum.org/Media/Default/Collections>, consulted on July 24, 2020.
- 24 Marvin Bolt, *Telescopes: Through the Looking Glass* (Chicago: Adler Planetarium, 2009), p. 222.
- 25 Ibidem, p. 230.
- 26 Interview with David DeVorkin on August 18, 1992, <https://www.aip.org/history-programs/niels-bohr-library/oral-histories/32485>, consulted on July 24, 2020.
- 27 I am indebted to Michelle Nichols at the Adler Planetarium for providing me with background information on the Doane Observatory and its history.
- 28 Unpublished communication on the 40th anniversary of the Doane Observatory by Larry Ciupik, 2017.
- 29 Adler Planetarium and Astronomy Museum, *Astronomy's Inspirations: A Guide to Art at the Adler* (Chicago, 2005).

LSS DIGITAL PLANETARIUM SYSTEM

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**Abstract: Building your own fisheye digital planetarium system for less than \$2000 is possible!
Follow the instructions on our website and build beautiful presentations for your audience.**

The Lhoumeau Sky-System is a concept of a planetarium at low cost for small and medium planetariums. Website : <http://www.lss-planetariums.info/>

It consists of ...

- A videoprojector with the best quality, luminosity, contrast and resolution you are able to find without a too high price. Prefer by far the DLP, because even with a FullHD LCD, the screen effect is clearly visible, which is really despicable on a dome ... Optoma EH 400+ (1080p) Optoma WU470 (1200p) Optoma UHD 420X (2160p) for 6m dome. Optoma 4K550 (2160p) for 8m dome.

- An optical device with a camera optic (50mm at F/1.4), a diagonal mirror (2 inches) and a fisheye lens (Peleng 8mm at F/3.5).

- A computer with a decent graphic card (nvidia GTX750 or higher) and a SSD hard-drive. Notebooks are not recommended, mostly because of the unadapted graphic cards. Some exceptions are possible. But you have to put the LCD panel off because it produces too much light pollution spreading on the dome.

- A software permitting to project the starry sky in fisheye projection (The Open Source planetarium software derived from Nightshade Legacy named SpaceCrafter is recommended). <http://www.lss-planetariums.info/spacecrafter/index.php?lang=fr&page=spacecrafter>

- A retrolit keyboard for an easier control in the dark (Logitech G110 or equivalent).

Help for Model Selection

German site www.hcinema.de references most current projectors. Main characteristics are:

Auflösung: resolution

Projektionsverhältnis: projection ratio, determine the choice of condensor. For zooms, the range is variable and could manage to do better adjustments. For example, a range of 1.15 - 1.4 is good for the 50mm. You'll need a ratio equal or lower than 1.4 (but above 1.15).

Building the LSS optical block

We need:

- a condenser consisting of a 50 mm F/D1.4 (lens size) , as New Canon USM 50 mm f / d or 1.4 as used Lens screw (M42) for reasons of rings coupling -a diagonal (threaded 2 inch 2 sides , the case of Kepler and Skywatche “basic” , but not necessarily all other models)

- Peleng 8mm fisheye with mount M42 screw (the Samyang is an aspheric and therefore less interesting because it deforms the projection on the horizon) for **mounting** a M42 camera lens for **mounting** a “Canon” camera lens

Abbreviations used:

M : male

F: female

T2: 42mm diameter 0.75 mm

M42 : 42mm diameter 1mm

SCT: diameter 50.8 mm (2 inches) , not 1/24 “

M48 : 48mm diameter (internal thread of 2pouces) not 1/24 **the list of supplies** I do not have shares in TS, but they have everything you need (fast and cheap).”

Horizontality of the projector

Because of the DLP technology and the need of most classical projection rooms, the image is not centered in the lens axis causing the image to be projected with an angle. To correct this in our case, the rear of most projectors should be raised to project horizontally. With some projectors, tilt corrections can be diminished with mechanical levers or software adjustments.

Project on a small screen as a reference. Put the altazimuth grid and compass cardinal points on and suppress the atmosphere in Stellarium360. By moving the screen, the image should zoom in or out but the center and the E/W points must remain on the same line. If this isn't the case, adjust by tilting the VP, for example in using the adjustable feet. Height blocking: Adjust the height of the block so that the circular image is formed at the center of the lens. Warning: the four legs must be at the same height to avoid creating extra angle. Using a bubble level for horizontality can be useful.

When you place the optical block, most of the time it isn't aligned. The result is a staggered pattern onto the dome. You can help the adjustment with a translucent bulb for the setting.

Centering the projector in the dome

It's uncritical to be slightly shifted from the center of the dome. If the offset is too important, some parts of the picture will appear brighter than other parts (the side the projector is close to).

Troubleshooting

According to the optics, you will discover that you have sometimes to cheat and reach a compromise, otherwise the edges will be sharp but the zenith will be blurred or sometimes only one side of the horizon. It's due to spherical aberration of the lenses.

Two options: use a diaphragm or more radically change optical elements for something better. A basic rule: always check the horizon in front of you, not just on the horizon to your left or right. Sometimes the image appears blurred on one side, but when you shift to the opposite way, the sharpness becomes acceptable.

Price of elements

Computer \$700

Fisheye \$300

Diagonal \$100

50mm \$300

Videoprojector \$500 (for 1K projection system)

IN THE BLINK OF AN EAR
changing perspectives

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Originally produced for the International Conference on Music and Sounds hosted by the London Centre for Interdisciplinary Research at St Anne's College, University of Oxford on 13 June 2020 (presented online).

Abstract: While Virtual Reality (VR) tends to be an individualistic immersion into the digital realm, the shared immersive experience offers the added perspective of an audience dynamic. This shared immersive experience is possible in places such as domed theatres and planetaria. Domed theatres / planetaria aim to immerse and transport audiences collectively to visualise especially scientific concepts and knowledge.

Due to the change to the format of both the International Conference on Music and Sounds and IPS2020, I presented the talk and the poster as a video making use of the visual aspect of the medium. This has created some difficulties with writing this down. Thus I have decided to basically stick to the script as recorded.

The original video can be viewed at: <https://youtu.be/NSk-bTnwfDU>

Also I feel that it is fitting to acknowledge the huge amount of work that Olena Lytovka and the team at LCIR have put into finding a solution to the difficulties that had arisen due to the crisis the world finds itself in. And also to Mark SubbaRao and the IPS2020 team where the information was originally to be presented as a poster, but also turned into a virtual experience. Thank you all so much.

A trip to Tokyo in 2017 resulted in my developing a new perspective on the language inherent in these systems.

Japan 2017

In Japan I attended the *Data to Dome* workshop at the National Astronomical Observatory of Japan's headquarters at Mitaka a suburb in the south of Tokyo. The Data to Dome movement has gained traction as these shared immersive systems allow scientists and researchers to experience their data in ways not possible on a flat screen in the laboratory (SubbaRao, 2017). I have deliberately said 'experience' as there is a growing interest in using auditory interpretations of data too.

But I digress...

This workshop was followed by the 7th *International Festival of Scientific Visualization* at Galaxcity in Adachi, Tokyo (International Festival of Science Visualization, 2017).

After the first day of this Festival where each film (even those produced in Anglophile countries) was in Japanese, my hosts at my guesthouse thought that a better translation of the Festival's title would be *The Festival of Scientific Visualisation with International Content*—it was aimed at a Japanese as opposed to an international audience. And I am about as fluent in Japanese as I am in Klingon.

Still, it led to some interesting deductions...

I sat with a Hollywood producer of full dome films and a Canadian distributor—because we were linguistically in the same boat, trying to work out what scientific argument each successive film dealt with. The producer's comments on each film became a loud litany of "More circles, more orbit lines."

I eventually began to notice what he was getting at—regardless of whether the film dealt with string theory or the Northern Lights, they all looked similar, and all were 'trapped' within the circular confines of the dome.

Titian and the Renaissance in Venice

My last morning in Tokyo was spent at Uena Park which is surrounded by several museums. My first stop was the Tokyo Metropolitan Art Museum which housed the *Titian and the Renaissance in Venice* exhibition (Villa & Kobayashi, 2017). Here I was in the Far East looking at high Western art.

Not long into the exhibition I was struck by a thought: Italy is where the shift from a single, flat view to 2-point perspective reached a climax in the realism portrayed on canvas in the Renaissance (Campbell, 2018). Basically, the canvas is just part of the composition—the painting extends outwards beyond what is seen.

And suddenly what I had experienced in the preceding week all came together and I was struck with the thought that that is the major problem with planetaria (or domed) films—they have to break out of the single point circular perspective and expand their language.

Naval Hill Planetarium

Back home at the Naval Hill Planetarium in Bloemfontein, it's not so much that the productions haven't pushed the boundaries, as it were—especially with regard to integrated live performances. The building that houses the planetarium was built as an observatory for the University Michigan (Snyder, 2018) and converted into the Observatory Theatre (ESAT, 2011) once the observatory had been decommissioned. From the start of its life as a planetarium the idea has been to use the space for extra-astronomical functions and even concerts. And, to this end, a baby grand is permanently housed inside the space.



Figure 1: Naval Hill Planetarium productions (Snyman, 2020)

Fly Me to the Planets

Following on from individual experiments such as a projected slide show with pianist Nicol Viljoen for Bastille Day and Edith Piaf's birthday in 2015, *Fly Me to the Planets* was conceived as a fully integrated music and full dome show (Snyman, 2016, 2017).

Written for a Brass Quintet and Percussion Duo performing music from the Classical and Jazz repertoire and TV and Film music, the production used different dome systems for different items in the show.

For instance, the First Movement 'Allegro' of Mozart's *Eine kleine Nachtmusik* - Serenade No 13 in G is accompanied by a panoramic view of Salzburg painted by Johann Sattler, a contemporary of the composer, projected under the virtual view of the night sky as it would have looked the night of the composer's birth. Gustav Holst's work for a double orchestra, *The Planets*, is reduced to seven players and about 17 minutes duration—drawing the essence out of the work. The music arrangements defined the visual elements. The idea of just looking at spinning planets in front of the audience seems to be a waste, not to mention boring. As Holst wrote the work mainly from an astrological as opposed to a strictly astronomical perspective, each movement started with a description of the mythical characteristics of the planet and its musical identity before flying to the planet and then on to each planet's moons. Four infographic cards to the sides gave details of astronomical details.

D.I.O.D.E.

Unfortunately live performances of this nature with musicians are expensive to stage. This is partly why *D.I.O.D.E. Digital Instrument Orchestra and Dome Experience* has been put on hold (Snyman, 2018).

The ensemble explores the elements of a unique digital and electronic instruments. Apart from the 'standard' digital instruments of the music world, a few unusual instruments are also in the line-up: Electric Wind Instrument (EWI) is a unique wind instrument that uses clarinet/sax fingering to produce a 6-octave range of changeable electronic (and acoustic) sounds; the digital drum set and keyboard work in a similar fashion within their respective instrument families; the electric violin uses pick-ups and expression pedals to expand the sounds of the acoustic instrument; the Theremin is a unique electro-acoustic instrument which is the only instrument played without physical contact by the musician. The Dome complements the music with the visuals that take on an immersive experience appealing to the auditory and visual. More than astronomy is explored on the Dome as the make-up of the ensemble opens up the possibility to explore visuals using fractals and other unique influences.

We have also tried our hand at drama productions—some of these are cheaper to stage:

Die klein prinsie (The Little Prince)

Our first sojourn into this world was an Afrikaans rendering of *The Little Prince* which we later repeated both in Afrikaans and in English (Morgan et al., 2016, 2017, 2018). This made use of images super imposed over asteroid belts and panoramas for the earth-bound scenes. We eventually made use of Antoine de Saint-Exupéry's sketches where possible. Actor Chris van Niekerk brought the story to life from behind the author's desk, under the dome.

Under Milk Wood

Dylan Thomas's *Under Milk Wood* was staged by an amateur group as though recording the radio drama of 55 voices with ten performers in studio with live Foley and Sound FX (Thomas, 2017). Probably the most unplanetary feature in all the productions attempted was the panorama of the fishing village—set in the Southern Cape so as not to have to try to replicate 55 Welsh accents—changing imperceptibly above the audience from one Spring midnight to the next.

The Wounded Healer is an in-depth contemplation of the consequences of the cost to oneself of the commitment to one's career and calling—an exploration of the ethics behind the everyday decisions (Rossouw, 2019). Albeit that a Trauma Surgeon (and that the work is thus situated within the Medical Profession) is the protagonist, the work speaks to anyone who is in a profession which demands commitment and sacrifice beyond the standard work week. Various visual elements are used from panoramas of Hong Kong and the Karoo, to full dome fisheye perspectives of the Award Dinner in the story. Sound again was live—performed by the writer himself.

War of the Worlds II

A planned project, *War of the Worlds II*, would use sound to disorient the audience (Snyman, 2018). While it is easy to cause motion sickness under a dome, here the idea was to try to recreate the unease and 'panic' of the original Orson Welles radio broadcast with the planetarium audience without causing nausea.

Once a security checks have been passed, the seating 'descends' 25 stories into Naval Hill to a secret bunker where the scientists start the briefing: HG Wells (1898) wrote the science fiction work *War of the Worlds* over 120 years ago in 1898—10 years after the first photograph of Mars was taken (Martz Jr, 1938) and the theory that Mars had water canals on it and, therefore life, developed (Nall, 2017).

Over 80 years ago, Orson Welles's radio adaption caused 'panic' in America (Jacobso, 2018) and a few months later the first colour photograph ever of Mars was taken at the Lamont-Hussey Observatory in Bloemfontein (Isaacs, 2019). This production uses live actors and the dome to explore the invasion of Earth by the Martians—*The War of the Worlds*. But then continues to explore the developments in technology and astronomy that has allowed humans to now send probes and rovers to Mars: we have invaded the red planet—there will be repercussions—hence *War of the Worlds II*. But will there be a new invasion of Earth by the Martians... And what if the Martians use the Moon as a base for their attack, turning it red.

Planetarium Sound

All these live shows are either unplugged for the most part (*Fly Me to the Planets*) or can only be linked up in stereo (the drama pieces). The prerendered planetarium films (dealing mainly with astronomy) use a 5.1 surround sound system.

Already the 'slicing' as the procedure is called to render the film in a format suitable for showing on the individual systems at each planetarium or domed theatre, is determined for each theatre depending on its size, shape and projection system. The film is supplied as a series of still images—generally 30 images or frames per second of film—called a dome master in the resolution the projection system can handle. At least the sound is fairly standardised at either a stereo or 5.1 surround system. But this is not necessarily the best solution for immersive sound. (Bolles, 2019)

M.A.R.S.

A full dome film project we are developing, *M.A.R.S.* or *Man's Amped Rubicund Supplements* (2019/2020), has an android packing Martian soil as 'the new rhino horn', to treat fevers back on Earth. But the android learns and becomes creative, sculpting the contents of the vials until it is rebooted and the process repeats until it is eventually discarded in the Martian soil.

The 'uncreative' android sees in monochrome and cinemascope and, as it learns and becomes creative, colour is introduced and the image moves to the full dome.

Here's a bit of what is happening in the soundtrack: The soundtrack draws from Holst's 1st Movement - Mars, the Bringer of War from *The Planets* (Holst, 1921) and (*Is There*) *Life on Mars* by David Bowie (1971). Holst's Mars has 5 beats in a bar and the thematic material has a distinctive rhythmic element. Bowie's *Is there life on Mars* features a harmonic progression with a descending bass line in semitones.

The image shows a musical score for the 'MARS theme' from the film M.A.R.S. (2019). The score is for Tuba, Marimba, and Maracas. It features a 5/4 time signature and a tempo of Allegro, quarter note = 100. The score is annotated with colored circles: red for 5-beat patterns across two bars, green for rhythmic elements from Holst's 'Mars, the Bringer of War', and blue and purple for chord progressions from David Bowie's 'Is there Life on Mars'.

Figure 2: Theme from *M.A.R.S.* - Léon Snyman (2019)
Red – 5 beats across 2 Bars;
Green – Rhythmic elements from 'Mars, the Bringer of War' Movement I of Gustav Holst's *The Planets*;
Blue, Purple – David Bowie's *Is there Life on Mars* chord progression.

In the film's *M.A.R.S.* theme (Snyman, 2019) the rhythmic elements pick up on the Holst rhythmic patterns—5 beats over 2 bars though and the rhythmic theme is quoted verbatim albeit with added melodic elements. The work is bitonal with a Major 4th between the tuba and marimba keys—Mars is the 4th planet in the Solar System—with each instrument following the harmonic progression of the Bowie song in their own key.

This 55-speaker sound installation uses an excerpt from Ovid's *Metamorphoses* (Humphries, 1955, 1983) comparing the four life-stages to the seasons. The South African languages were supposed to be vehicles of unity through diversity, but have become symbols of division, a clamouring noise, obscuring meaning and communication. But listen closely, really listen—individual voices can be heard and sense and meaning carry through despite the chaos.

LX/vi (Snyman, 2018-2020) is an immersive digital sound installation that has developed from this process. The installation has twelve Raspberry Pi computers running fifty-five speakers and eleven vocal groups of five voices each, each group in one of the eleven official South African languages

Unfortunately the complexity of the system would probably not allow this system to be a useful alternative to the 5.1 Surround Sound system found in most planetaria.

AlloSphere

The AlloSphere at the University of Santa Barbara, California is a 54.1 Sound system with 26 projectors double dome with a catwalk through the middle housed in a 3-storey facility. Developed by Joann Kuchera-Morin, a composer and media artist, the facility's main function is to present large data sets on a massive scale—both visually and audibly (Cabrera, et al., 2016).

Eine Kleine GeneMusik

Nigel Helyer (2014) from Macquarie University in Australia uses DNA sequenced from an encoding of a piece of music. The DNA is then allowed to mutate and eventually is re-encoded into music. A sound interpretation of a scientific data set. In this version a transcription of a Khoisan piece *San Gorah* was DNA'd, mutated, and then arranged for 3 members of the Odeion String Quartet. He has since run other versions of the same concept.

Conclusion

As far as the use of sound in these environments go there are two areas that are problematic:

- the first is how to determine what elements in the datasets determine what sound elements;
- the second is the system itself—the standard audio 5.1 system is not the easiest to mix for and the speakers are generally placed round the base of the dome—the options are not extensive.

Still the potential to develop a standardised means of producing sound and music in these spaces exists—both with regard to the development of audio systems as well as determining a language for translating datasets into understandable audio representations.

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OUTREACH WITH A PORTABLE PLANETARIUM

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Abstract: During this session panelists will share their experiences and advice about marketing, scheduling, presentation techniques for various grade levels, how to successfully run a program with an analog or a digital projector, program evaluation, unique presentation venues, and other topics you may request.

Panel members were asked seven questions to assist them in making their individual presentations and sharing information from their personal experiences. Following are the questions and then the answers from each panelist:

Who are you? Where are you from...when and how did you decide to work as a director of a portable planetarium? (Are you an outreach from a larger planetarium or running a private business?)

What kind of research did you do before getting your equipment and determining the extent of your territory?

What do you think is the most important strategy for running a successful program?

How do you handle marketing, booking and scheduling?

What is your overall presentation technique or style and how do you adjust for various grade levels?

How do you handle program evaluation?

What are the most unique presentation venues you have encountered?

Marco Avalos Dittel



Marco Avalos—Producer at Planetario Aventura, Costa Rica

We are a family business, focused on video production for education and industry, and we have had our mobile planetarium since 1992, first with the “analog” cylinder projector, and lately with the digital fulldome. Our planetarium is currently called “Planetario Aventura” (www.planetarioaventura.com) and we are based in Costa Rica. It was the first planetarium in our country, and it is still the only mobile planetarium with fulldome capabilities.

Our country, Costa Rica, is quite small, and we can reach anywhere within a range of 7 hours max, so we cover our whole country. We designed our mobile equipment to make it comfortable, safe and at the same time, easy to carry in a small van vehicle.

Our most important strategy has been quality. We offer a professional service with high emotional and educational impact,

to students and the general public. We strive to make our programs a memorable experience for the people. And of course, we offer a good price based on having an adequate amount of students or people for each contract. Our current prices average between \$2 to \$4 per person for most cases.

Most marketing is done through Facebook ads, aimed mainly at teachers of all levels in Costa Rica. Other important work has come now from commercial companies, to run their own topics, which we produce ourselves in fulldome format and then play them back at the dome.

We design our programs for different educational levels. Our best success has come from using narrators of the same age as the public. That means, we actually have programs for Preschools narrated by a kid that age. We also take a lot of care with the music and ambiance inside the planetarium, and whenever possible, provide more personal interaction with the audience.

We usually have immediate feedback from students and teachers. That has included if the topics are relevant to what they are learning at school, if they were comfortable inside the dome, if they understood everything, and so on. We have gotten a very high level of positive comments and satisfaction.

Our country has many microclimates, so we have had to operate under very hot and humid conditions, where we have had little success trying to tunnel an air conditioner at the blower. Our first dome is nylon fabric, almost plastic, and we had already painted it once with an elastomeric paint on the inside, so it is very waterproof; this has allowed us to carefully try to operate it outdoors, wherever wind allows for it. We have also been the commercial stand for some companies at public fairs, national scientific fairs, internal demonstrations for employees, and similar big activities. We even made a religious Nativity program for Intel technology company (yes, please don't ask...)

Tilo Hohenschlaeger



Tilo Hoenschlaeger—Bornhagen, Germany

The name of my mobile planetarium is Schulplanetarium and is located in Germany.

I have been working with the mobile planetarium for five years.

I have a Masters of Physics in Astronomy, Space Science, and Astrophysics. The Schulplanetarium as a company was founded properly in 2015 but the owner did work with the mobile dome for another seven years before that. At the moment we have three mobile domes that travel in Germany and very rarely in other European countries to educate children and adults. We have, at the moment, a part time employee (which is me) and four students and one office clerk. After my studies I was trying to find a job in Science but was not very lucky. After two years of unemployment I found the owner of this company through a friend who was a teacher at the time and I applied for a job. I have to say that Planetarium work was not my first choice of work because I was not very comfortable to speak in front of larger groups. Working with a mobile planetarium for five years now, I have to say that I am really happy with my work and can't think of any better job.

As said, my colleague started the business with a small number of presentations in schools. The research he did beforehand for a business plan included not only schools but also fitness clubs and trade shows and exhibitions. Another part of the company includes also the rental/sale and service of complete fulldome projection systems. Because of that we were able to realize some interesting projects with some artists and museums as well. We are situated with our company right in the middle of Germany and the initial extent of our territory was between 2 and 2.5 hours driving time around our location. Part of the research for the equipment was done for the business plan as well. To work in schools we had to get a special material for our tents, which have a specific fire protection standard. Projection system wise we use a 2K and a 4K digital projector for our 6.0m, 7.30m and 7.50m tents.

As said before quality is the key. As the only properly trained person in the field in our company, I make sure all of our students that work for us, are up-to-date with the latest developments in Astronomy and Spaceflight. I am a member of the Royal Astronomical Society and the British Interplanetary Society to keep myself informed. I also keep good contacts with some of the best research institutions in our area. There are some advantages for mobile planetariums too. The first major advantage is that schools don't have to come to your place, which saves them a lot time and money. We bring an extra teacher to the school, so the teacher can take a break too and they don't lose another colleague for teaching because of travelling to a planetarium. The teaching experience is much better for the kids because of the smaller number of students in the dome, which gives more direct time with each student and their questions. As the price has to be good as well; we charge between 4 – 6 € per person. If it's a school for special learning needs the price is usually a bit higher. As a normal company we do not get any agency money. The price has to cover the travel and accommodation and all other business matters. Either the kids pay for the experience or the school has a sponsor who pays part of it or all.

