PROCEEDINGS OF THE 58TH ANNUAL

G.L.P.A. CONFERENCE

BUFFALO, NEW YORK
OCTOBER 18-22, 2022

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Invited Papers

Contributed Papers

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STORIES FROM A CHILD OF THE SPACE AGE

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From time immemorial, stories have been part of all cultures around the world. Young children clamor for stories from their parents. Elders use stories to pass on their wisdom and cultural values to the next generation, providing a connection to the past and a conduit to the future. Stories add richness and meaning to our lives. As planetarian professionals, much of our time in the dome is spent telling stories, whether they be in the form of narratives that educate and entertain our audiences or the rich mythology of the night sky. In this talk, I will share some of the stories that have shaped and molded my personal and professional life, with the hope that you may find similar meaningful and personal perspectives in your own life.

I hardly feel like I need to speak at all, after such a marvelous introduction by our President Dan Tell. Dan, as you read the letter from Armand Spitz, it reminded me of visiting the International Planetarium Society (IPS) archives. In the archives was the annotated copy of the speech that Grace Spitz gave as the first Spitz Lecture. There were notes in her own handwriting and it was just an incredible document to hold, a piece of history and to remember our origins.

You mentioned dreams, or maybe it was Armand Spitz who menttioned dreams in his letter. I had a dream. Well, maybe I should call it a nightmare. It was last Sunday evening. In my dream, I was at the conference and the conference was just getting started and breakfast the first day had been completed. Dan got up and said “Okay we're having the Spitz Lecture by Dave Weinrich.” I said, “What this isn’t Friday!” He said, “But we changed the schedule, didn't you know that?” So, I went running out to my car, to try and get my notes and more I tried to get the papers together, the more they scattered, and it was almost an impossible task. And here was the nightmare part. Someone, I have no idea whom, but someone came out and whispered to me, “You know, Dave, they really don't like you.” “Dave, they’re all against you!” And that was when I woke up and I said, “What a bunch of baloney!” Because I know that all of you are friends and colleagues. I know that and feel that. We're part of a family, as Dan and so many other people have mentioned. We're part of a family, a worldwide family. When we meet planetarians from other countries we find commonality. I'll tell some stories about some of those encounters and hopefully as I tell these stories, I hope that you will be able to identify things in your own life, things that you have experienced and that you can personally relate to the stories.

The magic of Storytelling. I’m just going to share one slide about a program that was presented a few years ago at Minnesota State University Moorhead, where I worked. We had a program where some Native American storytellers had a program where they told stories and taught crafts. They came into the classrooms of a Native American school nearby. As they taught the students how to make crafts, they were told stories about the sky and the Universe. I came and taught lessons about the sky, for example the planet Venus, to provide some context for the stories. One of my favorite stories was “The Star in the Cottonwood Tree.” If you cut a cross-section through a Cottonwood Tree branch, you will see a little star in there. The Dakota had a story of how that star got there. The star was wandering around and it found a village that it really liked. But he didn't want to alarm the people by being too close. It decided to go and hide in the Cottonwood Tree, so that it would always be close to this village that it admired.

I was a child of the Space Age. I was growing up in the early 1960s and I remember that I was already

interested in space. I didn't develop an interest in astronomy until a little bit later. I remember coming home from school, excited to get home in time to watch one of the first Mercury launches. I'm pretty sure that it was probably Alan Shepard because it was when we were living on a certain farm. It was on a school day so it had to be during the school year, so that narrows it down to the first launch. So I, at a very early age, became interested in space and was excited about it.

I wasn't interested in astronomy yet. I grew up on several different farms in Southeastern Minnesota, and when I was young, I was kind of afraid of the dark. We lived a farm where it was really, really dark. It was a long way from the house, over to the barn in the dark. I was a little bit afraid of the dark. I did later become interested in astronomy and of course I was no longer afraid of the dark because that's when you see the stars. This has always been one of my favorite sayings. "I have loved the stars too fondly to be fearful of the night."— Sarah Williams, "The Old Astronomer to His Pupil." It's inscribed on the tomb of John and Phoebe Brashear at the Allegheny Observatory. Isn't that a nice epitaph? "I have loved the stars too fondly to be fearful of the night." I remember, a few years ago, I was part of a discussion group, and I was telling the other members about how the stars connect me and I make me feel at home, wherever I go around the world. They give me a sense of peace and permanence. The stars have been there long before I came around and they'll be there long after I'm gone. It just makes me feel good. It gives me a sense of connection to the Universe.

I was about 12 or 13 when I first started looking at the sky. I was the oldest of six children and one of my brothers had an assignment to go out and find some constellations and being a good older brother, I went out with him. We went out on a dark Minnesota night. I think it was a February evening. We looked at the sky and found the Big Dipper and the North Star. We felt really pretty good about ourselves. Well, my brother went on to other things. He never became interested in astronomy, but I did. And so few nights later, I went out and tried to find the Big Dipper again and the North Star. And I happened to turn the opposite direction and said, Wait a minute, there's the Big Dipper of the North Star." "What did I see the other night?" I had seen the constellation of Orion and I thought Orion was the Big Dipper, and the course North Star must be the brightest. That was Betelgeuse. So, how in the world that I make it into a Dipper? Well, here's how I did it [slide shows some of the belt stars and other stars in the lower half of Orion, that I managed to construe as a twisted version of the Big Dipper and the North Star]. So that was my first constellation. Now, I did learn a little over the years and I forget what IPS conference it was that I won the constellation shoot-out.

Our parents, they always tried to give us gifts that were related to what we were interested in. My parents gave me a telescope, a spyglass really. It had no mounting, with a high magnification, so I'd have to hold against a fence post to balance it. But I used it to observe many celestial objects . If you're interested, you can find an awful lot of stuff with just a pair of binoculars.