Our main advertisement campaign is done via post cards to the schools. We used to send letters but found that teachers don't read too much of the text. For that reason we changed to cards. It's cheaper than letters as well. Our main campaign is during the summer school holidays. We also use Google advertisement. We have a Facebook page but that is not so much in focus with teachers. Our normal website works better for that. After five

years of service we get more and more mouth-to-mouth publicity from teachers as well. Usually the teachers call us up or send an email. Our office clerk then generates and sends an offer letter with all the programs we can do and a proposed date. Three weeks before the gig, the presenter gets in contact with the school to get all the necessary information.

We have a special program for the pre-school kids as well. Our programs for the school kids are all modular in design and refer to the local government school curriculum. Teachers can pick the things they are interested in and we use a very interactive teaching style to get the pupils engaged in the experience. Topics that double in different grade levels are adjusted to the age of the kids.

We usually have immediate feedback from the teachers and students. Sometimes we get more detailed written feedback from teachers if they want to improve the experience for their students the next time.

We do rent out the tent to a local church every Christmas time. I remember a gig in a working printing plant. And once when the school gymnasium was closed due to safety issues, a local farmer volunteered his horse riding stable to the school, so we did put a 10x10 meter tarpaulin down in the sand and put the dome on top. Once we did an installation with an artist in The Hague at the Mesdag museum.

John T. Meader



John Meader—Fairfield, Maine USA

I am the owner/director of Northern Stars Planetarium, a private planetarium business I started in 1987. I was running a small science center planetarium in northern Maine and wanted to move back to central Maine, the place I called home. The portable was the answer to living where I wanted to live and still teach in a planetarium. I currently have two classic Starlab domes, a 4.8 meter dome and a 6.7 meter dome. I visit 80 to 100 schools a year reaching between 16 and 18,000 students a year.

Having worked in two previous planetariums (University of Maine and Malcolm Science Center in Easton, Maine), I wanted to continue to do the type of live presentations I had been offering schools in both of those facilities. I also knew that I had to be

able to offer a variety of topics, so I built a portable console that operated four Ektagraphic III slide projectors and about twenty special effect projectors. This enabled me to offer a wider variety of presentations. Today I have added an LCD video projector and dropped two of the slide projectors and over half of the special effect projectors. I'm currently trying to simplify my outfit while retaining my diversity of programming. As for my target area, I mostly work within a radius of 150 km from my home in Fairfield, Maine. This gives me the concentration of schools I need to run my business.

I believe quality presentations presented live with a lot of audience interaction is the best strategy in a portable dome. Give them a presentation that the teachers cannot reproduce themselves in the classroom. You need to stay uniquely valuable. I also advertise my expertise and my programming, I want my target schools to want me—Northern Stars Planetarium, not just any portable planetarium.

Initially in the 1980s and 90s I did direct mailings, but today I have a website, and a monthly newsletter that provides astronomy information as well as planetarium offerings. I take bookings mostly by email and phone. I book four days a week, giving me a reserve-date for rescheduling due to snow cancellations. Once someone books, I have a PDF contract I send via email.

Most of my shows are presented live, some with short prerecorded parts, but mostly live. I ask lots of questions and lead the students through a discovery of the given topic. Offering presentations for groups as young as 4-year-olds through 8th graders and occasional adult groups, you learn to design programs for specific age ranges. For example, I have a show specifically for preschoolers with a tactile component of stuffed sky objects and constellations. Older groups get presentations tailored to their specific age level by a combination of appropriate subject matter to meet curriculum needs and proper vocabulary.

I have PDF evaluation forms available with my prep materials for teachers. They often fill them out and either mail them in, or email them back. I also get a lot of feedback via email and conversations with teachers at schools while I'm visiting.

As to unique venues...I have travelled to off-shore island communities numerous times, once I was supposed to do three shows of 60 students in each presentation, but due to a medical emergency the ferry was rerouted and I got there late and we only had time to do two shows with 90 kids in each show—we were packed like sardines, but the kids were fantastic and loved every minute of it.

Once I set up at the LL Bean flagship store in Freeport, Maine where we just touched the ceiling sprinkler system. I was so nervous that my dome might set off the sprinklers at LL Bean.

One time at the Maine Wildlife Park, I set up outdoors under a blue tarp strung up between trees, only to be hit with high winds and a thundershower, ending up with 15 cm of water inside the dome! Luckily it was just before the first show, so no one was inside but me. I won't do that one again.

I set up once in a barn with cows in stalls and every time the cows mooed, the kids laughed and laughed. I worried that the dome might carry the smell to the next venue, but luckily it didn't linger.

And one winter day I set up in a school without heat. The furnace had failed overnight and it was about 7°C all day long inside the dome. The kids wore their winter coats, hats, and mittens. That was as close as I've come to the dome actually feeling like an igloo, not just looking like one.

Guilherme F. Marranghello



Guilherme F. Marranghello—Bagé, Rio Grande do Sul, Brazil

The name of our mobile planetarium is Planetário da Unipampa. We are located in the Southernmost state in Brazil. We serve the whole state named Rio Grande do Sul and our most distant travel distance is up to 600km. We have worked with a portable since the beginning of 2013.

I've been a professor at university since 2006. There are also another professor and an educational technician that work with me and, at least, eight or ten students each year. However, I started working by myself with planetarium in 2013. I was tired of cancelling events because of the rain. When I got some money from the university, I bought a mobile planetarium. Since 2017 we run also a fixed dome.

We started using the mobile planetarium inside the university. The schools would come to us because in my city almost no school had an appropriate place to install the dome. We also started to visit some schools during science fairs and the closest cities but not so often. After we finished our fixed dome we also got a van and then we started to travel much more. Like Costa Rica, we visit almost all the state in seven hours. We started visiting the cities where the university has a campus. Now, we are visiting other cities too.

Starting with the cash, if we have support from an agency or the university, we travel for free. If we don't have this support, we ask for a place to sleep, food to eat, and enough to cover the gas. I guess the most thing important for us is the staff. We usually travel with one professor and two students. Selecting a new staff each year is hard, but getting good people to work with us is the most important.

Talking about the mobile, facebook/instagram are our marketing strategies. Fortunately, we don't need to work hard on that even because we can't miss too many classes at the university. After a school or city asks for our visit, we tell them everything we need and send a sheet for scheduling the schools.

We basically have one program for pre-school kids, another one for first graders and another one for older kids.

We had a huge evaluation program last year through a questionnaire and we are still working on understanding everything. However, we always talk informally to the public.

High temperature is terrible in Brazil as in Costa Rica, but we have low temperatures too. So, we have had shows at 5°C to 35°C. Brazil doesn't have heating as in Europe or US. We have some good and some bad roads, but sometimes we have some real adventures. But I guess the last sessions at science fairs are the most terrible sessions. People fill the line and get really crazy to get inside.

Ruth Grützbauch



Ruth Grützbauch - Wien, Austria

The name of my planetarium is *Public Space Pop-Up Planetarium*. I am based in Vienna, Austria and mainly operate in the City and surrounding areas, but I also visit other areas in Austria on request (and if there is a good public transport link). I've also taken the train to Switzerland (just across the border from Austria) and to Amsterdam (for the birthday party of my sister who is living there). I have worked with mobile planetariums in the UK for about two years and I am now running my own business for about 2.5 years.

I am an astronomer. I used to work in research as a professional astronomer for several years and then, due to various frustrations with the academic world, I decided to go into outreach. I then worked in different education and science centres in the UK for several years, one of which also had a mobile planetarium. I am originally from Austria and when I moved back to Austria in 2017 I decided to start my own mobile planetarium as a one-person business.

I first had the idea to run a mobile planetarium as a business when I worked in the science centre in the UK. Everybody loved the experience in the mobile dome and when I found out that there was no portable planetarium in Vienna, I wanted to import the idea from the UK to Austria. I wanted to have it as compact and portable as possible and was looking for a low-cost way to reproduce the experience. I was lucky enough to get an old dome in the UK, which I brought with me, but then the main research question was: How to build and run a planetarium projector without spending too much money. I first found the method of using a spherical mirror, but that turned out to be quite hard to get and expensive. But then looking for software to use I stumbled upon the LSS-planetarium website of Yves Lhoumeau, a treasure trove of detailed instructions on how to use a regular projector and a combination of lenses to project a full-dome sky simulation. There I also got the Software I use, Stellarium360, an open-source software running on Linux, which turned out to work perfectly for my purposes.

What has worked well for me is to interact with the audience and to use my own enthusiasm and fascination with the subject. I try to share my personal view and awe of the cosmos with the audience. I think this is one of the strengths of the usually quite small portable domes; the setting is more personal, the audience is all around the presenter and so there is a huge potential for interaction, which is usually not feasible in a large stationary dome.

I have an interactive Question-and-Answer approach, since I don't run ready-made presentations but I guide people through the simulation of the night sky. People don't watch passively, but they are invited to ask questions at any point and through that participate in the presentation.

I adjust to different grade levels and age groups by the feedback I get from the audience. In general with the smaller children we stay closer to home and just look at the Moon, the Sun, and the constellations, but the older they get the farther we go out into the Solar System and beyond. But I also adjust my presentations spontaneously depending on the questions and feedback I get; with some groups I go into a lot of details, if I feel they have a lot of knowledge already. So my shows are always different, which is of course quite interesting for me too, and I often learn something new myself through the different ways of thinking of my audience.

So I would say let out your own enthusiasm and don't be afraid to be emotional or personal. I am lucky to be a "real" astronomer and I found that people are not just interested in the science but also the person behind the science, which makes the whole subject more relatable.

I visit mainly schools and kindergartens, but I also do private parties and also events in public parks and squares, which is what I feel the mobile planetarium is made for. It is outreach in its literal form—we have the possibility to reach out to people who would maybe never think of going to a planetarium. I remember one presentation in an inner-city youth center, where I got a group of seemingly bored teenagers to come into the dome—and they were totally blown away by the experience. A few of them asked me afterwards how they could also do this as a job and if they could maybe do an apprenticeship with me, which was really touching.

I get feedback from the teachers and audience members after the show, sometimes also by email, but I don't have a formal evaluation procedure.

I have a website, as well as a page on Facebook and Instagram, where I post regularly. I also tend to tell everybody about what I do and usually there is a lot of interest because running your own planetarium is quite an unusual job. I also participate in a lot of networking events and events for teachers and people in education. The most successful marketing channel for me has been word of mouth—I hand out business cards at my events and rely on personal recommendations. I think this is really important here in Austria, since most people have never heard of a mobile planetarium and can't picture its potential. It's way more effective if someone who has experienced it passes it on. The booking and scheduling is done via email, which works well so far.

Conclusion

So that is a view into the wild and wonderful world of five amazing mobile dome directors. They are planetarians who are challenged to bring their domes to the kids, by car, train, boat, or even bicycle during hot and steamy days, rain, snow, sleet and hail! They must be extra versatile and flexible while bringing professional quality presentations to their audiences.

Please also know that we are always ready to help you in your work.

PROFESSIONAL DEVELOPMENT AND CULTURAL EXCHANGE OPPORTUNITIES

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Abstract: Would you like to travel to a foreign country or host a colleague from another country? We will discuss a successful model for this kind of professional development and cultural exchange. Winners and hosts of the “Week in Italy,” “Week in the United States,” and “Week with the GDP” contests will share their experiences. You can get involved as a participant in one of these existing programs or you can be an innovator in your own country by initiating a similar program in your region. Come and find out how you can participate and make valuable international connections.

This paper is designed to highlight three existing contests that are supported by the International Planetarium Society (IPS); these programs provide an opportunity for cultural and professional development exchange within the global planetarium community and are offered under the auspices of the International Relations Committee.

Applications are requested from educators or astronomers who work with any of the various models of planetariums. For more information about these and other projects go to <https://www.ips-planetarium.org/page/share>

The three contests are:

A Week* in Italy for an American Planetarium Operator:



Each year, in the spring, the Serafino Zani Astronomical Observatory (Lumezzane/Brescia) hosts an American planetarium operator, whose native tongue is English, to work with high school students of English. *The expected length of stay in Italy is actually 10 days.

A Week in the United States



Two international planetarians, from any country in the world, will be hosted for a week in the United States. The visits will be arranged to best fit the schedules of the winners and the host facilities. Applicants must speak English.



A Week with the GDP is offered by the Society of German-Speaking Planetariums (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.

It is hoped that these contests will serve as models for other countries to follow as they create new cultural and professional development exchange opportunities around the globe.

Rather than tell the entire story of their travels, the panel members agreed that answering some specific questions would highlight the most important aspects of these programs and inspire others to apply or establish some new initiatives in other countries.

John Meader

A Week in Italy Winner 2004 and host for Week in the United States 2019



(L to R) John and Laura Meader and Loris Ramponi, one of the Italian hosts.

John can you give us your perspective of having been both a guest and a host?

My name is John Meader, I run a mobile planetarium business called Northern Stars Planetarium in central Maine, USA. In 2004 I traveled to Brescia, Italy and spent a week teaching astronomy to Italian high school students. In 2019 I hosted Ruth Grützbauch from Vienna, Austria for ten days in Maine. Having had such a powerful experience teaching in Italy, I found the combination of teaching experience along with a cultural exchange over an extended time was most valuable. The juxtaposition between sharing where I live and exploring Italian culture was valuable for both the students and me. I found teaching in Italy was much easier than I anticipated, the students were attentive and inquisitive, and their English skills were far better than my Italian. It was a rewarding week for me in Brescia, and I hope the students took their own rewards from our exchanges.

When I was given the opportunity to host a similar exchange to an overseas colleague, I jumped at the chance. I wanted to have a quality exchange in professional development ideas with Ruth when she visited, but I also wanted to give her a genuine feel for my home state of Maine. So we mixed teaching in different venues such as my portable and visiting the Emera Astronomy Center with

its modern installation. We had sessions with elementary students, college students, and the public. We even helped run telescopes at a star party at Katahdin Woods and Waters National Monument, the only dark sky sanctuary in the eastern US. Beyond the astronomy activities I wanted to offer Ruth a cultural exchange and included local activities such as canoeing, hiking, and a cookout at the lake. We visited the Common Ground Country Fair, and went to an environmental rally at a local college. I wanted a well-rounded package and I think we succeeded.

The professional development between us was through numerous long discussions, watching each other teach in the dome, and exploring our various styles, backgrounds, and even the equipment we use in our respective portables.

The ultimate value in these exchanges is to see beyond yourself and your own culture. Getting to know colleagues from other countries creates a broader world view for all involved. You will establish friendships with colleagues that will become deep, meaningful, and lasting. I would say that professionally, these two exchanges are two of the most valuable professional development exchanges in my entire 41 years in the planetarium field.

What did I learn that was unexpected

When I was in Brescia we did one *Magic Walls* session where you project the stars upon the wall in a darkened room without the dome. I found it frustrating and swore I'd never do it again. That was largely due to the fact that we were given a room where we couldn't effectively block the light from the windows, and there were posters permanently mounted on the walls that could not be taken down. So I had to work with a very small piece of blank wall with dim stars. It was not ideal. But now with Covid-19 upon us, I'm rethinking *Magic Walls* as a way to present the stars in classrooms until it's safe to take students back into my portable dome again. I will take the positives and negatives from my experience doing *Magic Walls* in Italy to create my own version that will work for me here in Maine. I'm so glad I had that experience, it may be what keeps me working through these difficult times.

Ruth Grützbauch

Week in the United States winner 2019



Ruth Grützbauch giving a fireside astronomy chat.

Ruth, you visited John Meader as one of the winners of the "Week in the US" for 2019. You and John are both running a mobile Planetarium as a small business. Did you find that you have a lot in common in your work? And what did you take away from the experience for your own professional development?

Yes, we found a lot of similarities in our work and had a lot to share and talk about, but in fact we also found that we have quite a different approach, very different equipment and also different didactic methods. John is focusing more on story-telling and it was inspiring to experience his way of interacting with the audience through stories. It made me think about my own style of presenting and my motivation as an educator.

I think the point is that as educators we rely a lot on our own motivation and enthusiasm. To design and present inspiring programs we need to channel our own fascination with the subject and we need to let the audience feel that enthusiasm. And to keep that enthusiasm over the years of telling the same stories we need from time to time a new perspective on our work, we need new stories, new ideas and that is precisely what this exchange program is providing.



Ruth setting up scopes with amateur astronomers.

So I think the professional development opportunity is not just sharing good practice examples or learning about new techniques and programs. It is also about staying enthusiastic through new input and through making new experiences in a different environment. I also feel a lot more connected to the international planetarium community than before taking part in the program.

Andy Kreyche

A Week in Italy Winner - 2020 (Date of visit TBD due to Covid19)

Andy, why were you interested in taking part in a cultural exchange opportunity and what was your reaction when the program was delayed due to Covid19?

Beyond any practical obstacles, I can't imagine anyone NOT being interested in participating in such a program. A wonderful humanities teacher in college opened my eyes to the richness in the art, architecture, and culture of other places, including and

especially Italy. And as astronomy educators, we seem to share a natural curiosity that manifests into a love of learning and a desire to know what's out there beyond us. Pursuing and sharing that knowledge is rewarding enough by itself, but due to the nature of the subject, understanding more about the cosmos provides a marvelous bonus. Knowledge of the universe, by its nature, broadens our perspective of our place within it.



Photo Credit: Shmuel Thaler/Santa Cruz Sentinel

Andy introducing students to the mobile dome.

One of my favorite astronomy books is *The Astronomical Companion*, by Guy Ottewell. The combination of his clear descriptions and hand-drawn illustrations serve, for me at least, to help bring this cosmic perspective to the fore. On his website, he has a page that caught my eye many years ago and never fully left my consciousness, despite the fact it was never developed beyond two short paragraphs. The title of the page is “Xenophilia: In Praise of Human Variety.” This is his attempt to promote a new word meaning “love of strangers,” where people are encouraged to find interest and value in those different from themselves. The word is offered as an alternative to the unfortunately more familiar “xenophobia,” a word literally meaning “fear of strangers,” but in practical usage implies hatred and prejudice.

To me, wanting to learn more about the universe and wanting to learn more about our planet and the people living on it go hand in hand. I learned about the IPS “A Week in Italy for a Planetarium Operator” program some years ago, and was instantly attracted to the idea. For a number of reasons it took me several years to finally apply. When I finally did so in 2019 and was chosen, I was convinced that the time was right. The excitement of being chosen was palpable, and I was committed to making the experience a fulfilling one, for myself, for my hosts, the Italian students, and for my wife who would accompany me. Plans were made and shared, plane and train tickets purchased, and a whole European itinerary was developed. The date of departure for Italy was set: March 16th, 2020.

As with many plans during this unusual year, mine were interrupted by the harsh realities of a worldwide pandemic. The extent of the suffering brought about by Covid put the cancellation of my trip into perspective. Indeed, I learned lessons about the resolve of dealing with Covid from my new Italian friends because they were deep into sheltering in place before many of us (foolishly!) didn't see it coming here in the States. Even amidst their own hardships, my Italian hosts offered consolation and a guarantee that they would welcome me to Italy to fulfill the

program once it was practical to do so. So I try to see this delay as an opportunity in several ways.

Much of the fun of travel is in planning for and anticipating the trip. Now I have more time to do so. This has included getting to know my hosts better through various virtual means. And although learning Italian is not a requirement of the program, now I can learn more of the language than I would have with just six month's notice. Also, part of the program is to share about the place where I live. Having spent so much continuous time, both at home and within my community, I think I'm better equipped to share insights about them. In short, I fully expect to have a more rewarding experience in Italy because of the delay.

More broadly, another positive aspect to the pandemic is that it is a globally shared experience. In addition to this, there's also an analog with what I see as my goals in the planetarium. There, I try to provide a cosmic context that in turn gives a sense of wonder, clarity, and belonging. A sense of belonging I think is key to coming out of the pandemic as a healthier global society. There are lessons to be learned, and although they may be ignored by some, a variety of teachable moments come to mind. One concerns our effect on the environment, since the lessons of a temporarily cleaned up planet during shutdowns is an example of possibility that bears repeating down the line. But beyond the strictly scientific, there are human lessons as well: our need for social interaction, our vulnerability and interconnectedness as both individuals and a species, and in this time of reckoning, the need for just treatment of all. My time on the IPS Equity Diversity and Inclusion (EDI) Committee for the past few months has brought this last one into clearer focus. When I finally do make it to Italy, I look forward to fulfilling the promise of new friendships, shared experiences, and other commonalities. But I also expect that exposure to a different culture, with different practices and ways of being, will bring about changes in me for the better.

Michele Wistisen

A Week in Italy Winner 2010 and host for Week in the United States 2017 and 2019

Michele, we typically don't receive a large number of applications for these contests. Why do you think people don't apply to be a guest?

Maybe they feel they don't have anything to offer. I applied for the experience in Italy just because I thought it would be great to experience another country but **didn't** think I had something that was super outstanding that would set me apart from anyone else. So I think the message here is that we all have something to share.

Maybe they are not sure they will be able to share what they do outside of their planetarium (dome, system). Yes this is an issue. I experienced several different systems. Everywhere I went, the host ran their projection system and I was free to present the lesson without having to learn the equipment and I even presented my lesson without a projector. But I prepared something to fit every situation; it made my presentation even better! Thanks to what I learned from attending Live Interactive Planetarium Symposiums (LIPS) I was able to do this!

Some people may feel that they don't have the funds. It did cost me something but it was so minimal compared to what it would have cost if I was just vacationing and I was also able to experience the country on a personal level.

Another concern is having to take vacation time or to get leave from work. My school district actually gave me time off as professional leave. Maybe this is something that we can work towards having some sort of document that is through IPS.



Michele and a big dipper!

Michelle, why do you think that people don't apply to host?

Again, maybe they think they don't have anything to offer. I hosted twice. David Gruber was from Italy and Guilherme Marranghello from Brazil. I was truly surprised that someone was excited to come to a little planetarium in Wyoming. But after hosting I could see that the value of being the host was in the collaboration that occurred as we spent time together. It was a treat to share both of my guests with my community.

Possibly people are not sure their system is good enough. Actually, this is a great way to see how someone else can present using your system and even outside the dome. When David was here he only presented in the dome once and then the rest of the time it was in museums and in classrooms. It was fun to see him teach beyond the dome. I learned a lot from him.



Michele and David Gruber from Italy.

Possibly they think that they don't have the funds to take care of a guest presenter. I did have to do some grant writing to get enough funds for hosting plus IPS and a regional association, GLPA, helped by providing \$500 each toward airfare. In the future I would suggest collaborating with multiple planetariums or affiliate regions could also be helpful. Both David and Guilherme were willing to stay in my home which cut down on the cost of hosting them.

Of course another concern is that it does take time to host a colleague well. My suggestion is to get a team together if that is an issue. I did have help getting my guests to different places if I thought I would be busy. David also rented a car while he was here and was able to get himself around. Both guests were ok to hang with me when I had to teach and I worked with the planetarium in Laramie to arrange transportation for Guilherme. Everyone who had the opportunity to meet my guests thought it was a great experience so it was easy to get help with hosting them.

Today we are all talking about the value of participating but I think the issue is more about what is keeping people from participating. Having been on both sides, I can say the positives way outweigh any negatives. I would host again in a heartbeat.



Michele shares an activity involving light and shadows with her guest from Brazil, Guilherme.

Guilherme F. Marranghello

Week in the United States winner 2019



Guilherme in Casper, Wyoming, giving one of his presentations to the public.

How did this experience contribute to your professional development?

I started working with a portable planetarium in 2013 and with a fixed dome in 2017, when I became also the first director of the Planetário da Unipampa, so I consider myself pretty new in this business. The Week in the US program appeared to me as an amazing opportunity to grow and learn a lot about the planetarium in a short period of time. And that's what happened. Visiting Casper Planetarium and Vaughn Planetarium, in Laramie was a great moment of learning. Especially, these days with Michelle were really amazing. I really loved the way she works with her students, but what I liked the most were the lessons we shared. One of the first things I did when I came back to Brazil was to share the lunar phases model she showed me, built about 30 models, and went to a school to try it.

I also loved the visit to the mountain school, when it was snowing a lot. We almost don't have snow in Brazil and going up and down the mountain during a snowstorm was... WOW. But the time we spent with the students in the school was wonderful.

After all, Michele also arranged me to visit Dan at Denver Museum and I could take a look in three completely different types of planetarium, learn about their equipment, the way they run the shows, work with their monitors, and engage to the public.

Did you know about Casper, Wyoming before going there?

No, I didn't know anything but Michele was such a great host and the time I spent there was wonderful. It was great to meet Cordell and their family, especially their grandchildren. They took me to the mountains, to amazing restaurants and, of course, to museums, where I could learn a lot more about American history. Just be careful when you follow Michele trying to capture a good Moose picture, you may get stuck in the mud. Thank you so much Michele.

Tilo Hohenschläger

Week in the United States winner 2018 Organizer of the Week with the GDP 2019



Tilo (L) and Matthias (R) travelled to Florida in 2018 as guests of Derek (Center).

Tilo, what made you decide to setup the program "A Week with the GDP?"

Matthias Rode and I applied for the 2016 program "A Week in the US". Luckily we won and we travelled to Sanford / Florida in July 2017 to visit our host, Derek Demeter, at the Seminole State College. We spent the week learning about the American planetarium culture and taught school children and college students about astronomy. The big event was an evening show Friday night for a mixed audience. In between the sessions, we had enough time to travel around Florida to watch wildlife and visit the Kennedy Space Center. All in all, it was a perfect experience. After that we decided to invite Derek over to Germany, to experience the German culture too. Before that happened we all met again at the last IPS conference in Toulouse and Susan Button suggested a new program for our GDP. When Derek finally visited, it was kind of a test run of how an exchange program could work with the GDP. During the visit we travelled through Germany and organized teaching sessions in our mobile planetarium. In the end, the visit was a great success as well and Matthias and I decided that such an experience should not be a one-off opportunity. After consulting with the GDP we decided to go ahead and offer our new program "A week with the GDP" every year, officially hosted by the GDP. 2019 was the first year for applications and we were very happy to announce our first winning candidate, Sara Twidal from the Fort Worth Museum of Science & History, in the beginning of 2020. Due to the Covid-19 pandemia, nothing is sure for 2020, but the current plan is that Sarah will travel to the Planetarium Berlin in late September or early October this year. In case of further problems the trip will be postponed to the next year. While saying that, the application process is still open for this year to travel to Germany in 2021.

After all the great moments I had as a visitor and host in our planetarium community, I am really happy that we decided to take the next step in establishing our new program and I can only recommend to all members to do the same.

More information

For more information about these and other projects go to <https://www.ips-planetarium.org/page/share> or go directly to the individual contest page:

<https://www.ips-planetarium.org/page/italy>

<https://www.ips-planetarium.org/page/WeekinUS>

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

Applications are requested from educators or astronomers who work with **any** of the various models of planetariums (fixed or mobile). If you want to express an interest in any of these programs please feel free to contact Susan Button (sbuttonq2c@gmail.com) or any of the panel participants (emails above); we would love to answer any questions you may have.

MUSICAL MOMENTS OF WONDER

Derek Demeter

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Abstract: From commissioned music specific for the dome environment to simple musical additions for public star programs, we seek to create musical moments of wonder under the dome. Our session invites you to share a taste of some of these wonders to help inspire your own musical innovations.

Patty Seaton

I often use what I call “musical moments of wonder” in my programs. It can be anything from singing a simple song like “Twinkle, Twinkle Little Star” with the goal of involving the audience to something dramatic like setting up a saxophone player behind the dome to play along live with a recorded piece of music. I once set up a dancer behind the dome in silhouette and had her dance to a piece of music that went with the theme of my show. I call these musical segments “moments of wonder”, because they were just a small portion of my program rather than an entire concert (although I’ve hosted a few vocal and orchestra concerts in the dome as well). Last winter I invited the College Park Chamber Singers (a group that I sing with) to “flash mob” my public program by singing “Solstice Song” by Jan Garrett.

In my virtual segment, I invite the participants to bring along a snowflake from the file provided. Be prepared to pretend you are five years old, and come find a simple shape in the Northern hemisphere autumn sky. Then we’ll sing to move the sky to show us some stars of the Northern hemisphere winter sky. (The movement of the stars is less scary when you’re singing.) In this sky, we’ll find another simple shape. Then we’ll consider how many points or sides that snowflakes have (six), find a snowflake

in the sky, and dance with our snowflakes under a snowy sky! (Music from the IPS Resources Page: “Gold Planet Eve” by Natalie Pinkis. Starfields courtesy Stellarium.)

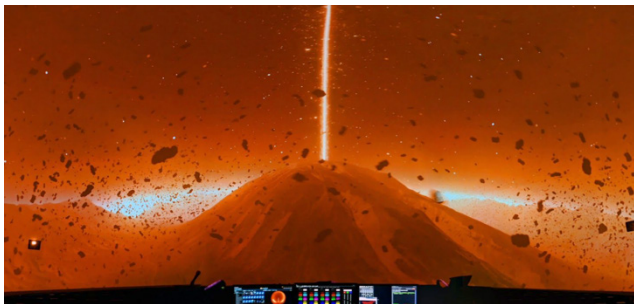
Michele Wistisen

Musical performances in the planetarium can be magical. However the venue often seems to be a bit daunting to organizers. But in 2014, the Casper Youth Orchestra performance, From Dawn Until Dusk, included a light show at the Casper Planetarium. The music had a classical feel, but most of it was composed in the last decade. It was a challenge fitting the 12-piece orchestra into the front of the 30-foot dome but the biggest challenge was trying to balance the lighting. The goal was to dim the room enough for the audience to experience a light show created with our programmable cove lights and still give the performers enough light to read their music. The conductor also discovered that the best way to keep the group together was to use glow sticks as batons.

Mike Smail

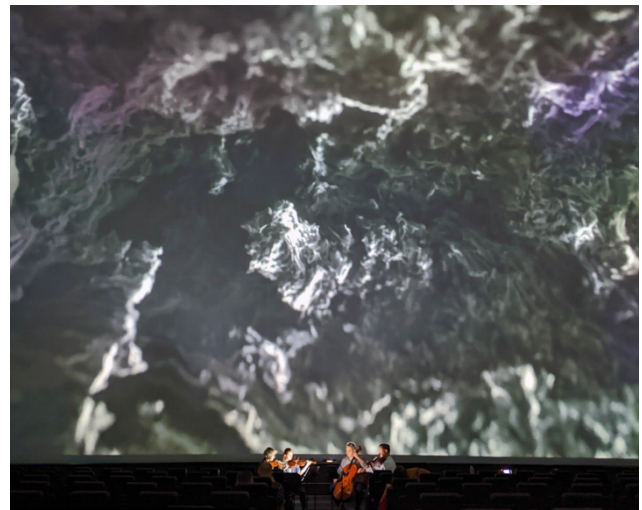
Here are two examples of live musical performances that

we hosted, or planned to host in our dome within the last year. *Sphere* is the brainchild of Los Angeles (by way of Germany) composer Robert Koch and German filmmaker Mickael Le Goff. It combines a driving electronic soundtrack with stunning space-inspired visuals, and is, in my opinion, the highest quality fulldome music experience currently on the market. Depending on your level of interest, and available funds, there are two options to present *Sphere*, either as a pre-recorded show, or as a live performance. We opted to have Robert come into our dome for two live performances last November, as a part of our Adler After Dark 21+ adult series. Setup for the live event is fairly simple, with a small synthesizer, laptop, and mixer that only requires a stereo input to the house system. Robert can then perform music live over top of a backing track, for the entire 45 minute show. As this was part of a larger event, guests had already paid \$20 to get into the museum. Despite that, we still sold out both shows, just under 400 tickets, as a \$10 add-on. It was wildly popular, with rave reviews and some guests having traveled from several states away for the chance to see it.



Sphere, in the Adler's Grainger Sky Theater. Courtesy of author

We've also been working for almost two years with Grammy-nominated local musicians, the Spektral Quartet on their new piece, *Enigma*. Icelandic composer Anna Thorvaldsdottir created a 30-minute work for string quartet (violin, violin, viola, cello), and Sigurður Guðjónsson created fulldome visuals to pair with it. Siggy was new to fulldome, so we worked closely with him to help him learn the ins and outs of the medium, what works and what doesn't, etc. The visuals are a contrast in scale, depicting microscopic images of rocks and similar structures, that when projected across the 70' dome of our Grainger Sky Theater become enveloping new worlds to explore. The technical setup for the live musicians is fairly simple as each of the four instrument microphones just passes through a small mixer/processor, before being run into our house system. We hosted an in-theater rehearsal and donor preview last October, which was the Quartet's first chance to see the visuals on the dome. Unfortunately, our planned public premiere in June 2020 was delayed by the Covid-19 pandemic, but we look forward to being able to safely host this event at some point in the near future.



The Spektral Quartet rehearsing for *Enigma* in the Adler's Grainger Sky Theater. Courtesy of author.

Derek Demeter

Music has been a part of my life since I was a child. I sang in school and community choirs for over 25 years and performed with the Orlando Opera on several performances including "The Flying Dutchmen" and "Aida". I also had the opportunity to perform in the Walt Disney World Candlelight Processional as a singer. The processional recounts the Christmas Story in an epic way. Narration by a celebrity, lights, visual effects, and of course music. Being a part of this wonderful program inspired me to emulate this mixed media to tell the story of our Universe. In 2011, I decided to collaborate with the Seminole State performing arts department put together a similar style event featuring live music, narration, and visual space effects. We titled the program "Sounds of the Universe".

Unfortunately the planetarium was too small to offer this ambitious event. With only 55 seats and a 30 ft (9.5m) dome, we felt the need would be served if done in the college's Fine Arts Concert Hall which seated over 300 people and had enough room to feature both the band and choir. For the space visual effects we would record scenes from our planetarium software (Uniview at the time) and high resolution space photos and sync them to the musical acts. We had to work with the choir and band directors to get the exact start and end time of each song in order to synchronize the music. The visual effects would include flybys of the planets Jupiter and Mars, pictures of Galileo and his works, pictures of nebulae, galaxies and much more. Between each song a narrator (performed by Michael McConville) would take us on a journey from the beginning of time to modern day. We would explore mythology, historical figures like Galileo, the Solar System, and eventually other areas of our Universe. I wanted the same feel as what guests experienced at the Candlelight Processional at Walt Disney World.

Below is the Overview used for the "Sounds of the Universe" show:

Sounds of the Universe Storyboard v. 1.0

Overview: A musical voyage through the history of the cosmos. Several types of musical styles will be introduced during the show such as classical pops to modern rock. The concert will consist of both the Seminole State Symphonic Band and Concert Choir. Visual FX's will be provided as well as live narration to introduce each piece of music. Some live acting will be done during "Galileo's Vision".

Act 1—Discovery

This act explores our early understanding of the cosmos to the foundations of scientific discovery by the father of modern Astronomy, Galileo Galilee.

Elements- Symphonic Band
Aquarius: Let the Sunshine In- Choir
Galileo's Vision- Symphonic Band

Act 2—The Solar System

This act explores the wonders of our solar system through several pieces from Holst: The Planets. This act also explores famous song inspired by our nearest neighbor in space, the Moon.

Mars- Symphonic Band
Jupiter- Symphonic Band
Uranus: This piece will also explore the outer bodies in the solar system such as Neptune, Pluto, and the comets. –Symphonic Band
Fly me to the Moon- Choir
That's Amore- Choir

Act 3—To the Stars

This act explores man's exploration into space and closes with a reflective piece by Robert Frost.

Medley: Rocket Man/ Space Oddity
Choose something like a star

The show was presented on November 8, 2011 at 7 pm in the college's Fine Arts Concert Hall. The response from the show we received was overwhelmingly positive and people loved the integration of music, visuals, and story. We would go on to present an encore of the show in November of 2013. My hope is to do another one but this time with the Central Florida Community Arts Choir and Orchestra sometime in the future at a larger venue here in Central Florida. Additional smaller ensembles are planned inside the planetarium as well.

VISION2020 AND IPS—THE ENDGAME (PANEL SESSION)

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Abstract: In 2014 the Vision2020 Initiative was created specifically charged to alter the business and usual attitude and design a big picture vision of how IPS could become a modern, new IPS. Has V2020 succeeded?

(Jon)

This panel session summarizes the initial purpose of launching the Vision2020 Initiative and the strategic, systemic changes it had on IPS, as well as encouraging the audience to give live feedback in the chat window on how they think V2020 did, and was the Initiative effective? What could we have done better? What still needs to be achieved? Where will IPS be in 2030? We invite the audience to respond following each of our brief presentations.

At the 2014 IPS Conference in Beijing, the Vision2020 Initiative was launched. Its primary directive was to boldly go where IPS had never gone before—envision a future that would fundamentally change how IPS operates, alter the business as usual attitude, react to change, and design a big picture vision of how IPS could become a modern, new IPS. It is now year 2020, has V2020 succeeded?

Evaluation of V2020

Major structural/governance achievements
White papers: making the case for V2020
Mission-Vision-Values statements
Strategic Plan
New membership categories
Officer term limits
Implementation of electronic voting
New IPS governance structure model and member representation
Redesign of website
MOUs with relevant organizations
Liz Monroe-Cook facilitating council meetings

The adopted Strategic Plan was V2020's most significant

contribution. Based upon the initiative's six goals, this plan is intended to provide a road map, a guide for what the Society's goals and priorities should be, and the strategies on how best to achieve them. It is hoped that IPS will refer to this plan when needed.

Unresolved Issues

How will the goals of V2020 remain relevant beyond V2020?
How IPS will meet the challenges of sustaining or increasing membership?

How can IPS support its members? Items of high interest are:
Online content such as Planetarian Net.
Training webinars
IPS partnerships
Professional development

Loose Ends

IPS is not as nimble as we hoped it would be by the time V2020 is phased out

There is a lack of decision/clarity about working groups that are taking on V2020 goals

Continued skepticism from some to fully embrace the vision put forth by V2020

Legacy

Vision2020 set out to expand the horizons of IPS, to provide guidance on what it could become; how fundamental, systemic change can alter not just the governance structure and how day to day operations get done, but also to fundamentally change how IPS does business on a global basis, create opportunities for an increasing diverse membership, and how we network and

communicate with each other.

IPS has already made these systemic changes, but a “new” IPS will likely be determined by how current and future working groups continue to push boundaries, evolve, inspire, and pursue the goals envisioned by the Vision2020 Initiative.

This past June, during the virtual Council/Board meeting, a motion was made to transfer Vision2020 goals into action items for completion by IPS working task forces. The new IPS Board is being charged with capturing the essence of the goals and then transition to working groups. The motion to continue the work of Vision2020 was seconded and unanimously approved by the Board.

(Karrie)

In late 2014 I was asked to lead efforts on Vision 2020 goal 1: “Improve and increase professional development efforts that are based on research and best practices (e.g. summer schools, KAVLI Institute).” I will briefly discuss

- (1) why and how I decided to create a team to work on this goal
- (2) a few major accomplishments; and
- (3) my hopes for future professional development efforts at IPS.

Our major accomplishments included:

- We crafted a survey in spring, 2015 on professional development desired topics and opportunities. I shared the results of this survey at three US regional conferences and at the August 2015 IPS Council meeting. Special recognition to Kaoru Kimura: She translated the survey questions into Japanese and then translated the survey answers into English.

- Designed and analyzed surveys after IPS 2016 and 2018 conferences; these survey results were shared with IPS Council and with future IPS conference hosts.

- We created an online spreadsheet of different types/settings of planetariums and the challenges associated with each. For example, a large fixed planetarium on a university campus has different challenges and PD needs than a portable dome used by a children’s museum for outreach. We then brainstormed ideas for PD that would assist these various types of domes.

- Given my relationship with LIPS (the Live Interactive Planetarium Symposium), there was a great deal of overlap between my LIPS work and my Vision 2020 work. On behalf of LIPS I signed a memorandum of understanding with IPS in spring, 2019; this laid out common goals and potential shared work.

- Started working on integrating goal 1 with other Vision 2020 goals, most successfully with Data to Dome workshops at three LIPS (2017 - 2019).

What didn’t we do?

- Webinars: We crafted a survey about this and received many wonderful ideas, but we never started a webinar series.

- We did not create a sortable, searchable database of PD resources on the IPS website.

(Ruth)

I joined the team in 2014 to achieve the goal “Expand International Collaboration.” In six years, these goals were achieved:

- Worked with affiliates to reach out to their members.
- Contact BAP members on a regular basis and spoke at conference about IPS Membership.

- Contacted sponsors to encourage giving IPS members discounts or exclusive offers.

- For my goal to continue beyond 2020, I joined the IPS membership advisory group and will continue my work within this group. I shall also work closely with the AMC to share my work and pass on feedback and finding.

- I have reached out to all the BAP members past and present to let them know about the IPS virtual conference and about the benefits of membership.

- Through my role on the membership committee I am heading up a team and contacting IPS past members in Europe to encourage to join.

(Anna)

I came into the Vision 2020 team at the beginning of 2019 to take on Goal 6: “Encourage and attract younger members to become involved in the future of the IPS, particularly in serving or contributing in leadership roles around the world.”

This goal is important if we want to keep IPS fresh and full of new ideas. Therefore, I gathered a team of five other young planetarians from around the world to try to get a look at what needs to be done to make IPS more accessible to younger members. Unfortunately, as with most things, the coronavirus pandemic has really thrown a wrench into accomplishing everything we wanted. There are several good ideas, however, that I would still like to see occur moving forward.

Accomplishments:

- Discussed the Equality, Diversity and Inclusion working group taking over goal six with the new leaders of that group. It was again agreed that this was the correct group to fold goal six into. It is the hope that what is being done to make IPS more accessible to planetariums through the work of the EDI committee will also appeal to younger planetarians.

- Started testing use of the IPS Instagram account. Instagram is more popular with younger generations than Twitter or Facebook,

and expanding its usage would provide a platform that could reach more young planetarians.

- Reached out to Membership to begin forming a plan for an IPS mentorship program for new and young planetarians. This program could also serve to help provide language support at conferences too. A thought for the future is that this could also be used in tandem with the current “Week in ____” programs to create an even wider planetarian exchange program within IPS.

- How to apply for a stipend is now more visible for members.

Needing further development/What we didn't do:

- The mentor program needs to be fully developed. The idea was for a beta trial this year in Edmonton, however unfortunately, this put a stop for the time being to this idea. It would be good to start this back up again to be in full swing in the future.

- We were unable to create materials that young professionals could use to convince their potentially unsupportive administration of why they should be allowed to and supported in attending an IPS conference.

It is the hope that moving forward; these open ends could be explored with the EDI committee in the future.

Conclusion

With the time remaining, we (panel participants) need to hear your feedback—has Vision2020 met its goals, made a difference, what still needs to be done, and do you care?

ARE PLANETARIUMS STILL RELEVANT?

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Abstract: Each panelist brings a different perspective. David Dundee's facility reopened in late June and is in the middle of presenting programs during an on-going pandemic. Benjamin Mendelsohn was scheduled to open a brand new, state-of-the-art planetarium when California canceled all such gatherings. He still has not had his grand-opening celebration. Philip Groce is working as a design consultant on several new planned planetariums in spite of the severe economic impact of the pandemic. Together, the panelists hope to provide a pragmatic but optimistic answer to the question, "Are Planetariums Still Relevant?"

When we originally submitted the panel title for the IPS 2020 conference, COVID-19 was not an issue. Now in this pandemic, many, if not most planetariums throughout the world are closed or operating at reduced levels. In this context, asking "Are Planetariums Still Relevant?" may have even greater significance.

First Panelist up is **David Dundee**.



David started his planetarium career in 1974 at the Flandrau Planetarium, Tucson, Arizona and then moved on to intern at the American Museum – Hayden Planetarium, New York, New York. In 1978 he headed south to Atlanta, Georgia to be the astronomer at the Jim Cherry Planetarium, Fernbank Science Center till 2008, when he became astronomer at the Bentley Planetarium, Tellus Science Museum, in Cartersville, Georgia.

During the Corona era until there is an effective vaccine we continue to do planetarium shows at Tellus Science Museum with 25% maximum attendance in our theater. So we are kind of in limbo right now, wondering if another shut down is around the corner. The "new normal" that everyone refers to will open many virtual doors for museums and planetaria. But through it all the planetarium theater remains relevant because there is still a need to experience the sky. Perhaps there will be a virtual way to experience the sky in the future. But until technology can bring the experience home, the planetarium will remain relevant.

The planetarium, through the decades of advancement, has evolved into a palace of technology where advanced concepts of the universe can be digitized and explored. Huge data sets can be crunched and transformed into images our human brain can perceive and begin to understand. The planetarium has grown up from its infancy with special effect projectors made from aluminum foil and baby food jars, 16mm film, slides, colored gels, and Kodalith. Now, shows are polished and visually stunning. Although I must admit I miss the ker-chunk, ker-chunk sounds of a bank of slide projectors advancing and the occasional unexpected misfire of a special effects projector, I don't however, miss the slide trays and lamp changes.

In the post-Corona era that will happen with a vaccine, many elements of the planetarium can be displayed and shared on a variety of digital platforms. Visualizations of the evolution of the cosmos, past events and future events can all be shared to home computers. Manipulation by audiences of digital content can all be done from remote locations. Museum collections can be displayed worldwide on-line.

The planetarium as a teaching tool continues to this day. It is a way to display the motions of the heavens and put these motions in perspective. We can digitally take audiences to any viewpoint in the universe to better understand the motions of planets, stars, and galaxies. Since all of this can be taken and put on a computer screen, why does the planetarium theater still exist? Is it a dinosaur awaiting the final asteroid impact? Is the Corona Virus the final act in the planetarium saga?

I think not. The planetarium provides the stage for a good storyteller to tell the stories of the night sky. Through these stories, we gain access to the imaginations of peoples and cultures around the world. The stars and the sky provide the context for these stories. The mythologies of the sky are the threads of the universe, and the stars provide the frame from which they hang.

Through all the technological advances, the central reason for the planetarium to exist continues: the need to see the black sky studded with stars. You can't do that on a small screen. We need to be immersed in it, especially since we live in a world with a rapidly-expanding envelope of light pollution. To see the sky, the Milky Way, and delicate deep sky objects just at the limit of our naked eye to perceive gives us a perspective of our human existence.

Our next Presenter is **Benjamin Mendelsohn**.



Benjamin Mendelsohn's love of planetariums began when he first visited the Morrison Planetarium in San Francisco's Golden Gate Park. In high school, he spent many after-school hours at the Charles F. Hagar Planetarium at S.F. State University. It was Hagar himself who recommended Benjamin to "The Morrison". He started as an usher and went on to be a lecturer and weekend technician. As an undergrad, he facilitated interactive planetarium programs at the Lawrence Hall of Science. After graduation, while working as an engineer, he also taught astronomy in the planetariums at S.F. State and at DeAnza College. He left the field of engineering to become the full-time astronomy faculty and planetarium director at West Valley College. Over the past decade, he has been laboring to open California's newest sky theater, the Jean & E. Floyd Kvamme Planetarium.

One of the primary missions of the community college system is to help students transfer to a university to obtain a degree. Non-science majors, the majority of our students in astronomy, will take only two collegiate-level classes in the sciences: one in biology and one in physical science. Consequently, our astronomy students are usually taking their terminal academic course in the sciences with us. While our primary content is astronomy, our work is distinctively positioned to influence the scientific worldview of non-scientists. Given that many of our students will go on to be teachers, voters, policy makers, etc., we have the responsibility to educate our citizenry such that they are better able to make informed choices.

Planetaria have long been known to generate inspiration, passion, and interest about astronomy and are one of our finest outreach tools for science literacy. We increase understanding and appreciation of science by telling stories of discovery in a way that serves to nourish our spirit and change our worldview. In an era where scientific thinking is losing ground, planetariums become more important than ever.