Then in 1966, when I was first interested in astronomy, some of you might know about the great Leonid meteor storm of 1966, the meteor "storm of the Century." Well, we lived on a small farm and the night before I'd been sick, so the next morning when I'd normally be up before dawn, my dad let me sleep because the night before I'd been sick. Then after I got up after sun rise, he told me about this storm. He didn't know what it was. And I said, "Dad you let me sleep through this wonderful event!" I never let him forget that. I'd always remind him how he let me sleep through the meteor "storm of the century.

Some of you probably aware of "the photon connection," a term originated by Jim. Mullaney, from Pittsburgh's Buhl Planetarium. He still writes occasionally for Sky and Telescope magazine. He had an article in the magazine about thirty years ago, about how when you look at a star, you're connected to the photons of light which have traveled for decades, even hundreds of years. When they strike your eyeball, there's a connection between you and the Universe. When you're looking at stars and galaxies, you're connected to the Universe.

A few years ago, I had the opportunity to go to the Week in Italy, sponsored by Italian planetariums. I woke up early on my first day and went out to look at the stars. I was thinking that I had heard a story about Arcturus, that it was the star they used to open the

Chicago World's Fair. They calculated that the light from the star, which was focused on a photocell, had left Arcturus about the time that the previous World's Fair had been held. I went out and looked at Arcturus and remembered that its distance is about 38 light years. I did some calculations and realized that I had been in Italy my first time when the light that I was seeing that morning had left the star. I used that illustration as part of the lesson that I was teaching some of the Italian students.

After I graduated from high school went to Luther College, a small Lutheran College in northeast Iowa. I got to work in the planetarium. That was marvelous! After about a year and a half of working in the planetarium, I realized that I didn't want to be research scientist, I want to teach. I changed my direction a little bit and became a licensed teacher. I had several mentors including the Luther planetarium director Dr. Emil Miller. A few years ago, as I was looking through some of the IPS archives I discovered that Dr. Miller had been at the Conference of American Planetarium Educators (CAPE) that led to the formation of IPS. Even though I was a student of his at the time, I didn't realize that he had went to that meeting.

I had the honor of student teaching under a planetarian that used to teach some of the Spitz Institute classes in the 1960s, Howard Schriever. My work with him helped form my philosophy of planetarium programming. He would come in while we're waiting for a group of fourth graders and he'd be rubbing his hands together, and say, "Oh boy, oh boy, we're going to have so much fun! I learned that you could have fun when you're doing science and that has been my philosophy ever since. Science doesn't have to be boring. Planetarium shows don't have to be boring. They can be fun! You can have fun with the kids as you educate them.

I taught at West Point. When I say that I always add softly, "Iowa." It was my second teaching job. But I need to talk about my first job, in fact for many years I wouldn't share this, but my first year of teaching I had a horrible time. I didn't know how to discipline my classes and by the end of the year, the principal told me, "You can either resign or be fired." But failure, isn't that big a deal, is it really? I mean, you just go on and try something else. How many times that Edison fail before he invented the light bulb. I came to a point of several years ago where I'm not ashamed to say that I was fired from my first job. It was just a learning experience. But even when I was at West Point, I still wasn't quite happy teaching. I still had some discipline problems and that leads me to the framework around which I've structured my talk this evening.

In 2005 Steve Jobs gave a commencement address at Stanford titled "How to Live before You Die."

The first point he made was about connecting the dots. *"You can't connect the dots looking forwards, you can only connect them looking backwards, so you have to trust that these dots will somehow connect in your future. You have to trust in something: your gut, destiny, Life, Karma, whatever. Believing that the dots will connect in the future will give you the confidence to follow your heart, even when it leads you off the well worn path and that will make all the difference."*

I didn't know that back when I was a Iowa science teacher, but I can see looking back now and connecting the dots, I realize that I did follow my heart and not the well worn path. My family sometimes thought I was crazy. In the mid 1970s I applied for some planetarium jobs and for one particular one in Hutchinson Kansas, at what later would become the Cosmosphere. I didn't get the job. The person who got the job was Mary Jane Butler (now Dodge), a woman who had been a student worker at what was then called Moorhead State University, which is where I eventually worked. I've never met her, but I'm going to meet her next week at the 50th anniversary of our planetarium at Minnesota State University Moorhead. Mary Jane later became quite prominent working in Giant Screen Cinema and IMAX.

So, she got the job. So, was that failure? No, not really. When I look back at my life, I realize what I would have missed if I had gotten that job in Kansas. I'm glad I didn't get it because if I had gotten that it, I never would have had the rich experiences that I had over the next 4-5 years.

As a teacher I had my summers free. Although some teachers need to work to supplement their income, I chose not to and spent my summers traveling around the USA and eventually Europe in the summer of

1977. I had caught the travel bug and decided to apply to the Peace Corps. I applied to the Peace Corps thinking, I probably won't go, but doesn't hurt to apply. The University of Iowa had a program encouraging teachers to serve in the Peace Corps. If you joined the Peace Corps, they would find someone to replace you at your school and after two years when you came back from the Peace Corps, you would get your old job back. But by the time I was accepted and invited to a host country, I found out that they hadn't been able to find a replacement for me. However, I was committed by this time and didn't care if I got my job back. I was going to leave this job and go off to West Africa.

That was one of the best things that ever happened to me! I went to Liberia. It was marvelous—the culture, the people, the students. And I remember one night setting up the telescope that belonged to the school, to look at the Moon and some bright planets. I was almost stampeded by the students. Everyone wanted to take their first look through a telescope. Astronomy fascinates everyone.

After serving two years as a Peace Corps Volunteer in Liberia, I transferred over to Ghana for two more years and taught secondary school science. I didn't meet Dr. Jacob Ashong until 25 years later, but I was gaining the experience that I would need for the Ghana Planetarium project. When I did meet Jacob and his wife Jane in 2006, we were able to work together to build the first public planetarium in West Africa.

Several years ago, Brother Guy Consolmagno spoke at a Great Lakes Planetarium Association (GLPA) conference. I wasn't there. I don't know where I was. I think that I was probably overseas somewhere. Brother Guy was a Peace Corps Volunteer before he became a priest. He served in Kenya. He had an astronomy degree and was assigned to teach astronomy at a university in Nairobi. He thought, "What in the world am I doing here? Why teach astronomy when there are so many people sick and starving here?" But periodically he would travel out of Nairobi, out into the countryside, to visit some of his fellow Peace Corps Volunteers that lived in small villages. He would give slide presentations about astronomy and set up his small telescope so that people could look at the Moon and some of the bright planets. Everyone wanted to look! He discovered that people in Kenya got just excited as people in Michigan had when they saw the Moon or the rings of Saturn through a telescope. He began to realize that everyone has a right. and everyone wants to see the Universe. Of course, it's a bad thing to be starving but it's just as bad to deny people the opportunity to participate in the great exploration of space, of going to the Moon, exploring the planets and finding out about the Universe. You deny that to people and you're denying a fundamental right. Everyone should have the opportunity, the chance to learn about this fascinating universe that we live in. And I said, "Yes, that's exactly what I've learned over the years."

The second point that Steve Jobs makes in his speech is: *"find what you love to do. The only way to do great work is to love what you do."*

Find your passion and try to get a job in that area. Of course, I never followed that advice. I'm not passionate. Am I?

I came back from the Peace Corps and at the last minute on the day, actually that the application process was closing, I read about a planetarium job opening at Moorhead State University. I called them up the next day and asked, "Is it too late to apply?" They replied, "No, please apply." A few weeks later I was invited to an interview and they offered me the job. As with most major decisions, I asked for some time to think about it before making my final decision. The job was only half-time. I certainly liked the job but was not certain that I could live on that salary. I went to an old friend in the church that I was attending and asked for his advice. He asked me, "Is this something you want to do?" Of course, I did! I had been an amateur astronomer ever since my early years as a teen. To get paid for doing my hobby. Who wouldn't want to do that? I said, "Yes, I want to take the job." He asked me, "What's worst thing that could happen if you took it?" Again, the possibility of failure comes up. My friend continued, "You might find out that you couldn't support yourself and you'd have to go somewhere else and get a job. But you're not married, you don't have a partner, or any children to support. It's only you that you must be concerned about, so why not go for it?" Of course, I took his wise counsel and I'm really glad I did as I connect the dots some forty years later.

Eventually, the job did get to full time status, but it took 17 years for that to happen. In the mean time, I took other part-time jobs to supplement my income. I taught labs and recitations at all three of the local colleges. I washed windows and you know, I was made making more money per hour washing windows then I did at the planetarium. I did what I had to do and I'm so glad I that I did because I was happy doing my hobby. I remember telling my boss one time, "You know this is such a great job. I would probably do it for nothing. But please don't tell the administration that." So, find something that you love. Find a passion; be passionate about life; be passionate about your job and what you do.

During the 1990s, I realized I had two passions. Of course, one is astronomy and the second one, because of my experience in the Peace Corps, is science education in developing countries. I wondered if I could possibly combine the two. I'd love to do that, but I didn't know how it would to do it.

In 2000, I heard about a conference in Sri Lanka. I had already spent all my professional development money for the year. I'd been to IPS in Montreal and to GLPA in Chicago. I didn't have any money left. I went to my boss and said, I want to go to this conference regarding astronomy in developing countries. He told me that he couldn't give me the full amount that I needed but if I could convince some other administration people to give you some of the money, he would contribute as well.

I went to University's President, to the Vice President, to the Dean and to several others. I got about three hundred dollars from each person and eventually raised about $1800. I just knew I had to go to that conference. I didn't know why, but I just felt it in my gut, in my heart. Something was telling me to go, so I found a way to get there. I booked a cheap flight for under a thousand dollars that took 48 hours to get there. I got sick with a cold, but I made it.

In a moment, I'll talk about the planetarium in Ghana. I met several of the people that helped to do that project at the conference in Sri Lanka, including Joanne Young and others. If I hadn't gone to the conference, would I ever met them? I knew that I had to go. Something was telling me, "This is your destiny. You have to do it." And so I did do it.

I went to Sri Lanka in 2001 for the conference. I met a lot of people from many countries— India, China, Italy, South Africa, Australia, Japan and of course the director of the Colombo (Sri Lanka) Planetarium T.C. Samaranayake. We always called him Sam. And a couple of years later when I decided to go on sabbatical in Sri Lanka, Sam organized my activities.

When I was in Sri Lanka during my sabbatical, I mainly went to schools and talked to students, usually in groups of several hundred at a time. During the six months I was there, I estimated that I talked to 15,000 students. I remember at one of the schools a young girl came to talk to me. "Professor, why doesn't the sun fall down from the sky?" I talked to her a little while and she asked for my address in Sri Lanka so that we could be pen pals. She started writing to me and eventually her family invited me to come and spend the weekend with them. We stayed in touch for a few months after my return home, but then we stopped communicating. But, occasionally over the years I would look for Dharanee on Facebook. I never found her. Some four or five years ago I received a message on Facebook. "Oh, Professor. I finally found you!" She had been looking for me too! A few months later, she posted some pictures of my visit to her family home in 2003. Some of her Facebook friends said, "I remember him. He came to our school." I became friends with some of them. One of them was of visually impaired and wanted to create programs for other individuals with the same issue. So, I connected him with Noreen Grice and David Hurd.

That's what I'm good at is making connections. Often, I don't know how to do something myself, but I know people who can either do it or know people that can do it. Making connections, that's what I'd really like to do.

I really enjoyed my time with Sam and learned a lot from him. He's really a wonderful and unique person. We spent quite a bit of time together, traveling around the country and having conversations about astronomy and Sri Lanka. Sam is a Buddhist, and he'd talk about life as being like passengers in an airport. Everyone comes and works together peacefully, boards their plane, flies to their destination and goes on their way. They get along. Why can't we get along in this world? Why can't we be like the passengers on

an airplane, cooperating with each other and getting along?

Sam had an astronomy program where he brought young people together who were Hindus, Buddhists, and Muslims with the hope that they would see that astronomy connected them to something much bigger than the conflicts that their country was involved in.