By this reasoning, investment in a planetarium is compelling. We also had practical concerns. While our campus planetarium solely hosts our astronomy classes, we wanted our investment to reach beyond the fifteen or so classes taught annually. We desired to build a facility that would extend our influence beyond the astronomy classroom and bridge the gap between science and society. Therefore, we set a number of design goals to ensure the planetarium would stay relevant for our college and in the community. As we courted a donor, the Jean & E. Floyd Kvamme Foundation found themselves in agreement with our priorities and their sensibilities.

Budget limitations steered us to build a box-shaped building with a level floor. Still, we wanted the building to state: "Astronomy Spoken Here". We accomplished this, architecturally, by placing an observatory dome on the roof. Funding for accessibility to the roof was out of the question, so the observatory will have to be totally robotic and video feeds from rooftop instruments will be piped into the planetarium, exhibit area, or the internet.

As a scholastic institution, we felt we should be presenting a scientifically-accurate sky and we should include a star projector that would produce a stunning night sky along with a modern

full-dome projection system. While we were restricted to a level floor, we placed a 41-foot (15.5 m) “hyper” dome, with a 5-degree extension below the horizon at the front, to increase the forward visual area. A hydraulic lift was specified for the star projector to be lowered, when needed. Rather than squeeze as many occupants in as possible, we elected to have only one row of seats south of the centerline of the theater that, we hope, will give every visitor a grand view.

We designed the space to be used for more than astronomical presentations—leaving ample space in the front of the room for a lecturer or to accommodate live performance. To enhance music and theatrical performance, we specified a low-noise air conditioning system. Inset into the stage floor are boxes with connectivity for microphones, monitor speakers, MIDI equipment (for reinforcement or recording). The same floor boxes support connections to power, a video switch, the internet (for example to connect a moveable lectern with computer and document camera), and lighting control. There are three low-light pan-tilt-zoom cameras to accommodate teleconferencing, lecture capture, or live broadcast. Since all video signals can be routed as required, live lecture can be projected onto the dome (via two data-projectors mounted on the dome ring at the rear), remoted to exhibit area monitors, or to a science lecture hall, if needed to accommodate larger forums. This design supports utilizing the planetarium as a broadcast space that will be beneficial during the pandemic. For theatrical performance, we have 15 theater parabolic aluminized reflectors mounted behind and under the dome.

In the lobby/exhibit area, with limited square footage, we elected to do many of our “exhibits” using five digital displays in different thematic areas with the addition of a high resolution three-by-three videowall for use in presenting time-lapse images of the Earth overlaid with scientific data, other scientific visualizations, or to be utilized as a large monitor for presentations. We could say that we installed a “centerpiece” exhibit of a Foucault Pendulum, though we had to tuck it into a corner due to the limited space. For free-standing exhibits to be developed later, we put power and internet connections in the floor and walls. We designed two openings in the south-facing wall to accommodate light from the Sun to be turned into a sun-painting and a solar image/solar spectrum exhibit. The space is tall enough to accommodate a hanging model once we locate an appropriate one.

We feel we have realized a planetarium space that will remain vital for years to come that fulfills our many goals. We will have a state-of-the art facility for teaching astronomy and presenting scientific visualizations. It will allow students in our Theater, Music Performance, Commercial Music (utilizing a 30.2 channel spatial surround sound system), Digital Arts & Animation, and Film, Television, & Electronic Media programs to have the opportunity to display their creativity and talent beyond a theater-in-a-box venue or rectangular screen format. We expect a high utilization for the space, including K-12 and public programming, that will assure the Kvamme Planetarium stays relevant.

We conclude this panel with **Philip Groce**, who started in planetariums in 1969, earning his way through college teaching astronomy labs. He went on to be director of three different planetariums in Tennessee, Florida, and Georgia, and is currently

President of Helping Planetariums Succeed, LLC, a planetarium design firm that has helped create more than 60 planetariums.



Given the many tragedies our world community has recently endured, it seems brutally unsympathetic to even consider the importance or relevance of planetariums in the middle of a pandemic. Before the pandemic, my experience as a planetarium designer was that more fixed planetariums were being built or renovated than were closing. With the resurgence of human spaceflight and planned missions to the Moon and later Mars, astronomy and space science were receiving renewed interest, and more of our public were seeking out planetariums...or at least that was our pre-pandemic hope.

I propose that planetariums are now and will be for some time very “relevant” for the following reasons:

Reason #1: *Planetariums fulfill our all-important need for awe.*

This essential human need for wonder and awe helped create the National Parks in the United States and encouraged the United Nations to help save remarkable World Heritage sites. Few things make us feel more in awe than thousands of stars seen against a dark sky. Our artificial skies can create such feelings, especially when presented by a knowledgeable and passionate guide. I am reminded of a Maya Angelou quote: “*I’ve learned that people will forget what you said, people will forget what you did, but people will never forget how you made them feel.*”

Reason #2: *Planetariums are the perfect tool for exploring the ‘why’ of our existence.*

For those who have felt inspired, humbled, or defined by a dark clear night sky, the planetarium reminds us that we are not alone in sharing this experience. As Mark Twain once said “*The two most important days in your life are the day you are born and the day you find out why.*”

My first visit to a planetarium was in 1968 in Baton Rouge, Louisiana. *Dennis Simopoulos* was the presenter, and it was on that day that I was smitten with planetariums. I wanted to be a part of this fantastic star theater whose purpose was to let each of us know that we are, indeed, “a child of the universe” and have an unending obligation to understand and explore it.

Reason #3: Planetariums teach and inspire more than STEM.

Beware of placing your entire planetarium's community and educational value simply on achieving STEM objectives and curriculum. These content standards are written for the classroom, not the planetarium. Many school principals and superintendents have told me that they have seen a lot of "STEM interactive" planetarium activities that could be done just as well in a dark classroom without a planetarium. They often cite this as a reason to close the school planetarium, usually the school's most expensive classroom.

The question we should be asking school administrators and teachers is, "What science should we teach that is difficult, if not impossible, in the classroom setting?" Our interactive presentations should always keep this question in mind and try to do more than the mandated STEM curriculum.

Our job is to inspire our students and their teachers to be life-long investigators of the universe. We should always be looking up and not down at school desks if we want to be truly relevant.

As Dante wrote, "The heavens are calling you, and wheel around you, displaying to you their eternal beauties, And still your eye is looking on the ground."

Reason #4: Planetariums show what we risk losing with every street light we turn on and every constellation of blinking satellites we launch.

It will be a sad day when the only places we can see the stars unhindered against a dark sky are in planetariums. This danger of loss is a major reason for our relevance. We are the preservationists, the Rachel Carsons, and the John Muirs of the sky.

"If the stars should appear one night in a thousand years, how would men believe and adore; and preserve for many generations the remembrance of the city of God which had been shown! But every night come out these envoys of beauty, and light the universe with their admonishing smile."

Ralph Waldo Emerson

Reason #5: Planetariums remind us that the night sky is the ultimate Rorschach test.

Billions of people around our world see the same stars and star groupings. Each culture, however, sees itself in the sky. The sky represents the largest study of comparative sociology and anthropology. Yet, in spite of our many differences in how we see star groupings, the stars have taught us that we humans are still far more alike than we are different. As long as we tell this story, planetariums are relevant. We are essential celebrants of the human dichotomy of diversity of culture and the unity of beings looking up from the same planet.

"The fault, dear Brutus, is not in our stars, but in ourselves."
William Shakespeare, from Julius Caesar

Reason #6: We learn and remember more when we share our experiences together.

If COVID-19 has taught me anything, it is the need for the shared experience. I miss going to restaurants, movie theaters, plays, ball games, parties, museums, and planetariums with other people. It has been painful watching late-night talk-show hosts try to be funny without an audience or shared laughter. The COVID-19 pandemic has spotlighted the isolation and many other learning limitations of "Virtual Classrooms".

While it is true that computerized desktop planetariums can provide as much astronomy information as any planetarium, this is not a shared experience.

It has been said that "a theater is a place where people go to sit in the dark, to watch other people perform in the light, all to learn what it is to be human."

By this definition, a planetarium is indeed a theater where the actors are the Sun, Moon, planets, stars, galaxies, and the people who study them. Our collective play is the "Universe Tonight." Few things could be more human or more effective or more relevant than sharing and exploring this universe together under a planetarium dome.

CLIMATE CHANGE IN THE DOME – A PANEL DISCUSSION

Session Leader:

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Presenters

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Abstract: Climate Change is a key issue for human society in our modern world and planetariums have some unique ways we can share this science with our audiences. This presentation will explore some ways that our planetariums can be a key resource in sharing the science and dispelling the misconceptions around this subject, and present some approaches to sharing climate change with audiences. From the Ghana Planetarium engaging students in classrooms to look at climate change, to use of visualizations in domes and how scaled data can help in global understanding, to tactics and strategies used by the Denver Museum of Nature & Science, and finally a project exploring creating a short course for planetarians to learn the latest climate science from experts in the field and utilize tools such as Climate Reanalyzer to engage audiences in a variety of ways.



Looking at Climate Change Education in Ghana

Jacob and Jane Ashong

We proposed to run a survey of teachers to look at Climate Change Education in Ghana. We wanted teachers to answer the

following questions:

- How often is Global Warming and Climate Change mentioned in class?
Is Global Warming and Climate Change part of another subject—if so, which?
How have you informed yourself about Climate Change and Global Warming?
What has hindered you in teaching these subjects?

We experienced some delays in implementing our survey, and during the lockdown in Ghana when schools were closed due to the Coronavirus pandemic, it was impossible to run the survey as planned.

We contacted the Head of the Science Resource Centre in Accra, Madame Olivia Opare. She showed us correspondence dated 19th September 2019 from the Ghana Education Service (GES) to Regional Directors, mandating the training of teachers to

improve the understanding of climate change in the New Curricula. The entire Primary School curriculum had been updated in 2019. The previous one (dated 2007) had not included Climate Change.

The training programme for teachers started on Monday 30th September in the Regional Capitals and was expected to be completed by the end of October. In each region, fifty (50) teachers of Science, Religious and Moral Education, and ‘Our World Our People’ were trained. These included 70% public schools, 25% private schools and 5% administrators (Directors and Supervisors) from the regional capitals. By December 2019, 12 out of the 16 regions had been covered and the training was being extended to all 275 districts.

The Primary Curriculum Teaching and Learning Materials were listed under two broad areas:

- Science
 - Weather (Basic 1)
 - Human Activities that are harmful to the Environment (Basic 2)
 - Activities that Pollute the Atmosphere (Basic 3)
 - Burning as a cause of climate change (Basic 4)
 - Impact of Deforestation (Basic 5)
 - Effects on Humans (Basic 6)
- Religious and Moral Education
 - Reasons for protecting God’s creation (Basic 4 – 6)
 - Care for the Environment (Basic 4 – 6)
 - Our World, Our People—Efficient Use of Energy (Basic 4 – 6)

Content Standards: Knowledge that Climate Change is one of the most important issues facing the world today. In particular children are expected to be able to do the following:-

- At Level B4: Explain that burning is one of the causes of climate change
- At Level B5: Identify the impact of deforestation on climate change
- At level B6: Know the effects of climate change on humans

Implementation of this project is expected to lay the groundwork for extension beyond Primary School to Secondary Schools and to Teacher Training. Most teachers are not yet trained in these subjects. The Environmental Protection Agency and Ghana Education Service are looking for partners to improve literacy in Climate Change and Green Economy.

Thomson Reuters Foundation writer Sebastien Malo reported research by scientists revealing that children may be their parents’ best climate-change teachers. (Thomson Reuters Foundation is the charitable arm of Thomson Reuters. News.trust.org/climate) Authors Danielle Lawson, Kathryn Stevenson, Nils Peterson, Sarah Carrier, Renee Strnad and Erin Seekamp, of North Carolina State University (Published: *May 6* in *Nature, Climate Change*) write about Child-to-parent intergenerational learning (IGL): the transfer of knowledge, attitudes, or behaviors from children to parents: “Children can foster climate change concern among their parents”. They may thereby overcome barriers to building climate concern.

Planetariums can play a role in improving literacy in Climate Change. Astronomy inspires children, and links naturally to the subject of climate change. Some full-dome shows specifically address such issues, including the following:

- “Climate Change: What Future are we Facing?”
(about how our climate is changing, causes, effects, adaptation)
- “Our Living Climate”
(about the history of climate change, how the atmosphere sustains life, climate, evolution of the planet, etc.)
- “Expedition Reef”
(rainforests of the sea, endangered marine ecosystems, etc.)
- “Dynamic Earth”
(inner workings of earth’s great life support system, energy, interlocking systems, atmosphere, oceans, biosphere)

Some shows have associated web pages or booklets showing how the show’s content can be used to teach environmental and climate topics. A prime example is “Journey to the Stars” (<https://www.youtube.com/watch?v=MXGUI9DCWwA>) which links to a website where numerous scientific topics can be accessed, including climate change (<https://www.amnh.org/explore/science-topics/climate-change>).

Planetarium shows provide rich and detailed visual content and expert commentary, with input by scientists, producers, visualizers, and educators. As such, planetarium shows can help with the current situation in which many teachers are not yet themselves well informed about the issues they are teaching for the first time.

For children, the excitement of visiting a planetarium can inspire greater interest in the subjects presented there and subjects linked to what is presented there. By virtually travelling outside earth on a journey into space, (such as in “Journey to the Stars”) audiences of both children and adults are enabled to see the fragility of our own planet home within the vast universe.

Scaling reality: climate change and scientific visualization

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How do large scale astronomical scientific visualizations assist in understanding climate change? Humanity shares the point of view of Earth in the Universe but the continuity between individual embodied points of view and the collective planetary point of view is often bypassed or taken for granted without a second thought. It is also important to consider the embodied aspects of direct experience, different cases of mediated experience where information from one situation translates to a different spatial and/or temporal situation, or the case of extended experiences such as telepresence, where experiencing happens remotely. Scaled

data in the form of scientific visualizations can also become an experience through immersion and interaction: connecting the extended spatio-temporal data from the Universe to the “virtual” cosmos of a planetarium dome. By defining direct, mediated and extended experience in those terms, the presenter would like to make the case that changing spatial and temporal scales in mediated or extended experiences including data visualizations – not only within cosmic scale realms– changes context altogether. Furthermore, extrapolating individual experience from an urban location, to a remote geographic area or to the planet as a whole (both in terms of time and space), can be counterintuitive, deeply misleading and even plain wrong. It is easy to forget that actions which seem minuscule and relatively safe at human scale are not necessarily so at smaller or larger temporal and spatial scales. For example: utilizing a single-use plastic cup for a morning coffee that is discarded after a few minutes does not overwhelm the visual field of the act of drinking the coffee and does not look particularly dirty in the context of a clean table. The same cup added to the ones used said morning by millions of people add to the week, the month and the year of use, its plastic liner and plastic lid remaining in the environment for decades or millennia. The same can be said for gasoline use where breathing the resulting fumes is only now exploding in human and planetary health consequences. In other words, there is a deep disconnect in scaling individual, institutional, and industrial behaviors to the multi-scale consequences of certain actions. Understanding how aspects of reality change according to spatial and temporal scales demonstrates that astronomical knowledge is not just important but essential to look at mediated and extended realities involving transcalar spatial and temporal interactions. Today, anything that the human body cannot directly perceive without tools is either mediated or extended, even on Earth itself. Planetarium domes need to urgently emphasize how different spatial and temporal scales change context and how transcalar interactions occur. Scientific visualizations that are presented in planetarium domes do provide a crucial means for humanity to understand the planetary realms at which the human species are affecting ecosystems, the biodiverse spheres and life forms with which humanity has co-evolved, and the nurturing environment humanity stems from and relies on.

Effective Climate Change Education with Planetariums

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Introduction

Although majorities of Americans are worried about climate change (Leiserowitz et al. 2019), a substantial minority of the populace are skeptical or outright hostile to climate change science. Within this group, the deficit model of science communication—the assumption that people are simply mis-informed and need to be given more facts in order to change their minds—is ineffective (Mooney 2010, NASEM 2017). Worse, delivering more information can backfire, by making these individuals dig into their heels even more, in the form of a “boomerang effect” (Hart & Nisbet 2011). This behavior matches what psychologists have long known about our cognitive biases. Humans are not

being purely objective and rational, but are often driven by biases and passions (NASEM 2017). One cognitive bias is motivated reasoning, where we look for evidence and arguments that support our prior beliefs, and suppress others that do not. In this manner, attacks on someone’s favored belief or position can actually increase support for it in that individual. Other barriers to action include uncertainty in the science, mistrust of scientific authorities, denial of the science, and discounting of risks as too far spatially or temporally removed (APA 2010).

If more or less information has no relevance to a person’s beliefs about the existence of anthropogenic climate change, then what does? Yale researcher Dan Kahan sees this as a culture and values question. (Kahan 2010, 2012). Do you share values with a group that thinks climate change is a hoax? Then no amount of evidence will convince you to go against your group identity. For instance, Kahan has performed experiments using subjects who valued individuality, were not supporters of environmental regulations because of their impact on commerce, and were more likely to be critical about climate science. Based on surveys, members of this group showed a positive correlation between science literacy and lack of concern about climate change. That is, the more knowledgeable they were about the issue, the more dismissive they were (Kahan et al. 2012). Hence, people are very good at taking in information and efficiently rejecting that which does not conform to their personal viewpoints. Climate change is not the only topic where knowledge of scientific facts does not lead to a change in belief. For some, evolution and the Big Bang are also politicized topics for religious and other cultural reasons (Kahan 2016).

So what are some of the preferred ways of communication that do not turn off an audience because of their political affiliations? One is that climate change stories should highlight issues at the local level, where individual action is possible. We all have expanding circles of empathy. We care more about what happens to our families in our homes than the nearby neighbors on our block, and more about our own country than other nations. Stories about the challenges of climate change are more effective when their focus is as narrow as possible. The larger scales of the problem cannot be ignored when explaining the science, but most people will care less about what will occur in the future halfway around the world compared to something happening now in their local neighborhood. For those living in the U.S., the National Climate Assessment (<https://nca2018.globalchange.gov/>) shows the expected or current effects of climate change on a region or state, while specific state and city-level studies can provide details at a more granular level.

Stories should also give hope, and not focus completely on the doom-and-gloom scenarios (something all too easy to do when dealing with the topic of climate change). The public is turned off when faced with depressing messages, which can lead to apathy and hopelessness if they feel that there is nothing that they can be done as an individual against an enormous global problem. The message of hope must involve a success story, to show that action is possible even at the individual level (Kristof 2009).

The Worldviews Network

From 2010–2013, the Worldviews Network was formed as a collaboration between the Denver Museum of Nature & Science, the California Academy of Sciences, NOVA/WGBH, The Elumenati, and affiliates from the National Oceanic and Atmospheric Administration (NOAA). Funded by a grant from NOAA's Office of Education, the Network helped partner informal science institutions (ISI) across the United States to develop "Bioregional Community Dialogues" (BCDs), interactive planetarium programs for promoting ecological literacy. ISIs collaborated with researchers and external organizations to co-construct narratives about a global change issue with local impacts. They used the unique visualization capacities of fulldome software to create presentations that spanned cosmic, global, and local perspectives. Content layers from a wide range of observed and modeled datasets were created to tell stories about Earth's coupled human-natural systems. Delivering this storyline, the team connected its target audience with opportunities to engage with issues at the nexus of science and society.

BCDs took advantage of dedicated geobrowsing features in planetarium simulation software. The dome's intrinsic geometry allows for realistic, immersive views of Earth that can potentially trigger the "Overview Effect," an affective response and shift in perspective reported by astronauts after viewing Earth from space (White 1998). The "Powers of Ten" transitions allowed complex relationships and interactions between Earth's cosmic environment and the planetary biosphere to become intuitively linked—from whole Earth to regional perspectives.

Narrative construction in the Worldviews Network used a "See, Know, Do" framework (Sterling 2011). "Seeing" involved creating immersive visualizations to engage visitors' visual and spatial intelligence. "Knowing" ensured that narratives help explain the web of physical, ecological, and social systems that interact on Earth. Finally, the "Doing" emerged from interaction among the public, researchers, and members of other organizations to help audience members conceive of their own relationship to the highlighted issue and ways they may remain involved in systemically addressing a global change problem.

The magnitude of climate change, its perceived remoteness, and the apparent inadequacy of an individual's response have been identified as obstacles to pro-environmental behavior (APA 2010). The adage "think globally, act locally" suggests the scale at which most of us can become actively engaged. The Worldviews Network partners developed stories by selecting a local problem relevant to their own communities and created a narrative that made connections from local to regional, continental, and global scales. Addressing ecological interactions from this perspective connected individuals to abstract issues both cognitively and affectively, and demonstrated the complex linkages between Earth's physical and biological systems and their relationship to human health, agriculture, infrastructure, water resources, and energy. We focused on critical thresholds, such as freshwater use, biodiversity loss, land use change, and anthropogenic changes to the nitrogen and phosphorus cycles. This model helped ISIs and their audiences understand that humans drive current trends in coupled human-natural systems—and that humans could choose

to play an important role in reversing these trends.

To inspire and give audiences hope, we provided examples of how small groups and individuals addressed complex challenges using the theme of resilience of human and natural communities. We highlighted examples of resilience, such as those archived by the Buckminster Fuller Institute (<https://www.bfi.org/challenge>). We demonstrated how organizations around the world are developing and implementing innovative strategies to comprehensively address humanity's most pressing problems.

We helped connect ISIs with scientific advisors at both the local and national levels to augment Worldviews Network team knowledge of the research field. ISI partners were encouraged to find local experts, including representatives from businesses, educational groups, non-profit organizations, NGOs, and community-based organizations with expertise on the chosen issue. These external partners typically co-developed narratives, assisted with identifying assets for visualization, reviewed scripts, and sometimes participated in the live public presentations, by describing solutions implemented at the local level.

Given the varying sizes of venues, BCD events have served dozens to hundreds of people at a given time. External groups provided unique viewpoints to propel discussions and lend expert credibility for audience members. For example, after the DMNS "A Global Water Story" dome presentation in May 2011, 40 audience members moved from the Gates Planetarium to a classroom where the director of a Colorado water education organization led a group discussion. Participants shared perspectives with one another about what they had heard, discussed how it related to their own work and lives, and conferred on strategies for addressing water issues. Such dialogues helped audiences remain engaged with network partners and the issues they highlight long after each event.

Effectiveness of the Approach

Evaluation results (Sickler & Hayde 2014) show the value of the Worldview Network's combination of technological and pedagogical approaches, combined with its ecological content, to create audience engagement. Questionnaires showed that the vast majority (81%) of respondents indicated that the BCD dome presentations helped change their understanding of the content, by giving them new perspective, and helping to visualize and understand content. When describing what they liked most about the presentation, respondents highlighted both the pedagogical approaches and technological tools. Similarly, comments about what made the presentation easy to understand tended to reference presentation style or visuals and technology. These results show that live, interactive fulldome technologies can provide a powerful way to educate the public about complex Earth systems, to help them understand bioregional effects of global environmental change, and in some participants, to trigger a strong affective response. Engendering such reactions from the public will become more important as we move from simply documenting global change to the challenge of designing adaptive solutions.

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Down to Earth: Climate and Weather Learning for Planetarians – A planned shortcourse

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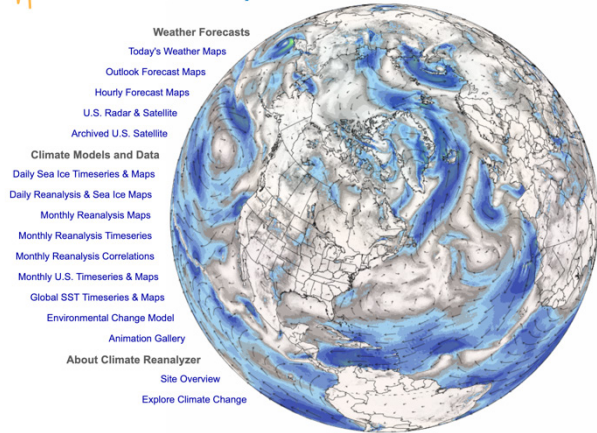
Emera Astronomy Center has been engaging a number of areas at the University of Maine with the aim of creating an immersive short course and data visualizations for planetarium operators to facilitate communication and informal learning in climate and weather science.

Climate change is widely regarded to pose an existential threat to the future productivity and security of human societies and economies worldwide. It is accepted by the broad scientific community that human industrial activity, primarily associated with fossil fuel burning and greenhouse-gas emissions, has driven an increase in the temperature of the lower atmosphere and ocean surface, particularly since the 1960s (IPCC, 2014). Impacts from a warming climate include sea-level rise (from melting glaciers), higher storm surge and coastal erosion, ocean acidification, more intense intervals of rainfall and drought, and an increased likelihood of heat waves. Such changes dictate a practical need for people to understand how the climate system works in order to inform their everyday lives and to provide valid information for decision-making.

Digital planetariums are posed to help improve the public understanding of Earth's climate by utilizing dramatic, unique visualizations that immerse learners in the science and to aid comprehension of complex phenomena. These planetarium systems can help people understand how and why climate is changing and provide information about what steps society could choose to take in terms of mitigating climate and environmental impact or adapting to changes projected for the future. However, to engage the public in this manner, planetarium operators, or "planetarians," must be trained and have the appropriate resources to communicate climate science to their audiences and help allay misconceptions. Emera Astronomy Center and the Climate Change Institute (CCI) at the University of Maine are exploring ways to create teach planetarium operators how to share the science of climate change with students of all ages as well as with the general public. We are developing a short course to be taught by CCI faculty and planetarium staff. The short course, called "Down to Earth: Climate and Weather Learning for Planetarians" is being modeled after the highly successful Kavli Cosmology Short Courses for Planetarians at the University of Chicago. The course will leverage the expertise of CCI and other UMaine faculty whose research is relevant to climate and the environment. Disciplines that we will bring into the short course experience include climate science, glacial geology, glaciology, oceanography, lake ecology, meteorology, anthropology, forestry, and environmental modeling. Expert presenters will utilize the unique resources of the digital planetarium in their presentations, and, when possible, provide laboratory tours and hands-on experiences for participants.

As part of this project, our group is working to produce an open-source module for visualizing historical and real-time climate and weather data on the planetarium dome. Climate and weather information will be provided via CCI's popular data visualization

website Climate Reanalyzer (<https://ClimateReanalyzer.org>) developed by Sean Birkel at CCI.



Climate Reanalyzer Homepage

CCI's Climate Reanalyzer data visualization capability has great potential for delivering real time weather and climate data content to the planetarium dome. Participants in the course will learn how to use Climate Reanalyzer in the dome to share a variety of key climate concepts. Climate Reanalyzer visuals will be supplemented with a number of short full-dome video playback clips designed to help planetarium operators share key climate and weather concepts with their audiences.

Understanding climate change requires access to a range of multi- disciplinary expertise. Our short course will benefit from UMaine's on-campus specialists in climate science, glacial geology, glaciology, oceanography, lake ecology, meteorology, anthropology, forestry, environmental modeling, and other fields.

We were originally planning to launch this course in 2021, but given the COVID-19 pandemic, our group is expecting to aim for the fall of 2022. We hope to have an update in mid-2021 on the status of the course.

BETTER STAFFING FOR BETTER PRESENTATIONS

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Abstract: What are the key attributes of a satisfying live planetarium presentation? When hiring a presenter what skill sets are prerequisite, and what skills and knowledge can be built on the job? How do you consistently find, challenge, and develop presenters who can become long-term assets to your team? We will explore desirable skill sets, avenues for recruitment, and strategies to maintain an engaged, skillful presentation team.

Introduction

Hiring for live presentations in the dome presents a unique set of challenges from a management perspective. We want skilled presenters. We want them to have a science background. We want them to have technical confidence and competence in running planetarium equipment. Constraints in the budget have to take precedence over hiring ideals, so a team of salaried presenters with top-notch presentation skills and degrees in astronomy or related fields is a pipe dream. A set of applicants may have pieces of the puzzle, but which traits should be used as bedrock on which to build a competent, knowledgeable, curious, and enthusiastic presenter who can inspire that spirit in an audience? Perhaps an institution has a trained physicist or astronomer on staff who can give adequate presentations, but doesn't particularly enjoy talking to groups or have the public speaking skill set to excite an audience and spark that connection to the universe that creates a lifelong space enthusiast.

The Ideal Live Show

The ideal live show inspires the audience to ask questions about the universe and look up on their own on the next clear night. To achieve this, a presenter needs to not only communicate information, but do it in a compelling manner. During or after the show, audience members can ask questions or request to see things on the dome, and the presenter can smoothly and seamlessly pull it off. They can also speak in a way that lends emotion to the show, speaking from a place of their own experience exploring the sky.

The Conundrum

The perfect blend of presentation skills and subject knowledge is extremely effective, but hard to achieve, and even harder to find in the wild just waiting to be set free. As with any hiring situation,

candidates are bound to be a mixed bag, with hardly any perfect fits right off the bat. Is it better to hire someone with lots of astronomy and science knowledge but little presentation experience or hire someone with lots of presentation skills that can engage a crowd, but with little to no astronomy knowledge? Let's take a look at two examples of candidates thrown in into a live show situation without proper training:

The Nightmare Live Shows

Presenter 1: The Astronomer. An astronomy post-grad talks for ten minutes in a monotone voice, using all manner of technical terminology, abbreviations and jargon, about a neutron star they've been studying for the past eight years. The stars are projected but the visuals never change. When opening it up to questions, there aren't any for a long time, until someone asks where this neutron star is located. The presenter is able to name the constellation but unable to find it on the dome.

Presenter 2: The Actor. A theater-trained improv actor gives their first live planetarium show, talking with great enthusiasm about how "cool" space is and how awesome the Milky Way looks, but ends up talking about how Polaris is the brightest star and Orion is visible in the evening all year. The audience gets caught up in the odd energy of the show and asks lots of questions, but the presenter is unable to answer. When asked where Jupiter is in the sky, they say they don't think it's visible with the naked eye, but then proceed to spin the stars rapidly to find it and try to compare it to an astronomy app on their phone. They end by encouraging the audience to get out there and see the sky.

What Happened?

In the case of the Astronomer, they had all the knowledge you could ever want, but didn't consider how to present it to the audience. Any sort of insight into why they were interested in it or what got them into astronomy in the first place would have helped, as well as considering why it should matter to the audience and how they might relate to the subject. They also did not effectively use the dome as part of their presentation by not using it to demonstrate the location of the star or offer complimentary visuals to their presentation.

In the case of The Actor, they had no knowledge of the subject at hand and the audience learned arguably fewer facts than with the post-grad. There was enthusiasm generated, but the takeaway was vague and very little knowledge was exchanged.

Which Do You Hire?

Given that any reasonable manager would have trained and prepared their presenter better and avoided the disastrous shows, which presenter would offer the easiest road to being show-ready? It is generally best to err on the side of the one with presentation skills and layer in the astronomical knowledge during training and beyond, as we will discuss later. Often presentation skills are based on a set of innate talents and instincts that are easy to cultivate but harder to build from scratch. Similarly, astronomical or scientific hobbyists or professionals build their skills and knowledge on innate talents such as curiosity and logical thinking. Those are hard to build from scratch, too, but their presence isn't a prerequisite to a successful presentation. It is important, however, that the actor be curious about and have a genuine interest in astronomy. This makes it easier and more enjoyable for them to learn the content needed for the shows as well as brings a genuine enthusiasm to their presentations. The point isn't to elevate or denigrate either set of talents, but recognize that in the case of presenting a live planetarium show, an actor who has learned about the constellations has a higher chance of inspiring an audience by instinct than an amateur astronomer who just started talking in front of crowds two weeks ago.

Is There No Hope for the Astronomer?

There are exceptions to the recommendation to "go for the actor," of course. If this person is being hired to help do public observing as well or participate in an astronomy internship, then of course the astronomy or scientific background would be more important.

More importantly, though, you could go for the science background over the presentation skills if you already have a number of highly-skilled presenters whose astronomy knowledge is only as deep as it needs to be for the shows. Having a team that can learn from each other is a great asset and one of the easiest ways to "lift all boats" among your employees.

Learning From Each Other

If you have a team of two or more presenters, the best way for them to improve their shows is to watch each other present in

front of an audience. Unlike with a manager evaluating a show, often peer-to-peer observations are well-received and the real beneficiary is often the person watching. If it is the Astronomer watching the Actor, they will likely pick up on bits of cadence and audience engagement. It is one thing to read about this, but to see it in action, especially presenting the same content but getting a much better response, is an excellent learning opportunity. Small things like asking open-ended questions or telling good (or purposely bad) jokes or relaying personal anecdotes during the show are easily seen, appreciated and imitated during a good live show. If the Actor is watching the Astronomer, they will almost certainly pick up interesting tidbits of stargazing and astronomy knowledge, learn about new concepts, and see how different ideas build upon each other in the sky.

Building and Growing Knowledge and Presentations

Using the planetarium dome as a teaching aid is the most important tool for training, but often overlooked is the real sky. True, it doesn't offer push-button manipulation or guaranteed pristine stargazing, but it does offer the same view that your audience will see as they step out the door after seeing a show. So whether it's a first-quarter moon in the blue sky or how Venus looks in the west 20 minutes after sunset (or before!) or how many stars in the Big Dipper you can see through the light pollution, it's always good to get out and see it in the real sky. The planetarium is an analog, and while the real sky may be imperfect, it's all the more real. It will help them connect more effectively with their audiences when they are able to describe what they can expect to see, under real conditions, when they look up in the sky.

If you have the opportunity, take your team on a stargazing experience. Pack some scopes, snacks and caffeine and head out to the darkest skies you can access easily and see the sky as it is meant to be seen. Often show presenters haven't seen the Milky Way in the real sky or spotted the head and paws of the Great Bear. Even if it is only every couple years, make sure they get to see the real thing.

Offer reading materials and videos for your presentation staff to peruse in their office time. Books related to show content, especially if you show pre-recorded shows about specific topics, and a subscription to an Astronomy Magazine can be natural ways for less-knowledgeable staff to pick up new information. Short videos, such as PBS Digital Studios' *Crash Course Astronomy*, are excellent at presenting astronomy topics to non-experts and provide auditory and visual learners another way to learn content. Fast fact sheets with targeted resource lists that are customized for the topics of your shows are also effective ways to encourage more content exploration. Bullet point facts are quick to memorize and be repeated in shows, but also provide starting points for content exploration for staff who may not feel they know where to start learning astronomy content.

Encourage questions. It is always good practice for presenters to find out the answer to a question they were unable to answer during or after a show. Encourage them to ask you or another presenter so the next time it comes up they're ready.

Encourage your presenters to try new things. This will come

naturally to those more theatrically-inclined, and let them know that as long as they're still presenting the content in a meaningful way they should find ways to keep it fresh. If you have a system with easily-programmed buttons or scripts, encourage suggestions and try to be as responsive as possible when they come up.

Addressing Insecurities

When hiring presenters without a formal astronomy background, you may find a certain feeling of an imposter syndrome start to set in when they are interacting with audience members. If they are asked what they studied in school or what their background is or even how they know all this stuff, they may be hesitant or feel judged when revealing a non-science background. This need not be the case, and often with some reframing of the situation, these fears can be properly allayed.

What better way to connect with the audience than to let them know that you, too, used to be sitting in their seat. You don't have a degree in astronomy, but you have a curious mind that was inspired by the sky and you think you have the coolest job in the world. A helpful target mindset is the "enthusiastic non-professional." It's as if you read a book about a subject that you thought was so cool and you don't know everything yet but you want to know more and you want to share it with your friends. That's the tone to look for. Science communication is so important, and as the go-between for the scientists and the public, it is almost always going to be filled by those not directly involved in the science in question. There's nothing wrong with that and your presenters should recognize the important role they are playing for the audience.

Conclusion

Live presentations are meant to spark the curiosity of the audience and inspire them to continue to explore the universe and night sky. To do this, you need presenters who can deliver content while conveying a sense of wonder and excitement through strong presentation skills. While it is hard to find the perfect balance between content knowledge and presentation skills when hiring, erring on the side of science-curious actors and developing a strong framework to support them learning the necessary content has been the most effective way to cultivate a staff of successful planetarium performers.

INDIGENOUS ASTRONOMY—BEST PRACTICES AND PROTOCOLS FOR INCLUDING INDIGENOUS ASTRONOMY IN THE PLANETARIUM SETTING

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Abstract: Indigenous people have nurtured critical relationships with the stars, from keen observation and sustainable engineering to place-based ceremony, navigation, and celestial architecture for tens of thousands of years. The Indigenous relationship and knowledge of the sky is exceptional in that it encompasses mind, body, heart, and spirit.

This panel is organized by the IPS's newly formed Indigenous Astronomy Working Group. It brings together Planetarium Professionals, Indigenous Star Knowledge Keepers, Indigenous Astronomy experts, Cultural Astronomers, and allies of Indigenous STEM communities from Canada, U.S., and internationally to discuss best practices for dissemination of indigenous astronomy specifically for science communicators and the planetarium community.

Introduction

Astronomy as presented in planetarium shows can be beautiful but ultimately distant with no way for audiences to link what they are viewing to their everyday lives. In contrast, Indigenous astronomy has people at its center. It is about people, relationships, and the sky, not just about the sky. As eloquently described by two well-known Dine scholars:

The Dine word, 'Sitsoii Yoo' (Star or original light that evolves) acknowledges the ancient relationship to the original light that came from the original star. It acknowledges all life, including human life, proceeded by the original energy of light, similar to astrophysicists' explanation that we are stardust. Ancient teachings tell us that when humans look at the Milky Way galaxy at night, they are actually looking at themselves, from which energies they actually evolved. (Maryboy and Begay 2020)

Clearly there is an enormous amount of wisdom in our Indigenous Knowledge Systems (IKS) and in particular, our Indigenous relationship with the night sky. Indigenous peoples around the world, from time immemorial, have seen the heavens, obtaining from their perspectives information that has helped them define areas of each culture, whether from a religious, biological, spiritual or even temporal point of view. And yet the enormity of post-colonization can and should not be understated. We might be living five-hundred years (c. 1492) after the Portuguese and Spanish armadas first sailed west and bumped into the North and South American continents, but the impact from the loss of cultural knowledge and language is a present, harsh, and enduring reality.

Fortunately, not all has been lost. Elders like Nancy Maryboy and David Begay began working on revitalization of Dine' Indigenous Astronomy over three decades ago. Other Indigenous voices from North America (such as Wilfred Buck and Annette S. Lee), from the Hawaiian Islands (Ka'iu Kimura and Kalepa Baybayan), from Mexico (Milagros Varguez), have been working together with African American/African Indigenous Astronomy scholars (like Jarita Holbrook), Maori Knowledge Keepers (such as Te Kahuratai Painting), Aboriginal Australian & Torres Strait Island communities (through Duane Hamacher), and more recently, Chilean-Argentine Indigenous Mapuche people (via Yasmin Catricheo). We are at a critical moment. People have an excitement and curiosity about the night sky, a kind of craving for more, but at the same time we are in danger of dark skies going extinct (Bogard 2014; Deudney 2020; Harris 2009). This moment is an opportunity to recognize that science is embedded with culture and history, and it is past time to widen the lens. All people from all over the world, throughout human history have had a keen relationship with nature and have therefore been practicing science/scientific thinking for millennia.

This document serves to support the Indigenous voice as the lead voice in revitalizing Indigenous star knowledge, starting with our own Indigenous communities. We offer this document as an introduction to present best practices and protocols for how mainstream institutions such as (non-Indigenous led) planetariums can support our efforts in an authentic and meaningful way.

What is Indigenous Astronomy?

The first step in creating a more inclusive, diverse, and equitable learning environment in planetariums, and indeed in all of STEM is to acknowledge that science is by definition embedded with culture. Culture is more than superficial or performative markers like holidays, customs, and ethnic food. Culture is often unconscious but has a huge impact on the philosophical underpinnings of a society (Lee 2020). Similarly, science has become the ever narrowing, laser focused, divide-and-conquer endeavor that we know today only in the past few hundred years. For example, the etymology of the word 'physics' comes from 'physica' or 'physicks' which is from Latin meaning 'the philosophy of nature or natural philosophy' (Oxford English Dictionary 2019). Certainly we can recognize that the multitude of peoples that have existed on Earth have had different ways of 'relating to nature'.

Similarly, a person's worldview is learned from the environment in which the person grows. As part of the process of inculturation, the newborn begins to learn not only the language and customs but also the basic assumptions, premises, and concepts of his parents, family, and community (Chate 2017). At the moment of removing a person from their culture (deculturation), they lose their identity and with it the chain of transmission of the knowledge of their ancestors to generation after generation is broken. By acknowledging one and only one culture's natural philosophy we are losing valuable perspectives related to the physical/natural world, acculturation/inculturation, environmental wisdom as well as methods of transmission of knowledge. Chilean researcher Michel Duquesnoy explains that people are intentionally denying their Indigenous origin because they want to appear 'pure' and because Indigenous people are still viewed with mistrust. He explains the importance of the state's responsibility in developing laws that respect Mapuche culture:

The problem is due to weak policies and the blindness of a somewhat discriminating society, dialogue is hindered or eliminated, which is essential in the development of a society and in the creation of a common identity. (Duquesnoy n.d.)

Whether we use the more formal term 'Indigenous Knowledge Systems' (IKS), or the more general term 'worldview', we can recognize that Indigenous people had and still have a keen awareness of the natural world. Relationships and participation with the natural world were and still are key elements in Indigenous science.

The term "Indigenous Knowledge Systems (IKS)" is rooted in the voice of post-apartheid South Africa, and similar movements followed in Australia, New Zealand, and more recently Canada. The South African government began to recognize IKS as a critical and valuable perspective worth protecting and promoting at the federal level. Indigenous African scholars like Munyaradzi Mawere, Lesley LeGrange, and Meshach Ogunniyi (Le Grange 2007; Mawere 2015; Ogunniyi 2005) give the following outline of the differences between Indigenous Knowledge System and Western Science:

Table 1 – Comparison of Indigenous Knowledge Systems with Western Science, Le Grange 2007, 585

Indigenous Knowledge Systems:	Western Science:
nature is real and partly observable	...versus nature is real and observable
events have both natural and unnatural causes	... versus all events have natural causes
the universe is partly predictable and partly unpredictable	... versus the universe is predictable
language is important as a creative force in both the natural and unnatural worlds	... versus language is not important to the workings of the natural world
knowledge is a critical part of culture	... versus science is culture free
humans are capable of understanding only part of nature	...versus humans are capable of understanding nature

Additional elements of Indigenous science are given by North American Blackfoot elder and scholar, LeRoy Little Bear, (1) all things are made of energy, “In Aboriginal philosophy, existence consists of energy. All things are animate, imbued with spirit, and in constant motion” (Little Bear 2000, 77); (2) we are all related, “In this realm of energy and spirit, interrelationships between all entities are of paramount importance...” (Little Bear 2000, 77). To reiterate this critical point, Lakota elder, Albert Whitehat writes,

Philosophically, ‘mitakuye oyasin’ states that a person is related to all Creation. ‘Mitakuye oyasin’ reminds us that we all come from one source, the blood of Inyan, and therefore we need to respect each other...Through these ways we maintain ‘wolakota’ peace... During pre-reservation times there was only one philosophy, one culture, and one language. We did not separate prayer from our daily life. Everything was the Lakota way of life, and ‘mitakuye oyasin’ was practiced in all situations. (1999, 46)

From a South America Indigenous perspective, a term similar to Indigenous Knowledge Systems (IKS) that is well-used in original cultures is ‘worldview’. The worldview consists of the assumptions, premises and ideologies of a sociocultural group that determine how they perceive the world” (Lafuente and Sanchez 2010). For example, from the perspective of the Mapuche people of Chile there is the belief that natural forces govern and regulate the universe. Within that universe, humans are part of this structure which is in harmony with everything and in balance between positive and negative. There is a very strong connection with nature and the environment in which one lives. It is cared for, protected, respected, and interpreted for the future good of the community in accordance with the past, and with those who are no longer there physically, but whose energy remains in every corner of nature. For this reason, the connection with nature is so important for the Mapuche community. As explained further, nature is not only a source of food and the home that welcomes us, it is also a connection with and representation of the ancients and those who were before us and who we have inherited the knowledge that allows us to continue to grow.

To the point, the Indigenous worldview is at times in direct contrast with the Western worldview. Western worldviews focus on how humans exercise dominion over nature to use it for personal and economic gain; human reason transcends the natural world

and can produce insights independently; nature is completely decipherable to the rational human mind (Knudtson and Suzuki 1992). As (Carter et al. 2003: 6) note, “The emphasis of Western science is on mastering, controlling, and transforming nature and promotes individual success and competition.”

The damage of colonization is still being dispensed when we put on our blinders and teach science (or astronomy) as ‘the objective truth’. As stated by Ininew elder, Wilfred Buck (2012: 73):

We as individuals tend to view our civilization as “the best” and when our teachings, knowledge, and belief systems are ridiculed, marginalized and then utterly dismissed as “quaint”, we begin to question our world view. This has happened and is still happening to First Nations people as well as all colonized peoples. Until other worldviews are proposed and considered, there will be a distinct “difference” and “quaintness” about all that is not mainstream. In addition, our children will see these differences and attempt to discard them in order to become more mainstream. These teachings reflect the differences and propose another perspective, broadening and giving voice to them...The implications for the educational systems (public schools and federally funded Band operated schools) in which our children are indoctrinated, is that it recognizes the “otherness”, and becomes a part of our multicultural nation.

Simply put, if astronomy is defined as ‘a natural science that studies celestial objects and phenomena’ (Unsöld and Baschek 2001), then we can define Indigenous Astronomy as ‘a living relationship with nature focused on the sky and celestial phenomena that is deeply embedded in keen observation and participation, anchored to heritage that goes back tens of thousands of years, and includes recognition that all living things are embedded with spirit and therefore related.’

Importance of Indigenous astronomy?

One important aspect of Indigenous astronomy is how knowledge connected to the sky or about the sky is culturally encoded for sharing as well as remembering. Stories about the sky often provide a mapping of the sky (Holbrook 2014). From

the Ewe people of Togo, Orion is the hunter, same as in the Greek myth, but he is hunting chickens (Spieth 1911: 53). Their constellation Dzeretsia fits the description of Orion, with a tattoo on his belly representing three people seems to be describing the belt of Orion, and his genitals seem to be the sword of Orion. Kolkovino (the chickens) as described is a cluster of stars, assumed to be the Pleiades but from the description it could be the Hyades; nevertheless, they are what Dzeretsia is hunting. Dzeretsia is connected with yam planting. He leaves the night sky at the time the yams are seeding, when he appears near the zenith at sunset yams are planted, when he appears in the west after sunset planting is stopped. There isn't a causal link between Dzeretsia and yams given that he is a hunter, but instead he only serves as an agricultural calendar marker. However, Dzeretsia seems to be given some agency over rainy and dry weather: When it is rainy, they say that Dzeretsia has dipped his foot in the water; and when it is dry, they say Dzeretsia is keeping his foot in the fire (Spieth 1911, 53). This example encodes important agricultural information about when to plant yams, thus the location of constellations in the night sky is entwined with the livelihood and food security of the Ewe.

Another example of place-based astronomical knowledge tied to seasonal and cultural agricultural practices is found in the Dine teachings of when to plant corn seeds. This occurs in the spring in Navajoland, when the Pleiades are visible and then disappear into the western horizon. They are spoken of as little boys who disappear behind some hills. That is a signal to begin planting. When the Pleiades become visible in the east, and the little boys reappear in the night sky, it is a sign to stop planting. Elders say, "Never let Dilyehe (the Pleiades) see you plant your seeds!" (Maryboy and Begay 2005, 2010, 42-3).