And that reminds me, I was going to talk about something that I discovered while I was in the Peace Corps. One thing I really learned, living in Liberia, and I learned it in my heart from experience, not because I read it in a book, or because someone told me about it. I really felt to the core of my existence that we're all the same. As human beings we're so alike. We all laugh. We all cry. We all want better, things for our children.

We tend to emphasize the differences instead of the similarities. But we're all the same. Why can't we get along? We're more alike than we are different. I talk about this concept frequently. I was telling this to one of the hotel clerks the other morning at 4 am. It's like I'm preaching the gospel wherever I go, telling people, "You know, we're all the same, we're not that different. Why don't we get along?" Sam used to talk about astronomy and how it could be used to unite humanity, to bring us together, and to look at something bigger than this planet and its problems. He really had a vision about using astronomy for that purpose.

Synchronicity sometimes occurs. In 2006, the family I used to live with, in Liberia lost their youngest son in a car accident. I went to the funeral in Liberia and had to travel through Ghana to get there. I'd been corresponding with Dr. Jacob Ashong for a few years. He heard that I was passing through and wanted to meet at the airport. He started talking about his dream. He had a big dream.

For over twenty years he had dreamed of a Science Center and a planetarium in Ghana, and he never gave up on that vision. He talked so passionately about it, that his vision inspired me. I decided to help him fulfill his vision. When I got home, I contacted various planetarium companies and tried to find an inexpensive projector. Nothing happened for a while. Several planetarians had a brainstorming meeting in the spring of 2007, but still nothing happened.

But that all changed when we went to the Triple Conjunction Planetarium Conference (GLPA, MAPS and SEPA) in the fall of 2007. Joanne Young told me that Jon Elvert's facility, the Louisiana Art and Science Museum, had donated a digital projector. Joanne and I sat together during a one-hour bus ride and worked out the basic plan that we would submit to Jacob and his wife Jane. I had worked in Ghana, and knew that they had to have a personal investment in the project. I wrote Jacob, telling him that we would provide the projector and asked him to pay for the shipping, to build a building with a dome, and pay for my air fare so I could come to install the projector and to provide some training .

Within less than a year after the projector was donated, the planetarium was completed. Jacob's passion inspired many planetarians, who had never even met him, to help with the project. The building and the dome were built with local materials. By the time I arrived in May 2008, the projector had been delivered, and six weeks later when the building was finished the projector was installed. Finishing touches were completed in late 2008.

I was able to return for the planetarium's grand opening in January 2009. I'll never forget the opening night. It was magical. Dignitaries including local chiefs and ambassadors were present; libations were poured and there were welcoming ceremonies. Then we moved into the dome for a short show about the night sky. The most wonderful part of the evening was a domecast hosted by Carter Emmart with participants from Ghana, Columbia, South America, Minnesota, and Illinois. It was an incredible event. Most of the people there in Accra, Ghana had never been in a planetarium before and here they were "driving" around the surface of Mars, guided by Carter. Afterwards, Jim Sweitzer answered questions from the audience. It was magic under the dome.

In the early 2000s I was starting to get involved in the International Planetarium Society. I was nominated to be GLPA's IPS Rep. Thanks Bob Bonadurer! And of course, thanks to all the GLPA members who voted for me, even though I was the only candidate! I never dreamed what that position would lead to. I started as IPS Rep in 2006, about the time that I met the Ashongs and started helping them with the Ghana Planetarium Project. Susan Button was IPS president

at that time, Susan kept mentioning the Ghana project in her President's Messages. Thanks Susan! Planetarians around the world begin to recognize my name. Then a couple of years later Joanne Young nominated me as a candidate for IPS President Elect. Thanks Joanne!

Now the question was, "Should I accept the nomination?" As I thought about it, I realized that I believed that if one has the time and the ability to serve, doesn't one have an obligation to give back to the organization which has given so much to us? My institution supported me. I had developed certain talents and abilities and realized that I could do it. Someone must do it. If an organization is to continue, people have to be willing to serve in leadership positions, as officers, committee chairs and committee members. So, I ran and was elected as President Elect. I served six years, from 2008 to 2014, as President Elect, President and Past President. Since then, I have served as an IPS Committee chair and as a member of several committees.

There does come a time to let things go. A couple of years ago, I decided that I would resign as Chair of the IPS Emerging Communities Committee. It's not that I didn't love the work or consider it to be important. Let me share a part of my resignation letter:

I will discuss some of the factors that led me to make my decision in the paragraphs below. In general, many of them are part of my personal leadership philosophy.

No one is irreplaceable. Some of us are retired, and while we loved our work, there came a time when we chose to let go of our jobs. We realized that there are others who can carry on the work, with fresh perspectives and renewed energy. Will they do it exactly as we did? Of course not. But a change of leadership is often very positive.

As time marches on, we pass the torch to the next generation and encourage "younger" planetarians to serve as committee members and participate in the leadership of our organization in various ways. We hope that they may have the same opportunities that we have had to realize the rich rewards of service. When we reach out to help others, we are abundantly rewarded as well.

Serving as committee members, chairs, board members, officers, etc., are personal opportunities that help us to grow professionally. We develop our leadership skills so that we may potentially serve IPS and other organizations in greater ways. All of us have grown from our work responsibilities. As we serve, we develop our own leadership potential.

One of the highlights of my time as IPS President was the IPS 2012 Conference in Baton Rouge. I really tried to promote a friendly family atmosphere, just like we have in GLPA. My Welcome message in the conference program encouraged members to enjoy reunions with old friends and colleagues, but don't forget the new people. Reach out and meet new people, meet the new members. Make them feel welcome. I felt that was very, very important. People told me that it was one of the best conferences ever, thanks to Jon Elvert and his staff. It was the largest attendance of any IPS conference up to the present.

I had another memorable experience there. During one of the sessions an Indian member from Chennai came into a paper session. I had visited his planetarium in 2003 and had been very warmly received. He walked to the back of the room, put a garland of flowers around my neck and draped an intricately woven cape over my shoulders. I knew, having visited India and Sri Lanka, that he was not honoring or praising Dave Weinrich. He was honoring the office of the IPS President. I realized that and it was very humbling.

When I was in Sri Lanka, I learned that one of the greatest honors that a child can bestow upon a parent or an elder is to prostrate themselves and hold the elder's feet. Sam had described to me how he would take his college-aged daughter to the bus station every day. She would kneel in the dirt and the mud and hold his ankles. That's a symbol of respect. As I was leaving Sri Lanka at the end of my sabbatical, there was a farewell program at one of the schools. We were late and there were only five or six students left. I think they were all young girls. I said a few words; they had a ceremony, but at the end they all came and knelt in front of me and held my ankles. Wow, I felt greatly honored! Greatly respected. That's the tradition in their part of the world.

Another highlight of my time as ISP President, was when I took the 2011 Council meeting to Russia. I felt that the Russian Affiliate was drifting away from our Society and that it was important to go and "bring them back into the fold." We had the most marvelous, wonderful, magical time. Some of you were there. Our host, Alexander "Sasha" Serber loved to sing karaoke. On the final night of the meeting the IPS Council combined with the Russian members who were there for a separate meeting. Sasha took us to a karaoke restaurant. He got up and sang a song. So of course, as IPS President I had to get up and reciprocate. The song that I chose to sing was "Imagine" by John Lennon.

As I sang that song, I was thinking of all the IPS members around the world. I felt that I was connected with everyone. I imagined what the world could be like. It was a really moving moment for me.

One more IPS memory. When we had the 2014 conference in Beijing, I wasn't planning to go. I was Past President and my term as an officer was almost over. But then we had a leadership crisis. Our President Elect had resigned. I just knew that I had to go, I had to find the money to go. It was a very successful conference, and I did talk to a lot of people about the crisis. I'm glad that I went as it gave me a sense of peace. The leadership crisis was averted, a new President Elect was chosen and IPS went on. Over the years there has been many changes in the organization and I'm especially pleased to see Vision 2020 and many other healthy indicators of growth. I see a lot of change. Look at our IPS President Elect Michael McConville. The torch is being passed to a new generation and it's wonderful! It's marvelous! I feel confident about the future of IPS. The organization is going to continue to do great things.

In Beijing, there were two things that really impacted me emotionally. The first one was during the opening ceremony. There was a group of young children that sang an incredibly beautiful song. Again, it showed me that one of the reasons we do what we do is for the younger generation, the children.
A few months later, I wanted to use part of the song for a conference presentation. But I wasn't sure how to edit it down to a shorter version. One thing I learned both in my planetarium work and in my time as an IPS officer is that sometimes you have to delegate and to ask for help. I don't know how to do a lot of the technical things, but I do know people that can. I called Jack Dunn and asked for his help. Even though Jack was in the last week of his job and getting ready for a retirement ceremony that week, he got it done. He sent me an edited two-minute version. People like Jack may not be in the forefront and may not be the people that everyone knows, but people like him, do so much behind the scenes, and are so valuable to the officers and the organization.

The second thing that really impacted me was just a small comment, David Eicher, the editor of Astronomy Magazine made. He mentioned a remark that Neil Armstrong had made at Starmus, an astronomy, space and music festival. Paraphrasing, Neil said, "As the twentieth century will be remembered for the development of science and technology, it is my hope that the twenty-first century will be remembered for the development of the human character."

I think that's something that we as astronomers can do to help people to look at something greater than the problems on this Earth. There's something bigger out there! Something vast! We're part of it. We're part of the Universe.

I want to briefly mention the work that Susan and Chu Owens are doing in Kenya. They also have a dream too and they want to build a planetarium. If any of you have met Susan, you know that she is another very enthusiastic person. When you meet people like that, you can't help but be energized yourself. I have met people like that here, especially some of the new planetarians. Wow! I believe that's an important reason for being part of an organization like GLPA or IPS, to be revitalized by new members of the profession.

Susan and Chu plan to build the Cosmic Hill Observatory. They haven't been able to do it yet due to the Covid pandemic. I went to Kenya in 2017 and visited them, talked about their plans and looked at two possible locations for the observatory. They're doing so many interesting things. They built a dome made of bamboo and were all ready to start doing

programs when Covid hit, and they couldn't bring people into the dome. But they found a way to elevate the dome and bring fresh air in through the bottom and out through the top, providing ample ventilation and allowing them to resume their programming.

Steve Jobs third point that he made in his commencement address is very important. *"Your time is limited so don't waste it living smene else's life. ... have the courage to follow your heart and intuition."*

Every morning for over 30 years, he would ask himself one question, "Do I enjoy what I'm going to be doing today?" And if the answer was "no" for too many days in a row, he'd find a way to change what he was doing. Why waste of time on something that you don't enjoy doing? Now, it might be difficult, but usually we can find some way to change it. I think that it's important to remember that we don't have forever. We each have something unique, something to give to this world, to give to the Universe. Don't leave it undone, thinking, well I have 20, 30, or 40 years. None of us know what might happen. So, seize the day, use the time and realize you have something to do. You have a reason for being here. Be a part of this wonderful world of astronomy education, exciting other people and giving them an appreciation of and helping them to be connected to the Universe. We're all part of one world. When you look at the world from space there are no borders, no boundaries. Again, we're all one. We're all together, all the same, so few differences. Let's remember that.

One of my last trips as IPS President was to a conference in South Korea. It wsa a very short trip, perhaps five days total and at least two of those days were used to travel. I was exhausted but not so much that I wasn't able to enjoy the conference. Afterwards, the conference organizers asked a young woman, a graduate student in astronomy, to show me around Seoul. At a market I saw a small stone, called a Korean name stamp. You use it to stamp your name on letters and documents. It is engraved with a saying in Korean. Minhee Hyun helped me to choose one that had an inscription that I liked. I have it on my desk at home and often hold it in my hand and remind myself of the inscription which reads "Dreams come true when you are thinking of them." We all have dreams. Keep thinking of them and making them come true.