Constellations, or Wanjen in Mapuche culture, were used as important calendar events and for deep spiritual connection. To the Mupuche in Chile, Weluwitraw (also known as Orion) represents a traditional Mapuche sport consisting of two men who have a rope in common tied to their necks pull in opposite directions until one of them manages to win, dragging the opponent. Orion's belt represents one of the men and the Orion Nebula represents the other, with the sword representing the rope between the two. In some sectors it is used as a temporal and spiritual variable. In other words, time of year observed and personal spiritual connection can change meaning.

Indigenous astronomy highlights the process of using long term (generational) observations of the sky to build knowledge within a cultural context and locational context. The cultural context is important because the observations of the sky and the implications were/are part of Indigenous life and livelihoods.

Why talk about Indigenous astronomy in a planetarium?

It is, first, important to acknowledge that narratives, language, knowledge and culture are essential in astronomy communication in planetariums. Currently, there is growing hunger from communities to learn more of Indigenous Astronomies (P. Harris and Matamua 2012) with Indigenous narratives being fundamental to understand this codified Indigenous knowledge (Hikuroa 2017). However, by uncritically centering Greek and Arabic constellations, star names and narratives, we are locating the night sky in Greek and Arabic

narratives, language, knowledge and culture. This intellectually positions the planetarium in Greek and Arabic lands, rarely the lands of the planetarium. At other latitudes, constellations appear rotated or even upside down. In this way, planetariums can further disconnect the audience from their night sky. This section explores this sense of distance between the audience and the night sky created by Western-Eurocentric Astronomy.

When located in other lands, such as Aotearoa New Zealand, the irrelevance of the Western-Eurocentric narratives in astronomy becomes even more apparent. As an example, there are no scorpions in the Pacific Islands, therefore Scorpius, the scorpion, has no relevance to the lives of indigenous peoples of the Pacific. Contrarily, this constellation is seen as Te Mataunui-a-Maui, Maui's fishhook. A fishhook is a familiar shape to the seafaring peoples of the islands in the Pacific, and recognizable as such in their night skies. Further, the heliacal rising of Rehua (Antares), the brightest star in this constellation (Scorpio/Mataunui-a-Maui), occurs in mid-December in Aotearoa New Zealand. Rehua rising signals the height of summer and ripens the berries in the trees within Māori narratives. Again, the indigenous astronomy is culturally embedded as well as situated within the local context. A wealth of relevant star knowledge can be observed connected to the environment and reinforces our relationship with the stars in the night sky.

Many astronomers and astrophysicists recall a visit to a planetarium being the start of a life-long relationship with the night sky sparking curiosity, excitement and careers. This speaks to the main purpose of planetariums—sparking a relationship with the night sky by representing the night sky, first and foremost, where you are. This is especially important in towns and cities where light pollution renders a star-filled sky invisible. The planetarium projects on to the dome what is out there in the sky, unseen and disconnected, communicating excitement and connection. If the intention of planetariums is to spark/build relationships with the night sky, closing the palpable distance between us and the stars, then locating astronomy in place through Indigenous astronomy strengthens the relationship between the audience and the night sky, and closes that sense of distance.

One of the key distinctions between Western astronomy and Indigenous astronomy as an Indigenous Knowledge System, is the acknowledgement of the relationality between the stars in the night sky and the rest of the environment. Indigenous star knowledge often reflects seasonality specific to place (Clarke and Harris 2018). The heliacal rising of particular stars can indicate months and the appearance of constellations at specific positions in the sky can indicate seasons (Matamua 2017) and reinforce our connection to the stars through our observation of this environmental seasonality.

The seasonality embedded in Western-Eurocentric narratives are out of sync with most local environments. As mentioned above in Aotearoa New Zealand, Rehua (Antares) returns to the night sky in December near midsummer signaling the driest hottest time of year, this time is dominated by the Western association with the constellation Aquarius reigning from mid-January to mid-February. Both occur in the height of summer, when there is rarely rain. In contrast, the Western narrative of Aquarius 'The Water Bearer' is seasonally distant and requires the audience to mentally

locate themselves away from the local night sky and planetarium.

Although this section focuses on the obvious cognitive dissonance between Northern and Southern Hemisphere astronomies, with a particular focus on Aotearoa New Zealand, similar examples could be used from across the globe, including the Northern Hemisphere. In some locations the differences can be subtle. The differences can also be as diametrically opposed as rain and drought. Including Indigenous astronomy in planetarium presentations, for Indigenous and non-Indigenous peoples, achieves the objectives of planetariums in a unique way specific to place. Indigenous astronomy can strengthen the relationship of the audience with the night sky, with the local environment and, most profoundly, with the local Indigenous peoples.

Bringing Indigenous Astronomy into Planetarium Programs

Planetarium programs such as Stellarium now feature a large number of culturally-specific packages under “Starlore”. These default plug-ins feature star names, constellation art, and cultural traditions for dozens of Indigenous communities and ancient cultures. Examples include Maori, Lokono, Maya, Tongan, Navajo, Mongolian, Tupi, Ojibwe, D/Lakota, Boorong, Aztec, Egyptian, Norse, and Chinese (among many more). Additional plug-ins can be developed through Stellarium, enabling the inclusion of Indigenous content from anywhere in the world.

Planetaria should include Indigenous content, or develop Indigenous-specific programs, whenever possible. Accomplishing this means adhering to established guidelines rather than the development of ad-hoc programs without relevant community consultation. Those guidelines are as follows:

Ensure all planetarium staff are properly trained in cultural competence (ACECQA, 2014);

Identify local communities/tribes with astronomical knowledge that could be included in planetarium programs or displays;

Engage in due diligence to see what knowledge is available, understanding restrictions, and identifying the key elders or representative organizations;

Follow established protocols for approaching and working with those communities/tribes;

Ensure constant consultation with the relevant community/tribe who must give final approval for all content and delivery options;

Ensure mutual benefits are in place for that community/tribe. This may include payments to elders, profit sharing, education and outreach programs for the local community/tribe, employment opportunities, educational materials, etc.;

Ensure Indigenous voices are centered and provide programs for local Indigenous people to deliver content whenever possible;

Produce a signed MoU that sets out rules and guidelines for permissions, program content and delivery, and future alterations.

Some of these guidelines need to be unpacked for further clarification and illustrative examples from various parts of the world are used to show these protocols in action and their benefits. Educators need to be knowledgeable about local communities and be culturally competent so as not to promote stereotypes or false information, regardless of intent. These are among the most problematic and common issues that face educators that can have long lasting repercussions. Many regions have established protocols for working with Indigenous people (ATSIEB 2015). In Australia, this is set out by organizations such as AIATSIS—the Australian Institute for Aboriginal and Torres Strait Islander Studies (AIATSIS 2015).

Educators should work with local communities on which the planetarium sits. While it is useful to discuss Indigenous astronomy across a specific country or region, it is critically important to include local knowledges and voices. Indigenous astronomy knowledge has to be collaboratively developed with tribes so accurate information can be shared. This collaboration must ensure that final approval for the delivery of all content is approved by the representative Indigenous body. Some communities have suffered greatly from colonization and much of their knowledge may be fragmented or lost, so this careful process is in response to this. Mapuche star knowledge, for example, was passed from generation to generation through oral tradition. There are no reliable records of Mapuche writing that reveals pre-colonization knowledge. In most cases Indigenous Astronomy is held as a sacred narrative that acknowledges a natural cosmic order that in turn determines a unique way of life, unique to the people involved, and in some cases this information may be sensitive or cannot be shared with non-tribal members. This may not always be possible, but it should be the desired focus. Tribal protocol contains appropriate tribal and cultural integrity and restrictions should be acknowledged and followed, parallel to the CARE principles for Indigenous data governance (Carroll et al. 2019). A clear MoU (Memorandum of Understanding) should be developed between the planetarium and the collaborating community/tribal organization. This should lay out the protocols for knowledge sharing, use of language and terminology, consideration of restrictions, protocols of future amendment, recognition of knowledge holders, plans for centering Indigenous voices, and the mutual benefits for the community.

The protocols and practices for working with Indigenous people are regionally specific. Many Aboriginal communities restrict certain knowledge to men, women, and/or senior initiated elders. These rules may vary from culture to culture. For example, the celestial emu is a motif featured in the traditions of a majority of the 350+ language groups spread across the Australian continent (e.g. Fuller et al. 2014a). Knowledge about the celestial emu may be public with some communities but deeply secret with others. Some elements may be restricted to men, while others are restricted to women (Michaels 1985). Some elements may be restricted to senior initiated elders, in sum certain indigenous knowledge may be freely shared or not dependent upon the ethnic group and their rules governing such knowledge.

There may also be restrictions on showing images and names of people who have passed away (NSLHD, 2015). In general, showing images and speaking names of people who have passed

away is considered taboo in many Aboriginal communities across Australia, so this must be considered when working with communities/tribes on programs and content delivery. This also means protocols need to be established to accommodate potential alterations in the content delivery in the future.

As opposed to the practice of archaeoastronomy, which tends to focus on cultures in the ancient past (which may no longer exist, or currently exist in a much different form), Indigenous Astronomy focuses on contemporary, living people and cultures (Medupe 2015). Therefore, it is important to acknowledge and understand the importance of focusing on Indigenous Knowledge as a living entity, to focus on the importance of Indigenous language, and to center Indigenous voices whenever possible. It is also critical that any program be developed and delivered in such a way as to not be derogatory towards Indigenous astronomy through comparison of Western astronomy (Ruggles 2010). When comparison is presented the equivalence of Indigenous astronomy to non-instrument Western astronomy should be emphasized. Indeed, when all the instruments are put aside, what shines bright is simply relationship to sky.

For the Sir Thomas Brisbane Planetarium in Brisbane, Australia, a large permanent wall-display was developed to feature Aboriginal and Torres Strait Islander astronomy, with a focus on the scientific elements of this knowledge (GC2018CGC 2018). Entitled *STARLORE*, it features examples from three different communities, showing diversity in terms of geography and representation: Wardaman (Aboriginal, Northern Territory), Euahlayi (Aboriginal, New South Wales), and Meriam (eastern Torres Strait, Queensland). It was decided not to show photographs of each elder, but elders gave their permission for their names to be shown even after death. Each section features a small map of Australia that shows the location of each community. The elders spoke at the launch and were centered in the media regarding the display. A similar display was developed at Perth Observatory (2018) in Western Australia entitled *Worl Wangkiny*, led by Aboriginal elder Dr Noel Nannup.

In the case of *STARLORE*, these three communities were selected because senior elders in those communities had published a significant amount of their astronomical knowledge (e.g. Cairns and Harney 2003; Fuller et al. 2014a, b, c; Guedes et al., 2018; Hamacher et al. 2018, 2019) and Senior Elders or Boards of Elders in those communities were able to give permission for that Knowledge to be shared and displayed. Given the relatively small size of those communities, such a thing was possible. With very large communities, there may not exist a single central body that can give blanket permission for knowledge to be shared. In select cases, any shared knowledge may need to focus on smaller sub-groups within the larger community, such as clan, family, or dialect groups.

Protocols vary from tribe to tribe. These protocols include and identify specific times when it is appropriate to tell stories of the sky. For the Dine, this is closely tied to the natural order of lunar, stellar, and seasonal cycles, usually spanning the winter months from late September to mid-March. There are also restrictions on viewing celestial events such as lunar and solar eclipses that vary among and within tribes. When Planetarium educators show

programs that are time specific, they should definitely acknowledge and follow the Indigenous Astronomer guidelines.

Restrictions will become clear as one works with different tribes. These are very important to the sharing of Indigenous astronomical information. In addition, it is always important to acknowledge the source of information (whether it is song or story) as coming from credible knowledge holders. For example, there is protocol around when star knowledge stories should be told. In Ojibwe one restriction is that certain stories should be told only when there is snow on the ground. As explained by Ojibwe elder W. Wilson, “Biboonkeonini – Wintermaker is a spirit that makes winter. Each season has certain spirits that make the season happen. Winter-only stories are told in wintertime because a person knows the Winter Spirit is there. No winter stories are told after the frogs wake up,” (Lee et al. 2014: 27).

Other tribes, such as the Dine in Arizona, Utah and New Mexico, also have strict protocols involving when stories of the sky can be told (Maryboy and Begay 2020). For example, Winter Stories are closely linked to cosmic cycles of the Sun and Moon. Generally speaking, one only tells these stories from late September to mid-March. When the First Thunder of spring is heard, it is announced all over Navajoland, by radio or newspaper or word of mouth. That is the time plants awaken and animals come out of hibernation, having been stirred by the energies of the Thunder and other signs. It is the time at which Winter Stories can no longer be told (Maryboy and Begay 2020). This protocol is extremely important to be followed if a Planetarium plans to show Navajo stories. There is one time around the summer solstice when some of these stories may be shared, but for educational purposes only. If the protocol is not followed, a planetarium can be severely criticized by local Navajos. Information may also be restricted by gender, phenomena (e.g. taboos around viewing eclipses), time of day, location, or other factors that must be taken into consideration through the MoU.

Finally, it is critical that Indigenous people are able to speak for and about Indigenous Knowledge (Carnes 2011). The collaborating community must give clear permission about how their knowledge is presented, especially if the planetarium educators are non-Indigenous or not from the community sharing that knowledge. Examples of centering Indigenous voices may include naming specific elders who shared knowledge, recording their voices or videos so they can deliver it remotely, or nominating an appropriate person to deliver content if an Indigenous staff member is unavailable or non-existent.

If the planetarium has no Indigenous presenters or educators, significant efforts should be made to correct this. Programs have been developed at astronomy-related education and outreach facilities around the world that provide pathways for Indigenous people to be hired and trained as astronomers, educators, and science communicators. Sydney Observatory developed an Indigenous program (Wyatt et al. 2014) that brought in Aboriginal guides to deliver Indigenous programs. The guides delivered programs that were not only culturally and ethically appropriate, but they were able to draw from their lived experiences, which non-Indigenous educators cannot do in this context. If possible, the planetarium should provide programs that can be delivered in

the relevant Indigenous language, enabling Indigenous educators to deliver programs to their communities in their language(s).

Conclusion

In 1999 the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in conjunction with the International Council for Science (ICSU) held a World Conference on Science. The resulting report advocated global governments to support and promote understanding of traditional knowledge systems. First outlined in the Preamble, “All cultures can contribute with valuable scientific knowledge” (UNESCO 2003, 9), with greater detail the report states:

...traditional and local knowledge systems, as dynamic expressions of perceiving and understanding the world, can make, and historically have made, a valuable contribution to science and technology, and that there is a need to preserve, protect, research and promote this cultural heritage and empirical knowledge. (UNESCO 2003, 14)

The report goes on to urge the scientific community to support, create dialogue, and build relationships, with “traditional societies and philosophers from all countries” (UNESCO 2003). Specifically:

Modern science does not constitute the only form of knowledge, and closer links need to be established between this and other forms, systems and approaches to knowledge for their mutual enrichment and benefit. A constructive intercultural debate is in order to help find ways of better linking modern science to the broader knowledge heritage of humankind. (UNESCO 2003, 40)

The recommendation is for scientists to respect, sustain, and enhance traditional knowledge systems and that traditional knowledge should be integrated into interdisciplinary projects. Clearly the world’s leading voice in science, education, and culture, UNESCO, understands the importance of widening the lens of science.

Lastly, an important concept guides this work in Indigenous Astronomy and museum collaboration, ‘*Etuaptmunk*’ or Two-eyed seeing. Here are the words of two Mi’kmaw elders:

Two-Eyed Seeing is learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of Western knowledges and ways of knowing, and to use both these eyes for the benefit of all. (Bartlett, Marshall, and Marshall 2012, 336)

In conclusion, it is important to remember that planetariums can provide immersive experiences where visitors can understand and connect to different cultures through the stars. Further, these experiences can be used to promote awareness that these stories are not just myths as they are often portrayed. These stories are a rich source of information about how ancient cultures lived and what was relevant and important to them. The stories are a rich source of scientific data that have been preserved in the stars and passed down from generation to generation orally. And in some cases the connection to the stars is a kind of a ‘spiritual lifeline’

or guidebook for the people to know: where they came from, what they are doing here, and where they are going. In Lakota, the stars were and are called “woniya of Wakaŋ Taŋka, the holy breath of the Great Spirit...when Lakota observed the movement of the Sun through their constellation, they were receiving spiritual instruction (Goodman 1992, 1)”. In either case, the teaching that the stars are ‘our oldest living relatives’ cannot be understated. As illustrated in this quote from a tribal member after first learning about the Ojibwe constellations:

I used to look up and see the Greek constellations, like the Big Dipper or Leo the lion... but now I know that there are stars up there that are ours. It does something to me inside, to have that relationship with the stars. It’s like finding a long-lost relative. (Tibbetts 2010)

This document serves to support collaborative efforts by museums and planetariums that desire to integrate Indigenous astronomy and science content “in a good way” into their programming, content, and institution. The roadmap starts with tangible efforts to build authentic relationships with Indigenous knowledge keepers and Indigenous scholars. More than a side-note, the Indigenous voice should be allowed to work collaboratively with museum/planetarium staff to lead the Indigenous content. Ideally, museums would aim to work away from the ‘add on consultant’ model towards the more sustainable model of hiring full time positions such as ‘Curator of Indigenous Scientific Knowledge Systems’ or various staff positions. Ultimately, the aim of this work is increasing STEM/Informal Science Learning opportunities for Indigenous youth, adults, and communities, but also has the foundational goals of increased cultural pride, engagement in science, and community wellness. For the non-Native audience, there is great value in learning and practicing cultural agility. Standing together we have enormous reach and capacity.

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THE EDUCATIONAL VALUE OF THE PLANETARIUM: INTERNATIONAL

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Abstract: This presentation session originally set out to gather global information about how planetariums are perceived by audiences in individual countries. To make it more meaningful during a time when many domes are still closed due to the COVID-19 pandemic, the focus has switched to planetariums making a difference in their countries, and how “The Educational Value of the Planetarium” is being applied.

Introduction

The presenters are Kaoru Kimura, Otsuma Women's University, in Tokyo, Japan, who looks at planetarium use in the schools; Sally Macfarlan, Iziko Planetarium and Digital Dome, in Cape Town, who notes the need for planetariums to help disseminate the growth of astronomy research in South Africa and the basics of STEM education; and Guilherme Marranghello, Planetário da Unipampa, who discusses the creation of a university in the extreme south of Brazil and its associated planetarium are affecting the education and economy of the region.

Japanese Curriculum

The teaching of science in the curriculum of Japan, begins in the third grade of elementary school. Astronomy, a part of science, is learned in the 3rd, 4th, 6th and 9th grades. The purpose of science is to familiarize students with nature and develop good observation skills, and to find out regularity and validity from the results.

In Japan, many teachers are not good at teaching astronomy. Night and long-term observations are difficult. Therefore, the government recommends using the planetarium and other accommodation facilities.

Even with university students, it is difficult to explain the phases of the moon. Many research papers say that many people

have insufficient recognition and understanding of space. It has also been reported that sufficient understanding cannot be achieved only through learning with model experiments and textbooks. It is one of the characteristics of the planetarium that people can experience two-dimensional and three-dimensional space. We give kids an immersive environment such as the planetarium to help them understand how and why science is important.

Producing local content for the Iziko Planetarium and Digital Dome in South Africa

Despite the major strides that Southern Africa has made into innovative astronomical research in recent decades, the general public remains largely unaware of these impressive developments or their significance. As discussed in the IPS document “The Value of Education in the Planetarium,” due to the immersive nature and unique capabilities of modern planetariums they are often effective and accessible tools to expose and educate a diverse range of people about astronomy and other Science, Technology, Engineering, and Mathematics (STEM) fields. Therefore, the Iziko Planetarium and Digital Dome (IPDD) has made it a primary goal in recent years to update old-fashioned preconceptions about planetariums, and to provide an up-to-date, modern window into the local scientific research world, including recent South African astronomical achievements. With this goal in mind, current IPDD projects include the pioneering use of the dome space to visualise and interact with large multidisciplinary research datasets, a locally-produced fulldome film that celebrates South African astronomy

achievements, and innovative research into the effective use of the planetarium as an educational tool in undergraduate studies.

The IPDD, located in the heart of Cape Town (South Africa) underwent a major 8K digital upgrade in mid-2017. In subsequent years, the IPDD has catered to a wide range of audiences, with a public show program, a dedicated schools' program (adapted to the national school curriculum), and an active research program. Indeed, it is one of the few planetariums in the world that are actively involved in research visualisation, led by a consortium of local universities and the IDIA Visualisation Laboratory (<https://vislab.idia.ac.za/>). IPDD research has reached increasingly diverse audiences through multiple data demonstrations and researcher interactions in multi-disciplinary fields. This facility is also ideal for the education of large groups, and, as such, is an active member of *Data2Dome*: an initiative that aims to present up-to-date science research to the public within the immersive planetarium space. (see <http://data2dome.org/> for more details on this global project).

Outside of pandemic restrictions, the schools' and public programmes offer daily shows, reaching around 100,000 people a year. However, since the upgrade, there have been very few local (and therefore relevant) digital planetarium shows highlighting research achievements in Sub-Saharan Africa. In order to begin to remedy this, we are producing a 25-minute fulldome film that promotes South Africa's astronomy facilities and research. The film will be free to download for both national and international audiences, and translated audios will be encouraged for greater global accessibility. It is hoped this film will promote a greater interest and understanding in STEM fields, while paving the way for the production of more local-content fulldome films.

We are striving to educate and popularise not only South African astronomy, but also a wide range of multidisciplinary STEM fields. In doing so, we plan to unveil even more of the IPDD's potential as a powerful educational tool, in line with the possibilities detailed in "The Value of Education in the Planetarium" IPS document. In the current political and economic climate of the country, we hope that by using local content (through locally produced films and research work), we can create a greater sense of pride in the country's scientific achievements and therefore work toward harnessing a more positive social environment.

Astronomy for Development in the South of Brazil

Planetário da Unipampa is a university planetarium located in the extreme south of Brazil, only 60 km from Uruguayan border. The university is spread in the Brazilian Pampa, which ranges from the Atlantic Ocean to the Argentinean border and covers 700km along the Uruguayan border. This region suffered a socio-economic decline during the decades before the university installation, which was created to become a turning point.

The planetarium is the only science center in the whole region and we receive kids from distant cities. We also travel with a mobile planetarium to cities all over the state, covering also another 25 cities where the university has distance learning centers.

As a university planetarium, we can address our educational

value to three different publics:

- the school students;
- the teachers, in teacher training programs;
- the university students, who are our monitors, and planetarians.

The IPS document "The Value of Education in the Planetarium" is very clear when it mentions that the immersive environment captures attention, sparks interest, and evokes a student's affective domain. The planetarium is "ideally suited for learning by discovery" and it is also a "place where diversity and equality can be promoted." So, the planetarium has an amazing value for education, going far beyond science education.

In Brazil, we have different types of planetariums, being mainly divided into public or private facilities and university, museum, or city domes. I will give the example of my public university planetarium, that considers that teachers training programs is the most important action a planetarium can do. In the region where the planetarium was installed, there were no courses on physics or astronomy. We started a work with in-service and pre-service teachers in the planetarium that may take several years. A standard teacher gives students a tour to the planetarium, while a well-prepared teacher offers kids a moment of learning in the planetarium that will be connected to their classes.

Finally, the Planetário da Unipampa staff is composed of two professors and one technician. Each year we open about ten places for students to work as monitors/planetarians. The most important content the students learn in the planetarium is: science literacy, diversity respect, the role of inclusion, public speaking, collaborative work and, of course, a little bit of astronomy. We know that even if the students will never follow an astronomy career, they shall leave us understanding how science is important, how it evolves, and many other skills working in a planetarium can offer.

After a few years, we have structured our work to have a planetarium focused on education, but it wasn't easy, because in a city far from big centers, we had to tell people what a planetarium is and why it is important. It would have been great to have the "Value of Education in the Planetarium" document when we started to distribute when people said "it is just to see little stars."