ASTRONOMY UPDATE 2022

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Introduction A Year In Review

As always there's a plethora of news stories in astronomy. Some major events include a brilliant view of all five naked eye planets in the morning sky over the summer. Many of us certainly got up early in the morning to get a peek at this spectacular view. We also got our first image of the black hole in the center of the Milky Way from the Event Horizon project (Event Horizon Telescope et al, 2022). The images were similar to that of M87 several years ago (Event Horizon Telescope Collaboration, et al, 2019). Ingenuity, the Martian helicopter, spotted the wreckage of the main pod on Mars from Perseverance's lander (Lewis, 2022). It is the first image of its kind. LIGO has also released data found from late 2019/early 2020 showing the experiment has moved into routine observations of gravitational waves from black holes (Cendes, 2022). What was so exciting has become run of the mill. It's a good form of progress.

In less happy news we also said goodbye to Eugene Parker. He was a solar physicist and the Parker Solar Probe was named after him. He died March 15, 2022 at the age of 94. He was originally from Houghton, Michigan and went to Michigan State University. He spent most of his career in Chicago (Lerner, 2022). We also saw a fire threaten the Kitt Peak National Observatory. There ended up being 3 buildings that were destroyed during the fire. Luckily all the telescopes were spared (Howell, 2022).

This year also saw the start of the war in Ukraine with unjustified aggression from Russia against its neighbor. These events are impacting our colleagues in Ukraine in obvious ways. The war is also impacting astronomy and space exploration in unsurprising ways as well. Most notably Europe has ended its cooperation with Russia on the Exomars rover program (Marples, 2022). The future of the International Space Station and the relationship between Russia and other countries is up in the air and seems to be on track to end(Roulette, 2022).This was all in addition to international condemnation against Russia before the war started when they blew up one of their defunct satellite in an anti-satellite test, resulting in significantly more space junk in orbit around the Earth (Gohd, 2021).

Perhaps the most exciting astronomy news of the year was the launch of JWST on Christmas Day 2021. It took several months of travel, unfolding, and calibration before we could see the first images from JWST (NASA, 2022). But it was worth the wait. We saw the new space telescope's ultra deep field image, Stephan's Quintet, the Southern Ring Nebula, and the Eta Carina nebula at the first group of image drops. Since then we have had amazing views of Neptune and its rings as well as Jupiter in an eerie glow in infrared light and a gorgeous web-like image of IC 5332. We will be opening these christmas gifts for a while.

We also were reminded of the dangers of space for our lovely new toy. There were micrometeorites impacting the mirrors. Most of the impacts sustained so far have no to very small effects on the telescope. One was rather significant and caused more damage than expected (Howell, 2022). The damage will have lasting effects and increase the errors on that mirror segment. However, across the whole telescope the damage is relatively small. But it does raise questions on how dangerous this region of space really is in terms of micrometeorite impacts. It will be something to keep an eye on.

The Double Asteroid Redirect Test (DART) mission

was also an exciting piece of news. It launched November 24, 2021. On the 26th of September this year the spacecraft crashed into Dimorphos, a small satellite asteroid that orbits Didymos. The goal was to adjust the orbit of the Dimorphus noticeably as a test run for nudging potentially threatening asteroids away from Earth. On October 11 it was declared a success when it shortened the orbital period of Dimorphos by 32 minutes. That is much more than the 73 seconds NASA hoped for (NASA, 2022). What was really intriguing was we were able to watch the crash in real time.

Finally, the first launch of Artemis 1 was scheduled for early September. However, fault sensors, hydrogen leaks, and a Hurricane scrubbed the planned launch three times. The next launch window they hope to use is in November 2022. This is a brand new program that will take humans back to the moon and the first launch of the Space Launch System. Artemis 1 is an uncrewed mission followed by a crewed dress rehearsal around the moon with Artemis 2 and landing people on the moon with Artemis 3 (Froust, 2022). Better to get it right but late than on time and destroyed.

Great Dimming of Betelgeuse - Again!

In late 2019 Betelguese began to dim significantly. At one point it was even dimmer than Bellatrix. We knew that Betelgeuse was a variable star and there were periodic dips in its magnitude, but this surpassed anything we had seen before. The effective temperature did dip, but not enough to explain the significant dimming (Levesque and Massey, 2020). There was also noticeable dimming on the lower right quadrant of the star compared to the rest. One suggestion was that there were significant star spots on Betelgeuse that developed while another suggested it was a large dust cloud obscuring part of the star. There was dimming in sub-millimeter wavelengths which would suggest it wasn't a dust cloud as sub-mm light can pass through the dust (Dharmawardena, 2020). However, others looked at longer term data and several spectral lines that pointed to Betegeuse coughing up material that then cooled and resulted in extinction of light (Dupree, 2020).

There's a new paper now that sheds a bit more light on the whole ordeal using a rather unique observing method. Specifically researchers used the Himawari 8 meteorological satellite to study Betelgeuse. This satellite takes pictures of Earth every 10 minutes. That means as it takes pictures there are times where it will serendipitously catch an image of certain stars, such as Betelgeuse. The satellite observes in infrared light and averaged an image of Betelgeuse every 1.72 days. They were able to use this data over 4.5 years to get time variable data on Betegeuse's radius, effective temperature, extinction of optical light, and the optical depth which would be the result of dust (Taniguchi et al. 2022).

They look at two sources of dust that have been studied around red giants. There's a diffuse layer that is tens of stellar radii away and tends not to change. It is unlikely to cause the dimming. There is also a closer source just outside the star that is a dust clump that condenses and then is sublimated by the heat of the star and falls back into it. This seems most likely. They also look at water in the dust and see it is non-existent before the dimming and then it is detectable during the dimming. This would require clumps of dust. There was also a transition from absorption to emission suggesting the clump rapidly changed. So they called this an "episodic bursty event".