Final Remarks

We can imagine a universe of wonders when we think about a planetarium, but certainly education, on all levels, is the most tangible embodiment of our domes. Even though this is clear to our community, it is not obvious to the whole population. "The Educational Value of the Planetarium" IPS document is a source of information that will help planetarians make its point clear to everyone who enters our domes. We can continue to think about different ways planetarians think about education in Asia, Oceania, Africa, Europe, or in the Americas. We mean to offer a few initiatives during this meeting and in the planned follow-up meeting.

LET'S HAVE A CENTENNIAL!
PROJECTS FOR THE 100TH ANNIVERSARY OF THE PLANETARIUM

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Abstract: The 100th anniversary of the first planetarium—the Planetarium Centennial—will be observed as a nearly-two-year-long, global series of events and activities, celebrating our history, presenting what we have become, and highlighting what we plan to achieve in the future. The Centennial will showcase to the world what planetariums offer to their patrons and to society as a whole. We, the IPS Centennial Working Group, are now launching multiple projects for the Centennial, and we invite everyone to discuss with us how to best present the Centennial in social media, in print, in planetarium shows, in public events—and more!

Background

The first public presentation of a planetarium projection took place in October 1923, and the first permanent planetarium opened to the public in May 1925. The upcoming 100th anniversary of these events, the Planetarium Centennial, is a unique opportunity to highlight what planetariums are offering today. The IPS Council has thus determined, back in 2017, that IPS should use this opportunity to attract public attention for the planetariums around the world, and to showcase what planetariums today can do for society. In a word, the Centennial should be employed as a large “marketing” initiative for the planetariums.

With this aim in mind, the IPS Centennial Working Group was formed in late 2017, during the Pleiades National Planetarium Conference in St. Louis, USA. One early discussion was whether to celebrate the Centennial in 2023, 2025, or both years, or all of 2023–2025. After collecting much input and in-depth discussion of the benefits, we arrived at the current plan:

The Centennial celebrations and projects should start in October 2023, the anniversary of the first demonstration of a planetarium projector (in a temporary setting), last through 2024 and into 2025, and culminate on May 7th, 2025, the anniversary of the opening of the first projection planetarium. Projects such as exhibitions, shows, etc., could thus launch in October 2023 and run until mid-2025, with a final “100th birthday of the planetarium” ceremony on May 7th, 2025.

Planned projects

In 2018, brainstorming sessions were held at the IPS conference

in Toulouse as well as at some affiliate conferences, collecting input and ideas from the community and resulting in a list of more than 100 concrete ideas for projects and activities. Further input was collected online.

Since the working group is not able to work on that many projects, instead all proposals were discussed, and ranked, leading us to a two-tier shortlist of “core” projects that we want to focus on.

1st tier

- Centennial Website / Centennial on social media: YouTube, Twitter, Instagram
- fulldome teaser
- Centennial-branded t-shirt / apparel
- “digital exhibit” (poster design to reprint by everyone)
- at least one global celebratory event, e.g., on May 7th, 2025

2nd tier

- planetarium show
- planetarium history textbook / image-heavy book on planetariums of the world / booklet
- TV documentary
- online calendar of astronomical discoveries 1923 - 2023, “calendar of planetariums”
- domecasting series (100 domecasts)
- travelling exhibit, organized by IPS or by affiliates
- establish a new “IPS day of planetariums”: May 7th, the “birthday of the planetariums”
- more than just one celebration event, e.g., a launching

event in October 2023

This list does not mean that we want to limit ourselves to just these projects. In fact, each and every project for the Centennial that someone wants to work on is most welcome! This list is merely that of “core” projects that we think should be realized in any case, thus we are currently focusing on these.

These are “global” projects that should be available, once they’re finished, to every planetarium in the world. But we also invite everyone to think about creating your own regional, or local projects! We plan to highlight such projects in your region or your city on a “Centennial World Map” on the upcoming website. Thus, please work out *your* ideas and get in touch with us!

Laying the foundations

As a foundation for all further activities, the Centennial needs a slogan, logo; as well as a website URL that’s easy to memorize. That URL is: *planetarium100.org* Versions of this website in different languages should use the same “planetarium100” line, but under different top-level domains (e.g. “.cn”, “.ru”, “.fr”, ...).

The slogan to be used by all Centennial projects should be: “*Centennial of the Planetarium—the stars were only the beginning.*” This line captures the main “ingredients” of the Centennial: There’s an anniversary, it’s about stars, but also about more than “just” stars; today, planetariums do offer so much more than back in those days; and they’re striving to offer even more in the future.

Even more important than the slogan and URL is a logo. IPS held a logo design contest, and chose the winning design in late 2019, submitted by our member Emily Hromi:



Current work

Before starting these projects, however, the working group needs to find financial support, and hands-on help from the community for each individual project. It is very helpful that the Society of German-Language Planetariums (GDP) formed its own Centennial Working Group in 2018: They have started to prepare regional projects for the anniversary, but they have also launched a fundraising initiative to even help fund the global “core” projects together with IPS. We are now negotiating with several foundations and companies, and are hopeful that the money will be there to realize most, if not all, the projects on our list.

So far, the IPS and GDP groups have done preparatory work “only”: We’ve determined slogan and logo, identified the “core” projects, have started to find funding, are currently preparing a “flat” trailer video to be released shortly, have laid the foundations for a Centennial website also to be released shortly, and are currently running a series of #MilestoneMonday posts on IPS’s social media channels to raise awareness of the upcoming Centennial.

Launching the projects

After laying the foundations, now is the time to launch the “core” projects, so that they are ready to be presented in October 2023!

For this—for every project on our shortlist—we are currently looking for hands-on support from the community:

- *Who is interested in helping us to program, write, and edit content for a website?*
- *Who is interested in planning, editing, and coordinating the release of a planetarium history textbook, or other printed publications for the Centennial?*
- *Who is interested in working with us on the “Domecast 100” project, i.e., find, plan, and coordinate opportunities, speakers, and content for a year-long series of Domecasting events? Who is interested in working with us on any technological hurdles that may arise during this project?*
- *Who could work with us on a “digital” (poster) exhibition on the history of the planetariums, or even on “physical” (traveling) exhibitions, ideally one for each affiliate region?*
- *Who can offer help in planning, designing, and preparing the launching event (October 2023) or the final “100th birthday” event (May 7th, 2025)?*

Ideally, each of those core projects would be prepared by one “sub-group” of our Centennial Working group. We ask everyone who is interested in working with us on any of those projects to get in touch with us!

Also, if you have your own idea for a project in your region, or “just” in your planetarium or your city, please work out your ideas and let us know! We plan to highlight *your* projects in 2023–2025 on our Centennial website world map.

Let’s work together on making the Centennial a global success, with one clear aim: In 2023–2025, everyone in the world should hear about planetariums, and learn what awesome experiences they are offering *today*!

AESTHETICS OF THE PLANETARIUM EXPERIENCE

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Abstract: This panel brings together multiple viewpoints from educational, theoretical, and practical perspectives about the planetarium aesthetic and its effectiveness. We will examine the research that supports best practices that relate to educational and cognitive gains based on the aesthetic elements and presentation modes. One panelist will present a theoretical approach by rescaling spatial and temporal phenomena down to perceivable human proportions, and how audiences can be re-trained into a new way of seeing. Our final presenter will show how domes can be used to explore cultural heritage, and how human scale design connects with the perception of the greater cosmos.

Aesthetics of the Planetarium Experience: Awe and the Sublime

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Based on interviews with planetarium professionals, Croft (2008) found five aesthetic elements that were considered to be core elements of the planetarium experience. These aesthetics are intrinsic to the medium, and are critical contributions to the audience experience. In two earlier papers (Yu 2019, 2020), I reviewed the research literature that provides support for the best practices that define the aesthetics of live presentations, visual immersion, taking audiences on a journey, and using music. Two other aesthetics supporting fulldome video presentations—having multiple frames of reference, and being able to show a range of size scales—were also examined. The reader is encouraged to refer to the two earlier papers to learn about the research supporting these aesthetic elements.

For this discussion, I will focus on the final aesthetic: that of slow-paced storytelling that defines many planetarium programs. For many dome theater enthusiasts, one of the unique attributes of the planetarium is its ability to mimic the experience of being in a dark, quiet place looking out at the night sky. In these programs, the audience member can sit back under a simulated sky, reflect on what is represented by the pinpoints of light overhead, and contemplate the vastness of the heavens. No research exists that examines what the audience is feeling under these circumstances, but it is easy to speculate what is happening. A slow, contemplative experience that involves gazing at stars above, and pondering the immense scale of the universe leads to a feeling of being tiny compared to the vastness of space, and a sense of awe.

This type of wonder and sense of reverence is connected with the concept of the *sublime*. The sublime is a quality that tends to inspire awe, because of exceptional beauty, grandeur, or scale, in the example of staring out into the infinite of space. Enormous scale can make one feel small, and lead to the mathematical sublime, the sense of being overwhelmed by the “infinite.”

Other aspects of the sublime are also in effect in planetariums. The dynamic sublime has been explored in artwork depicting nature in a way that inspires awe. Romantic painters showed the power of natural phenomena, via their depictions of rough seas that threaten to wreck ships, waves crashing onto shore, thunderstorms, and volcanic eruptions. Artists in the Americas, such as those of the Hudson River School, painted landscapes of environments with a sense of scale not found in Europe, with high mountain peaks or deep canyons surrounded by far-reaching wilderness, or monumental Western rockscapes with distant, billowing clouds. The sublime could also be evoked at smaller scales, such as in paintings showing trees towering overhead, with distant blue skies beyond the foreground and mid-plane branches and leaves.

Astronomical imagery returned back from space-based observatories, and processed for the public by telescope public relations teams can also lead to the sense of the sublime. The iconic Hubble Space Telescope image of the “Pillars of Creation” in the Eagle Nebula is a powerful draw, because it reminds us of the awe-inspiring geomorphology on Earth (Kessler 2012). The creation of color composite images for press releases often use guidelines informed by artistic principles (Rector et al. 2017).

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Towards Characterizing the Learning Space of the Digital Dome

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To date few detailed studies have been carried out that focus on the learning gains made when material is taught in digital planetaria. The work of Ka Chun Yu carried out at the Denver Planetarium is one of the few examples of such work (Yu, Sahami, & Dove, 2017) in which marginal but long-term learning gains were documented under the conditions detailed.

Carrying out studies that aim to "map out the learning space" in digital planetaria is challenging for many reasons. Key amongst these is that visual and immersive media are complex terrains to understand as engagement in the planetarium has both cognitive and affective aspects (Slater & Tatge 2017). Thus, personal experience can potentially differ from person to person for the same presentation. In addition, physical features of the planetaria can also play a role, as demonstrated for example by a finding that the difference of an upright and a reclining body can affect spatial mental models (Franklin, & Tversky 1990).

The present work is part of a larger program of detailed studies to characterize the learning space at the Iziko planetarium in Cape Town with the aim of providing evidence-based guidance for teaching. We report here on two exploratory studies that were carried on the same cohort of 75 undergraduate students of an introductory astronomy course at the University of Cape Town during two planetarium visits that were part of the course fieldwork. Both shows used the available SkyScan Dark Matter software. At the end of each show, students were asked to complete a questionnaire that covered issues such as what the show was about, what they had learnt, and to what extent that they had enjoyed the presentation. The questions were structured in a manner that lead to both Likert scale and free writing responses. The questionnaire was based on a standard method used in the Physics and Astronomy Education Research (PhAsER) group at UCT in which a posited debate is used to elicit responses (see Figure 1).

Q1)

Your friend comes up to you after the planetarium show. He says,

"I missed the show! What was the best part of the show?"

What do you tell your friend?

Q2)

Your friend then asks,

"So, what did you LEARN from the planetarium show?"

What do you tell your friend?

Q3)

Your friend then says, "Can you explain to me what you know about the celestial sphere?"

Explain to your friend what is meant by the celestial sphere and why it is useful.

Figure 1. A sample of the questions administered to students in Show 1.

Exploratory Study 1: The show was planned and narrated by the course instructor while a planetarium staff member controlled the software. The learning material was explicitly limited to the geocentric capabilities of the software and primarily focused on the topic of aspects of the celestial sphere that was concurrently being taught in lecture. This topic lasted for about 20 minutes; however a secondary presentation of about 15 minutes included a musical montage of modern telescopes, a review of constellations, a demonstration of earth's precession, and a debunking of astrology. After the show, each member of the research team commented on various issues they had observed. This included the inclusion of the secondary, background music played during the instructor's presenting of the contents, etc.

Exploratory Study 2: Taking into account the observations from the first show, a second, more focused study was carried out. The second show was planned, narrated and, controlled by the researchers with content explicitly using the allocentric capabilities of the software in order to demonstrate relative scales of size in astronomy. This session was adapted from a previous quantitative study that recreated the "Powers of Ten" visualization as a planetarium experience (Yu et al. 2017). The content was chosen because of its disciplinary scalability in that multiple age groups could potentially both understand and appreciate distance demonstration. Also, as opposed to the first show, the second show allowed a space-based perspective to be shown, allowing for potential comparisons across perspectives (Plummer, Kocareli, & Slagle 2014; Chastenay 2016). No music was included in order to constrain the sensory modality to the visual, as added irrelevant stimuli has been shown to be cognitively distracting and detract from learning (Mayer 2002).

The show itself was given in two parts, approximately ten minutes each. In both, the space-based camera of the scene begins with a view of South Africa. With the Earth kept fixed to the front of the dome, the camera then backs up to demonstrate the relative distances between various celestial objects. Part A uses a series of concentric circles as a grid visual and the camera maintains a perpendicular path to the grid (see Figure 2a). The spacing of the circles is relative to the object distances and spacing increases by 10 every 10 circles in a logarithmic fashion. Part B uses a counter displayed at the front of the dome with the camera moving along the path of the objects in series, allowing objects to come into view starting from the rear of the dome. The counter normalizes its unit after every object (see Figure 2b). Part A was intended as an allocentric two-dimensional experience with Part B acting as an egocentric three-dimensional experience.

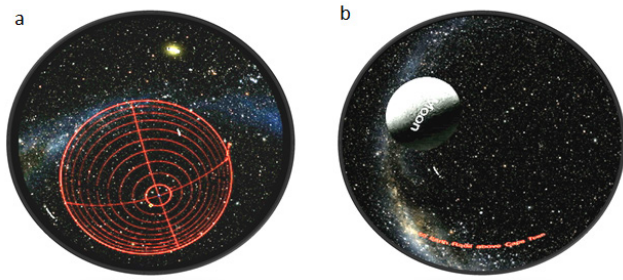


Figure 2. Snapshots of the dome for parts A and B of Show 2.

One of the new additions to the questionnaire (placed under each seat prior to the show) was to include the seat number to allow for the coding of responses to be related to seating position and viewing.

While a detailed analysis of the data is still underway, a selection of preliminary results from both studies are shown below (Figures 3-5). A sample of written responses from students is also included at the end in Figure 6.

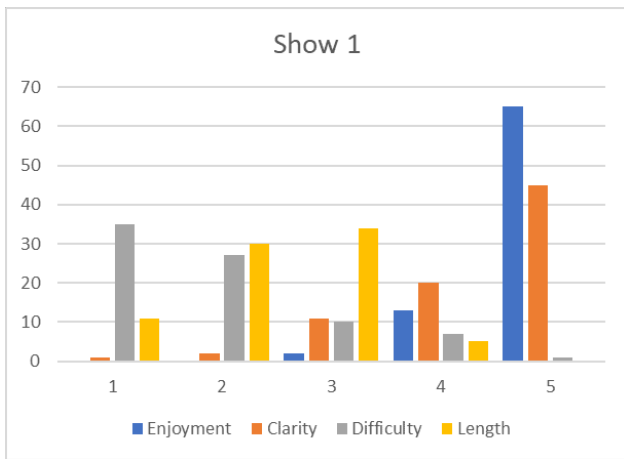


Figure 3. Likert scale data from Show 1. For 1 to 5, Enjoyment is mapped “Not Enjoyable” to “Very Enjoyable”, Clarity is mapped “Very confusing” to “Extremely clear”, Difficulty is mapped “Very easy to understand” to “Very difficult to understand”, and Length is mapped “Too short” to “Too long”.

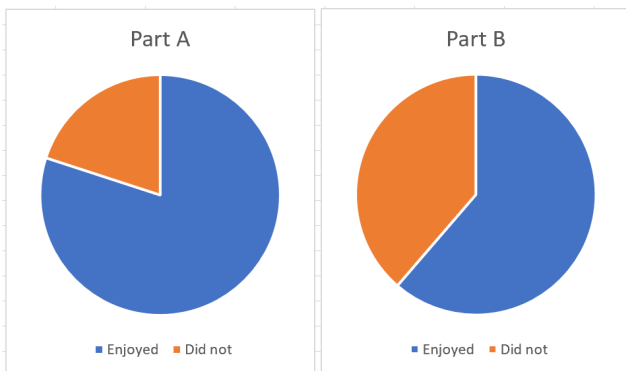


Figure 4. Comparison of Likert scale responses to whether students enjoyed or did not enjoy the two parts of Show 2.

Figure 1

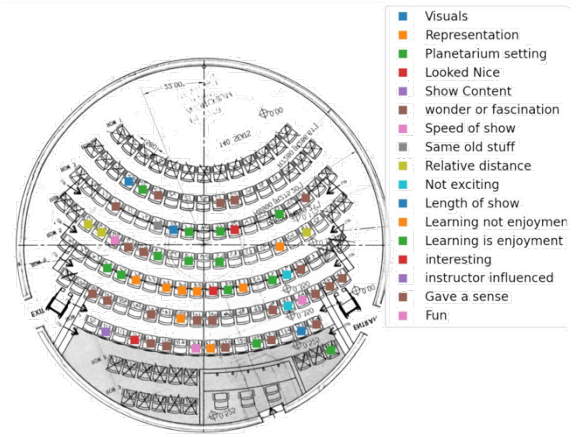


Figure 5. Preliminary coding of Show 2 responses overlaying a blueprint of the Iziko Planetarium seating plan.

The first show where there was music being played in the background and telescopes being shown

The first show where there was music being played in the background and telescopes were shown

The best part of the show was seeing the beauty of the stars and learning how to visualise the celestial sphere in 3D but in your head.

The best part of the show was seeing the beauty of the stars and learning how to visualise the celestial sphere in 3D but in your head.

Everything was great but my favourite part was when we saw the different constellations and realized that everyone's star sign has changed.

Everything was great but my favourite part was when we saw the different constellations and realized that everyone's star sign has changed.

Figure 6. Sample student written responses for Q1 from Show 1 (see Figure 1).

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The cosmic aesthetics of proprioception

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The aesthetic experience of the planetarium is very unique in a number of ways by being capable of collective immersion in a kind of dynamic architectural navigation of virtual spaces that traverses scales by orders of magnitude. The experience is seamless and usually slow and majestic which technically helps prevent car/spacecraft sickness, which in turn would reveal the conflict between the human senses of vision and balance—where vision says the person viewing is moving but the middle ear says the person is not moving. Yet, as media such as Virtual and Augmented Reality (VR/AR) become popularized, more people learn to detach the senses of vision and balance when there is peripheral motion, and the aesthetics to manage how our senses converge changes.

This presentation argues for the addition of the proprioceptive sense in the aesthetic considerations of designing a planetarium show that traverses these scales, not only from cinematic parameters, but from the understanding that viewers are increasingly becoming familiar with media that has tracking, and thus expect revised aesthetics from the shows—even if shows do not include an individual tracking capability. Moreover, the offerings of planetarium shows in VR mode for the public to watch from home during the time of the Covid-19 world pandemic, where viewers can look around using head mounted displays (including mobile phones mounted in holders), is undoubtedly pushing forward the need to consider an expanded notion of immersive and tracked aesthetics.

Planetariums and perception

Unlike flat screen theaters, planetariums and other hemispherical projection theaters afford the public to look around as if surrounded by the image presented, and having imagery in the periphery of the visual field indicating one is inside the world being portrayed. In recent decades, the advent of digital domes merged digital cinema with star projection systems showing real time movement through the image being seen, and algorithmically scaling to star and galactic realms. Still, such scale shifts are not noticed by the public because the image is usually monoscopic and perhaps there is no parallax to be compared when scale shifting. Even though movement is perceived, scale change may not be acknowledged via the sensory clues in multiple places provided by a planetarium experience.

Cross sensing space

Space is directly sensed and acted upon in many ways by the human body: from looking around, to hearing how sounds echo or reverberate, to humidity and temperature, and the overall the effects of moving through an environment. Even with eyes closed it is possible to have an understanding of the space surrounding the body through sensory clues "through the logic of relation from the point of view of emergent order" (Peirce, cited in Masumi 2002).

It is also worth considering how sensory clues work together in evaluating space, and non-neurotypical individuals such as those who have different sensory motor ranges live in spaces around the world and navigate their daily lives by interacting with the situated planetary space with all their senses and actions, accumulating an understanding that is shared among people, even if there are non-average sensory motor differences in how the space is being perceived. This is done by mapping the world to experiential knowledge which interestingly signifies that shared spaces are what people may have most in common rather than the kind of body or experiential history they may share.

But what about media being such a common environment? Media constrain sensory motor information to what the media utilized can capture, which can be solely an image, a sculpture, a movie, a dance, or any multi-sensory representation. The affordances of tracked representation in turn, unlike static or purely visual media, cover a larger array of the senses and actions that enable experiential knowledge encompassing time and space through proprioception in particular, among other sensory cues. The extended affordances of tracked media affording motion parallax and other spatio temporal cues then require the revisiting of aesthetic parameters on how the senses interact with each other in the accumulation of experiential knowledge.

Proprioception and space perception

The inclusion of the proprioceptive sense (that is, the sensation of position in relation to other forms in the environment and of the movement of the body) in media therefore calls into question how some senses associate with spatial relationships and motion, and following that, to the overall experience of being in space with a human body. In older media, conventions developed to establish a relationship between the media and the body. The relationship, however changes with the notion of a non-fixated point of view from where space is declared (Aguilera-Rodríguez 2019). Non-tracked and not immersive have been media of confrontation analyzed from an outsider point of view which now has parameters different from Virtual and Augmented Reality (VR/AR). According to Dan Sandin, VR is "the first redefinition of perspective since the Renaissance" (Sandin 1998, p.14). That redefinition, it could be argued, in turn redefines the aesthetic experience of all media as it primes the senses and actions to project spatial and temporal expectations into representation. In VR in particular, both motion parallax and stereoscopy tell the person what scale the world is. The slightly different views generated by the separation of our eyes for near objects allows for comparison of objects to the body, whereas motion parallax, that is moving the tracked head or body through space, significantly afford calculating the scale of larger and/or distant objects.

The reformulation of space enabled by tracking technologies therefore has brought a sense of presence in the virtual spaces being navigated as well as a sense of proprioception that tells the person what their spatio-temporal relationship in the form of scale is to the virtual environment. As planetarium shows are shared with the public in VR mode through HMDs, and new shows are designed to be presented at planetariums, the sense of scale must be either presented along with, or by suggesting the agency of a tracked device. For example, through intentional motion parallax that suggests natural human navigation.

In this regard, it is no coincidence that in recent years movies have started using the shaky camera technique that enhances motion parallax in order to resemble first person tracking and not just to suggest earthquakes and accidents (something that would have perhaps been frowned upon just a few decades back). Therefore, designing proprioceptive agency is paramount to contemporary media.

Planetary aesthetics and cosmic scales

At the turn of the twentieth century, imagery, objects and buildings shifted to styles related to fast motion enabled by the increasingly familiar experience of moving trains and cars, yet what is at stake is not about style which provides a finish but aesthetics providing perceptual consistency and a “formal coherence as we see in nature” (Munari 1966, p.30).