New type of Nova - the Micronova

There are several types of novae and all are cataclysmic variables that are a binary system. Classical novae involve a white dwarf that accretes material from a donor star. When enough material builds up on the surface of the white dwarf and the white dwarf heats it, it can undergo thermonuclear runaway, igniting the hydrogen across the surface. There are recurrent novae which are the same but do it over and over again. Dwarf novae are similar except it is hydrogen that is ignited in the disk due to instabilities changing the disk's viscosity (Caroll & Ostlie, 1996). Finally there are Type 1 X-ray bursts that are similar to recurrent novae. Except they involve a neutron star and ignition of helium on the surface.

TESS, a space telescope that can see very faint changes in stellar magnitudes is used primarily to find exoplanets. However, it also caught several rapid bursts from TV Columbae in a row. It also observed similar outbursts in EI ursa Majoris and ASASSN-19h. TV Col has three rapid bursts, EI UMa had two, and ASSASN had just one but all had a total energy release between 3-12x10^38 ergs. Each one

lasted less than a day and had a total energy release 6-7 orders of magnitude less than a classical nova. So, it's clearly a different kind of burst, but what causes it?

One is, can it be a dwarf nova? They can happen more often and with less energy than a nova. But they wouldn't happen in rapid succession like in TV Col and EI UMa and they tend to be more energetic than seen here. Also how quickly these events changed brightness has a steeper, faster gradient than dwarf novae. Another idea could be magnetically gated flares where weak magnetic field drive flares. This requires a specific mass transfer rate that would happen with greater regularity. Enhanced Mass Transfer involves instability in the donor star so there's an overflow of material onto the white dwarf.But what is observed would require several back to back instabilities which is unlikely. Finally, there is the idea that the donor star itself could be flaring, but those have never been observed to be this bright and is 4 orders of magnitude dimmer than what is seen here.

The rise gradient is similar to classical novae. So this suggests runaway thermonuclear fusion on the surface. The profile seen in the light curve is similar to Type I X-ray bursts which further supports thermonuclear runaway. To ignite fusion you need a critical pressure on the material. When you do that across the whole star, you need quite a bit of material that then explodes with quite a bit of energy. But you can get the amounts shown here if you reduce the area where this fusion happens to a smaller surface area which could be from magnetic fields funneling the material to the poles. There are some blueshift and spectral lines that suggest outflow of material as this is happening. In some cases the material is ignited, cools, settles, and reignites resulting in multiple quick peaks. In others a shock wave travels through the column of material resulting in one bigger burst as seen in ASSASN (Scaringi, 2022).

Neptune like planet found in a Neptune Desert

M-dwarf stars are the most common type of star (Carrol and Ostlie, 1996). We have found many Earth-like and super-Earth planets around them, but not so many gas giants. There are some that have been found but we do not expect to find many according to accretion models. However, what we do find can help us narrow down the expectations in models as well as explain migration of gas giants. Neptune-sized planets are particularly difficult to find, likely because of evaporation of atmospheres close to the star or gravitational disruptions of material forming a planet.

A team followed up on a planet candidate, TOI-674 using the Spitzer observatory, El Sauce Observatory, the Las Cumbres Observatory, TRAPPIST-South, La Silla, and Gemini to confirm its candidacy. The data combined photometry and images to constrain parameters based on best fit models and rule out any visible companions near the star. It fit the data as best it could with both a circular and a non-circular orbit. Depending on the choice the planet does seem to vary a bit in possible densities and eccentricity of the orbit. But overall, both models agree within error bars. It seems to be about 5 times the mass of the Earth and less dense than Neptune with an orbital period of about 2 days. So it's a close super-Neptune (Murgas, 2021).

Because of its proximity we can observe the light and how it's absorbed through the atmosphere to detect elements. The surprising bit is that it does appear to have water. This is surprising because of how close it is to the star, most of it should have evaporated away. How much exactly will help constrain things like where it formed and how it migrated. It's a good candidate for this type of follow up from JWST.

Past Merger of Large Magellanic Cloud

The current cosmological model suggests hierarchical galaxy mergers occurred over time. So smaller seed galaxies merged to create large galaxies, which merged, and so on until we end up with that we have today (Volonteri et al, 2003). Galaxies also have many satellite galaxies that orbit around them. It is expected that these satellite galaxies have their own satellites and they can merge as well. The Magellenic clouds, being our largest satellite galaxies make excellent testing grounds to see if this is true.

But those satellites of the LMC are likely ultra faint dwarf galaxies (UFD), dark matter dominated galaxies (Nowakowski, 2022). Gaia data offers more detailed kinematics and suggests 4-6 of these UFDs are indeed satellites of the LMC. But it's unclear how many it used to have and if there were mergers. Any other details seem to derive from complex interactions between SMC and LMC.

They choose to use chemical tagging of globular clusters in order to determine the past merger history. Globular clusters of different galaxies have their own abundance signatures. So, the Milky Way globular clusters are chemically different from the Large Magellenics Cloud's globular cluster. Also, Globular clusters are handy because they may be apart of a past dwarf galaxy but their density allowed them to survive the merger in tact. So, if an anomalous one is found it can suggest a past merger. That is exactly what this study did (Muciarelli, 2021).

They looked at several different rations of chemical abundances such as copper, calcium, silicon, and zinc. They found that the globular cluster NGC 2005 was significantly lower in those elements compared to the rest of the LMC globular cluster. They also compared abundance ratios of the Milky Way GCs against LMC GCs and NGC 2005. It again showed a significant difference. They also even tried to look for systematic errors by adjusting one ratio in NGC 2005 to LMC GC ratios to see how that affected the model. This made all the other ratios even further off. So this suggests the effect is real.

Additionally they ran models of the chemical evolution of dwarf galaxies. The abundance ratios seen suggest it comes from a dwarf galaxy with suppressed star formation, which is expected from UFDs.

Isolated Black Hole found by Microlensing

There are expected to be between 10 million and a billion stellar mass black holes in our galaxy based on stellar evolution expectations. However, we have only found about 24 of them in binary systems. Not all black holes will end up in binaries so it's not a representative sample at all. Constraining information on black holes helps us better understand stellar evolution. So microlensing events can help identify these objects. Of the 1000 or so microlensing events that are observed each year, about 1 percent, or 10 of them, should be black holes. However, focusing on the longer events, the likelihood goes up to 40% chance of finding a black hole.