In gaming, navigation and exploration, and therefore composition of a first or third person point of view is not just a style but a means for spatial agency (Murray 1997, p.126-153). The first person character is a scale reference as are the environments where the action takes place. Motion in such cases is anchored in familiar forms and objects of human scale and further expressed in a body equivalent. And still, there is no change in scale in those kinds of games. The aesthetics are those of the planetary experience of a human moving through known kinds of environments that broadly match planetary physics.

And yet humans inhabit the cosmos encoded in Earth’s planetary experience, understanding how senses couple with planetary physics, not individually, but in specific multi-sensory configurations derived from the existence of the human body on its host planet. Configurations held to corresponding feedback points among interdependent clues with which the inhabited cosmic environments are constructed.

Perhaps inhabiting another planet or moving through space at gigantic scales need not be always slow, fast to the point of not seeing but flashes of light or for constant speeds that suggest weightlessness. For example, applications such as Universe Sandbox (<http://universesandbox.com>) afford playing with physics while seeing what happens when interdependent parameters change. Some stereotypical depictions of interactions with alien environments in planetarium shows may have been practical in order to alleviate sensory conflicts from the audience but just like shaky cameras in cinema can be used to present more than earthquakes, the way navigation itself is depicted can increase a sense of proprioceptive agency to characterize the physics of

other worlds from available data. For this level of expression and scientific visualization to make sense, however, the public needs to learn to observe and understand the basis of our human proprioceptive existence on planet Earth.

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Thinking Outside the Dome: A Case Study in Immersive Presentation

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In the early 1700s, Maharaja Jai Singh II built five astronomy observatories, known as Jantar Mantars, in north central India. The Maharaja’s interests in science, mathematics, astronomy, and astrology led him to design and build large masonry structures for naked eye sky observation. His rationale was that the brass astrolabes used to determine the positions of celestial objects were too small for precise measurement and lost accuracy over time as their moving parts became worn. His solution was to build instruments, many of his own design, at extremely large scale and to give them the permanence of masonry construction. The Samrat Yantra in Jaipur for example, an equinoctial sundial, has a gnomon that reaches more than 70 feet in height. The size and forms of many of Jai Singh’s instruments are such that human observers become immersed upon approaching or entering them.

This was my experience when I first encountered the observatories in 1989, and the immersive experience became one of the foremost principles I applied when in 2001 I began developing a website and a body of visual work to celebrate the Jantar Mantars and bring them to the attention of a global audience. www.jantarmantar.org features virtual tours based on spherical panoramas, along with descriptive and explanatory material about the observatories and how they work.

In 2005, as part of the Western Alliance of Planetariums conference, I presented a selection of panoramas of the Jantar Mantar in the dome theater of the Gates Planetarium at the Denver Museum of Nature and Science. The presentation placed the audience, virtually, within the walls and curved surfaces of the observatory's instruments. In 2010, I began a collaboration with Mark SubbaRao, Director of the Space Visualization Lab at the Adler Planetarium, that led to an immersive lecture about the Jantar Mantar with perspectives on the history of naked eye astronomy in India. The presentation incorporated live music and a live lecture and programmed sequence of panoramas and 3D models to move the audience from place to place within the observatories in accord with the lecture.



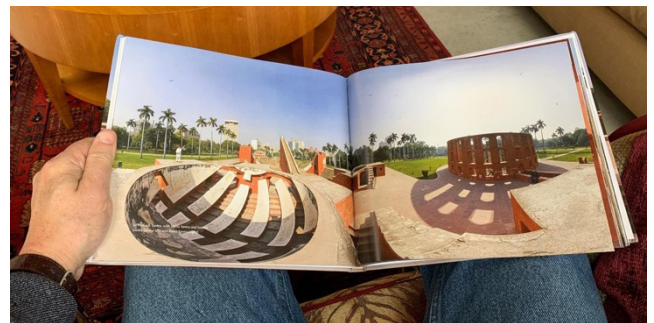
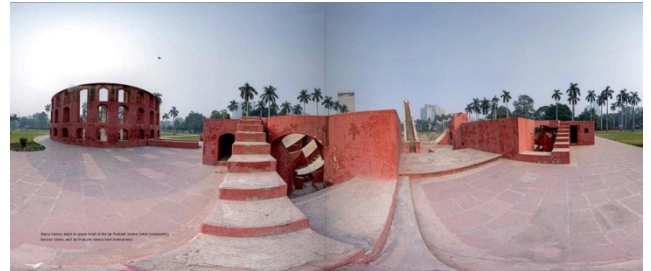
The author, right, with Dr. SubbaRao at the base of the Samrat Yantra as projected in the Grainger Sky Theater at the Adler Planetarium in 2013.

At the same time that I was learning about the dome theater and its power as an immersive space, I was developing a book about the Jantar Mantar that would make use of the extensive photographic work I had done there. The hours spent in conversations with Dr. SubbaRao and occasional visits to make tests in the dome theater began to inform the approach I took in the design of the book and the decision to devote a major portion of the book to the idea of immersion.

The spherical panorama is a perfect source for immersive content. Capturing everything that can be seen from a single viewpoint, it places the viewer within the world that existed at the moment of capture. A flat, backlit display incorporating projection software enables a vivid virtual experience by presenting a window into that world with realistic color and detail. A projection of the image in a planetarium dome, enables an immersive experience by eliminating nearly all other references.

We know that books can be immersive in the sense of storytelling, capturing our imagination and fascination with a character or plot. But how does a book become immersive in the sense of visual experience? Since the beginning of my work with spherical panoramas, I have made equirectangular projections and presented them in the form of exhibition prints. To many viewers they are at first glance exotic looking and disorienting because of the distortion required to map the spherical surface to a 1:2 rectangle. But longer time spent with an equirectangular projection leads to the discovery that one can become oriented with respect to the image, and that our eyes and mind can learn to

translate the image into a seamless, sweeping space that brings us in. This feature became the anchor for the Immersion section of *Celestial Mirror: The Astronomical Observatories of Jai Singh II*. It was designed in a landscape format that mirrors the 1:2 format of the equirectangular projection when the book is opened. The book is comfortably sized to be able to be held close, affording a more immersive experience, and the detail and color along with the tactility of the page and the experience of holding the image help intensify the experience.



Double page spreads from Celestial Mirror: The Astronomical Observatories of Jai Singh II.

It's still on my agenda to develop an immersive presentation based on the Jantar Mantars that can be shared to planetarium theaters anywhere, but in the meantime I think it is also worthwhile looking, and thinking, outside the dome.

SCIENCE STORYTELLING FOR THE PLANETARIUM

Ka Chun Yu
Carolyn Collins Petersen
Dani LeBlanc
Ryan Wyatt

Abstract: Storytelling is a fundamental skill for anyone who plans to deliver a presentation or write a script for the dome. However, most planetarians learn about storytelling on the fly, discovering by trial and error what works and what does not. This session will help remove some of the mystery behind this skill by covering the science behind storytelling; structures for creating engaging science stories; guidelines for storytelling and scriptwriting for an immersive medium; and expanding on the spatial and embodied experience defined by the “Academy style” of fulldome storytelling.

Science Storytelling Structure

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Stories have a bad reputation in science. An often-repeated aphorism is that “the plural of anecdote is not data.” This implies that in science, we cannot rely on just one story or example about a phenomenon in nature. It is dangerous to generalize a single sample. Instead, multiple confirming examples, preferably with data collected from careful observations, are necessary to derive any conclusions.

However, despite this adage, single stories are usually the best way to communicate with the public. Storytelling, through thousands of years of refinement, is one of the most compelling ways to communicate. The human brain may in fact be wired for storytelling (Gottschall 2012), with scientific research now showing how stories can engage and keep the interest of their audience. Stories are easier to read and remember than other forms of exposition (Zabrucky & Moore 1999). When stories are used to convey information, people remember that information better and can even perceive it to be more truthful (Dahlstrom 2010). Studies using fMRI scans show that both storyteller and listeners show the activation of the same parts of the brain when telling or listening to the same story (Stephens, Silbert & Hasson 2010), while brain scans show that movie scenes can similarly activate the same parts of the brain in multiple individuals (Hasson et al. 2008).

Science communicators at planetariums are competing with other media sources for public engagement. Even for well-publicized astronomical phenomena such as the 2017 total solar eclipse, the public actively visited a planetarium or science center at far lower rates when compared to other sources of information such as newspapers, magazines, the Internet, public libraries, television shows, and YouTube videos (Miller 2018). Many of the content creators in those other media are already adept at telling stories, with many having spent substantial fractions of their careers mastering the art form. Hence, learning to tell effective science stories will help planetarians stay competitive with their peers.

One of the biggest proponents of using storytelling techniques for science communication is Randy Olson, a marine biologist who quit a tenured professorship to attend film school at the University of Southern California, so that he could learn from the entertainment industry to craft science stories. In his workshops and books (Olson 2009, 2015, 2019), Olson has identified the difference between science communication that conveys rote information that is forgettable versus information that is relayed effectively using a story-based narrative framework. He calls the former the “And, And, And” (AAA) approach, where statements of fact can be linked together by the conjunction “and.” Unless the person listening to this type of story is already interested in the topic, the AAA approach can fail to stay interesting and engage the listener. The AAA story has no conflict to resolve, does not reach a narrative conclusion, and hence is unmemorable.

The second technique builds on the type of stories that human brains are wired to enjoy. Olson’s “And, But, Therefore” (or ABT) is similar to the three act structure found in fictional narratives, involving a setup, a conflict, and a resolution. The “And” statements introduces facts that are not in dispute and can be agreed upon by all parties. There is no intrinsic tension or conflict around this introduction. The “But” section gives out information contradictory to the “And” statements, inserts tension and conflict, and makes the audience question the setup. Finally, the “Therefore” component resolves the conflict between the “And” and “But” sections, and allows the narrative to conclude. As formalized by Olson, the ABT framework can be used to describe story-based narratives in media as distinct as scientific papers, movies, songs, comedy routines, and political speeches.

The ABT format can be used to construct astronomical science stories for planetariums. Many classic planetarium presentations describe phenomena and concepts that are remote, unfamiliar, and abstract for the public. Instead of a list of facts that an audience member may forget immediately outside the planetarium, ABT reconceives the information into a memorable narrative form. The following story examples are based on ABT, but they also fall into three separate categories that I label as *individual struggle*, *historical struggle*, and *misconception-based* stories.

Stories of *individual struggle* in science—which could involve the difficulties of understanding nature, or conflict with others who have similar or antagonistic goals—draw the listener in by personalizing a scientist’s conflict, to make it understandable and relatable. The following two examples are story outlines for Isaac Newton’s discovery of his laws of motion, and the more recent discoveries surrounding fast radio bursts. In these examples, the conflict and drama come from the protagonist(s) trying to uncover the laws of nature, or investigate a novel natural phenomenon:

Newton’s Laws of Motion:

Johannes Kepler had developed empirical rules describing motions of the planets. This included showing that planets moved in elliptical orbits **AND** that their speeds varied in their orbits depending on their distance from the Sun **AND** the orbital speeds also varied from planet to planet based on its average distance from the Sun. **BUT** the principles merely describe what is happening in the universe. They do not explain why it is happening. Mere description does not reveal any underlying principles or tell you about universal laws. During a 2-year long stay in the countryside to escape the plague, Isaac Newton built on the work of Kepler and Galileo. He had to invent calculus in order to succeed, but Newton was able to derive laws of motion that tied together the concepts of force, velocity, acceleration, and mass. **THEREFORE**, Newton came up with his three laws of motion that unified the motions of objects on Earth as well as the orbital motions of planets and moons. This showed that universal physical laws could be discovered that applied everywhere, not just on Earth. It also showed that mathematics was a powerful tool that could be used to describe the physical laws.

Fast Radio Bursts:

Astronomers have discovered and explained many extreme phenomena in the universe. For instance in the 1960s, powerful, regular radio signals were discovered from objects that turned out to be rapidly spinning neutron stars, an end stage of massive stars. **AND** astronomers have known about cataclysmic events that occur when massive stars die in the form of supernovae and gamma ray bursts. **BUT** starting in 2007, millisecond length bursts of radio energy were discovered accidentally in radio telescope observations. These types of signals didn’t seem to be like anything else we knew about in the universe. Because they happen so quickly and radio telescopes typically see large patches of sky at once, it was difficult to locate exactly where they came from. They also did not appear to repeat, suggesting that they could be the result of cataclysmic one-time events. However, because they did not repeat and happened so quickly, follow-up observations couldn’t be made. We had no idea how far away these events were, and whether they were located inside or outside of our Milky Galaxy. **THEREFORE** astronomers started to dedicate time on radio telescopes to find more of these events. They eventually found over 100 as of today, with a small handful that were repeaters, but many that were not. Follow-up observations by Jason Hessell and his team with telescopes of the repeaters revealed they were located in distant galaxies. However, we still do not know whether FRBs are two different types of phenomena (cataclysmic vs. repeating) nor do we have any ideas about what types of objects could be causing them.

Instead of concentrating on an individual or a small team tackling a problem within a continuous period of time, *historical struggle* stories introduce multiple personalities, who can be geographically separated and who work over broad, disconnected spans of time. The drama in a historical struggle is about the collective efforts of many to understand the natural world. Because such narratives have multiple personalities, story arcs, and narrative waypoints, the story can be constructed from multiple, embedded ABTs.

Heliocentrism and Motions of the Planets:

Classical thinkers once believed that the Earth was made of imperfect elements, **AND** the heavens (including the Sun, Moon, planets, and stars) was perfect. Observations showed that the Sun, Moon, and planets appear to travel around the Earth. **BUT** with more detailed observations, models that could accurately depict the observed motions became more and more complicated with the addition of epicycles. In addition, new telescopic observations made by Galileo showed that not everything orbited the Earth (phases of Venus, moons of Jupiter), and the heavens were not perfect (spots on the Sun and mountains on the Moon). **THEREFORE**, Nicolaus Copernicus proposed the idea that not everything traveled around the Earth. Only the Moon did. Instead it made more sense for the Sun to be in the center of the universe, and everything else (including Earth) to move around it.

[**AND**] The Copernican model was successful in explaining some phenomena. **BUT** it still relied on circular orbital motions, which meant epicycles were still required. **THEREFORE**, using careful observations of planetary motions made by his boss, Tycho Brahe, Johannes Kepler proposed elliptical orbits, with the Sun located at one focus of the ellipse, and planets moving faster when closer to the Sun, and slower when further away.

The *misconception-based story* starts with the incorrect notions typically held by the public about astronomical phenomena, and then introduces contradictory information to create doubt about these prior ideas, so that conceptual change can occur in the listener. In order to construct such a story, the storyteller must be familiar with the types of misconceptions that are common, as well as what information must be needed to address them.

Seasons:

Over the course of a year, we experience the seasonal cycle with changes in temperature and the amount of daylight, and the appearance/disappearance or alterations in the appearance of plants and animals. [**AND**] if you ask someone, they will attribute the seasons to Earth moving in an elliptical orbit so that it’s closer to the Sun in the summer. [**AND**] some people think seasons have to do with the tilt of the Earth putting people on parts of its surface closer to the Sun, and others further away. **BUT** the Earth is actually closest to the Sun in early January, when it is winter for people in the Northern Hemisphere. The seasons are also simultaneously different for people in the Northern and Southern hemispheres. Finally, the Sun-Earth distance is so vast that Earth’s tilt negligibly alters the distance of people on Earth to the Sun. **THEREFORE** the reason for the seasons is due to Earth’s tilt,

not by altering the distance to the Sun, but by changing how high the Sun is in the sky during the day, and the length of the day. The cumulative heating of the surface over multiple days as the days lengthen and the Sun arcs higher at noon results in warmer summers. The opposite patterns lead to colder winters.

Restructuring a science narrative around ABT is more difficult than simply listing facts via AAA statements. The ABT story requires statements that conflict with each other in the “And” and “But” sections. The narrative requires that the storyteller understand the scientific discoveries that allow the “Therefore” section to resolve the contradictions between the previous two sections. Thus, it is simply not enough to list facts, but context is needed to drive the narrative forward from one stage of ABT to the next, leading to a conclusion that is satisfactory to the audience.

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Immersive Storytelling

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tell a tale in a space that imposes visual and auditory constraints that other types of venues (classrooms, regular theaters) do not have. Because audiences are surrounded by the visual and auditory experience, it’s important that the story be equally immersive—but not overwhelming.

We are not just telling the audience facts and figures. We are creating a realm in their minds in which our story can exist. The words we give them assume shape and form within that realm. The visuals they see and the sound they hear are all integral parts of that story. Remember that when crafting your tale, and don’t let the other two thirds of the “sensory experience” overlap your story. The voice of the story (the narrator) may be the only human “touch” in the story, so our narrative should be crafted as conversational. It should be a “one to one” story, reaching into the audience member’s mind to deposit the story we want them to remember. It should also engage some emotion in the audience member without overdoing it.

The storyteller utilizing the dome must take into account the possibility of audience overload when crafting the tale they want impart. The oldest advice in the book is still valuable: keep it simple. Or, less is more.

Storytelling at the Charles Hayden Planetarium

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The Charles Hayden Planetarium in Boston has been producing and presenting most of its own content since it opened in 1958. There are over 400 show scripts in the institution’s written record including a myriad of live presentations from the Planetarium’s early days (using its star projector only), to its automated, slide-projection shows of the 80s, 90s and 2000s, to the handful of the Planetarium’s most recent full-dome digital productions. However, many of the lessons and principles in good Planetarium storytelling transcend technology, and equally important, many are evergreen. Before its staff entered the full-dome show production scene in 2010, the Boston team was highly experienced at producing shows for an immersive space and telling stories in a dome. These learned experiences informed and prepared them to adapt quickly to the production of shows in the digital era. Many of these considerations—including finding the balance between script, visuals, and score—have led the production team to awards in science storytelling. More recently, the team has begun to play with its familiar principles of traditional Planetarium storytelling. They have experimented with other narrative styles, including a first-person voice narration used in the Planetarium’s most recent production, *Destination Mars: The New Frontier*.

Each of the topics of the Museum’s four full-dome productions (the search for exoplanets, the richness and variety of moons in our solar system, the excitement of spacecraft exploration, and humankind’s path to Mars) were selected for different reasons. But in each, the show’s scripting process could be broken down in similar ways:

Storytelling for full-dome media requires creators to be able to

- Find the themes and ideas within the overarching topic that can connect to what excites and interests an audience, while meeting the educational and creative goals of the program.

- o Ideas for key concepts or scenes may start coming out in fragments or sketches.

- Building on these sketches, develop a treatment—a fleshed out outline—that can serve as a backbone of the story and guide the pacing and flow of the show’s words and visuals.

- o The treatment identifies the most powerful visual scenes and important educational concepts.

- o The treatment can also be used to manage the show’s time budget.

- Begin writing drafts of scenes in whatever order comes naturally, or as inspiration strikes, and continue to plug these in to the show’s backbone. Sometimes these just come out a few lines at a time. Often the words are really bad when they first come out.

- Keep working through the scripting of scenes, paying attention to the balance between a scene’s visuals and the words in the script, and making space for each to exist without the other.

- o Anticipate these moments as much as possible but know that as the different elements come together, finding the balance between words, visuals, and music becomes easier.

- o Read and/or record sentences aloud to ensure the writing style sounds consistent and natural when spoken. Listen to and refine phrase cadence as needed.

- As soon as scenes or major sections of the show’s script are complete, do a scratch (temporary) recording of the words and begin to lay it out against the draft visuals.

- o This process is extremely iterative.

- o Editing is happening throughout.

- o Find the balance in your word count. Say as much as you can in the fewest words possible.

- o Science and/or content advisors can assist with accuracy.

- o In refining the script, be deliberate about word choice. Each word has an impact on the conveyed meaning or emotion.

- o In the scratch read, leave some breathing room between sentences, to give viewers a chance to digest the show’s content as it plays out. The music track will naturally fill in any gaps. To establish this pacing, it may help to listen to scratch reads with a temporary music bed underneath.

- This cycle of sketching, drafting, editing, and refinement continues throughout the production and overlaps with visual development so that narration and visuals can be developed concurrently and responsively.

I have been writing and editing show scripts since 2003, and have writing credits in more than a dozen of the Charles Hayden Planetarium’s show titles. These are a few of the regular practices that have emerged from my experience scriptwriting for the Planetarium. The above is not meant to be a standard recipe

book, but instead, is an example of a process that can guide the development of a show’s story. While our team recognizes that these stylistic and creative choices that have worked for the Museum of Science and its audiences, we also enjoy surprises and encourage our colleagues to break the rules sometimes to see what else works!

Expanding Academy Style

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The California Academy Sciences has produced seven award-winning planetarium shows in the last dozen years. Six of these followed a general pattern outlined in the “Academy style” article published in *The Planetarian* last year (Wyatt 2019). However, for the seventh, most recent show, *Big Astronomy*, the production team needed to change its way of working.

For most productions, the Academy’s visualization studio has worked almost entirely in computer graphics, following a production approach nicknamed “Academy style.” In brief, the intent is to create human-centered content (including, for example, starting shows at a human scale) that minimizes cognitive load on the audience (primarily accomplished by maintaining camera motion and continuity in the form of long camera moves and keeping visualizations “easy to read”).

With *Big Astronomy*, the production team had no intention of abandoning these stylistic choices, but “Academy Style” had to grow to encompass a very different story—namely, the first-person narrative of the people who work at Chile’s great observatories. The backbone of the show is a series of interviews conducted with nearly 30 people, both in English and in Spanish. The interviewees describe their work at these great observatories, detailing their jobs and sharing their perspectives on how they got interested in the work, and in the process, highlighting the variety of STEM careers that contribute to the function of “industrial-scale” astronomy.

Among other outcomes, the show sets out to disabuse audiences of the idea that astronomers observe the sky all alone, with their eyes glued to the eyepiece of a telescope. By introducing a diversity of people and allowing them to tell their stories in their own voices, the show attempts to give viewers a new perspective on how observatories work.

To complement these interviews, the show uses full-dome footage of the interviewees doing their jobs—against the backdrop of the Chilean landscape and the monumental observatories Cerro Tololo, Gemini, and ALMA. No attempt was made to have people speaking to camera, in large part because the bilingual nature of the production required the visuals to work with either an English or a Spanish soundtrack.

Rather than employing a multi-camera set up (e.g., a GoPro six-head camera), the team elected to use a cinema-grade camera with a fisheye lens. After some testing, the team settled on a Sony

Venice 8K camera, combined with a Canon fisheye lens. As an added bonus, the Sony Venice supports a split-head set up that allowed the team to mount the lens and detector separate from the camera's electronics, enabling shots to be made with a Ronin (a three-axis stabilized mount similar to a Steadicam). This permitted a shot, for example, in which the crew followed one of the documentary subjects as he walked through the desert—a hand-held shot in fulldome!

Other camera mounts included a jib arm and a Dana dolly. The team even set up a fixed camera on a scissor lift in order to move the camera vertically through the large volume of an observatory dome.

In each case, the technology allowed the team to move the camera seamlessly and steadily through a shot, in keeping with the “Academy style” approach to maintaining camera movement. Although the average shot length in *Big Astronomy* is much, much shorter than the average shot length in previous Academy productions, the attempt was consistently made to create shots that provided context and continuity. Critically, keeping the camera in motion allows for a sense of dimensionality in the imagery—when the camera is not moving, the image becomes relatively static and two dimensional.

Not every shot in *Big Astronomy* makes use of a physical camera, but only about a third of the film is computer-generated. Sequences in the film include contextual graphics describing Chile's unique physical environment—ideal for observational astronomy—and the remarkable discoveries made by the observatories related to the formation of planetary systems. By expanding on “Academy style,” the human story and the astronomical story are woven together in a way that allows audiences to learn directly from the people who live and work in Chile at the great observatories that make *Big Astronomy* happen.

References

Wyatt, R. 2019, “Academy Style: An Institutional Approach to Fulldome Storytelling,” *The Planetarian*, 48(2), 24-28, 30, 67.