They used data from the Optical Gravitational Lensing Experiment. This is an experiment run by the University of Warsaw and is a sky survey that is run out of the Las Campanas observatory in Chile. It's been running since 1992. The data used for this study included data observed over 7-11 years with follow up from Hubble. The data was modeled with a point-source background object and a point-source lens. They had 4 good candidates, but only one had significant results - OB110462 (Lam, 2022).

The data was modeled as a point source for both the lens and background object. They tried two different models, one where they put equal weights on the light data (photometry) and the position data (astrometry) or used the default weights in the model. Overall they were able to conclude it was relatively close at either 0.7-1.92 kiloparsecs and it was a good sized mass between 2.15-3.8 solar masses. This suggests it has to be a dark lens, where we cannot see it. So that gives us either a neutron star or a black hole. Depending on which model you use, it is either 50% - 44%-6% chance of being a neutron star, a black hole, or a white dwarf or it's 100% likely to be a black hole. Either way it's very likely it is a compact object. Another paper that came out around the same time suggests it has a mass of over 7 solar masses, putting it squarely in the black hole range (Sahu et al, 2022). More study needs to be done but it's a big result regardless.

AGN Models challenged or maybe not

Active Galactic Nuclei are very bright galaxy cores that have a feeding black hole with a bright accretion disk. Some hav3 radio jets coming out and some do not. Those with radio jets are quasars or radio galaxies, while those without are called Seyfert galaxies. Many have a dusty torus with clouds of material with either broad or narrow emission lines depending on their proximity to the central black hole. The Unified AGN model suggests that the types of AGN we see are based on the presence of jets and the viewing angle. This unified model has been widely used for decades now. In 2020 a paper came out that suggested we needed a radical change to the model. Their work with the GRAVITY project using the Very Long Baseline Interferometer suggested that, based on the temperature and the radius of the disk it was a thin ring of material viewed at an inclination so 20 degrees (Pfuhl, 2020). This would be much thinner than expected in the unified model and there needed to be an extra cloud blocking the broadline region.

A new paper this year looks again at this particular AGN, NGC1068, using the new MATISSE experiments on the Very Large Telescope

Interferometer that has a wider wavelength range than GRAVITY in order to better constrain the parameters of the NGC 1068. Used three image reconstruction pipelines and got similar images. They also checked for artifacts from the observations. The features remained consistent across wavebands.

They also got spectral energy distributions that were used to get the temperature of the material with that wider data set. They modeled it using standard interstellar dust, or a mix of olivine and carbon. Those with olivine and carbon matched much better which can help constrain the temperature. They also obtained radio data and overlaid it with the infrared and were able to match them clearly. Using the peaks in the radio they were able to determine where the black hole would be and where molecular clouds were. All of this suggests that for the dust and molecules to be present, the material had to be cool dust and not hot gas as the other paper suggested. Also the location of the black hole was below where the brightest part of the torus was, which is consistent with the AGN Unified model. So not only did this preserve our understanding of the AGN unified model but also showed data pinpointing the detailed view for the first time (Gamez-Rosas, 2022).

Transitional Quasar in Early Universe

Quasars are very powerful active galaxies with a central supermassive black hole engine. There was an expectation at one point that black holes would merge and form the really big ones we see today (Mezcua, 2017). Another idea is that they feed very quickly and rapidly grow. The expectation is that in large starburst galaxies the material falls into the black hole for it to rapidly grow. But it's also very dusty, so at first the quasar is shrouded from view, then it transitions to a partially obscured quasar, to finally an unobscured quasar. The original ideas put these quasars much later after the big bang. But in more recent years we have begun to find some at a redshift of about 7 which is about 780 million years after the Big Bang. This is much earlier than expected. At this redshift we have found unobscured quasars and the earlier shrouded starburst galaxies but never the in-between state.

Using archival Hubble images from the GOODS survey, a high-redshift galaxy candidate was found. Iso far it's still a point source and is unresolved. But compared to other galaxies found at that redshift it's particularly bright in the ultraviolet and non-existent in X-rays. So that rules out an unobscured quasar as that would be bright in X-rays. So it could be a compact starburst galaxy or it could be one of these "missing-link" transitional quasars. The team behind the study modeled the SED of this galaxy and found that if you remove some of the energy that would be from an active galactic nuclei, the star formation is near the possible limit. If you don't remove the AGN activity, it is not possible. The modeling could not be explained by star formation alone. So this suggests that this is an early galaxy with a high star formation rate that could rapidly feed a black hole but that AGN is shrouded since we can't see it in X-ray. Thus it seems to be the transition stage at a redshift near where we have found the farthest quasars (Fujimoto et al., 2022).

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STARS IN THEIR EYES. ____ IN THEIR BRAINS?

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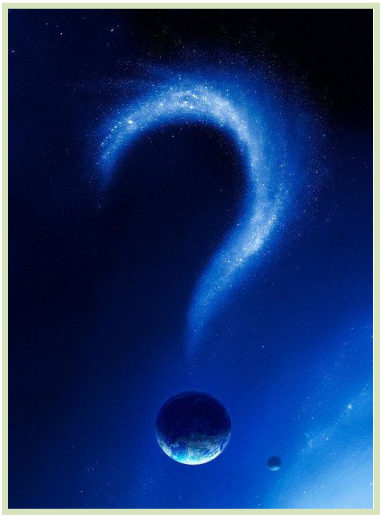
What do our planetarium visitors think about space? The planetarium? What do they love? What's weird? What's their favorite planet? Discover these answers and more in the Soref Planetarium's Fun & Short Survey!

Why a Survey?



1. Question Mark

Why survey? I was curious. I wanted some data on general perceptions of space and our planetarium. We are building a new museum and planetarium and well, understanding your customer always help.

1a. New MPM Museum & Planetarium 2026

A Very Short Survey

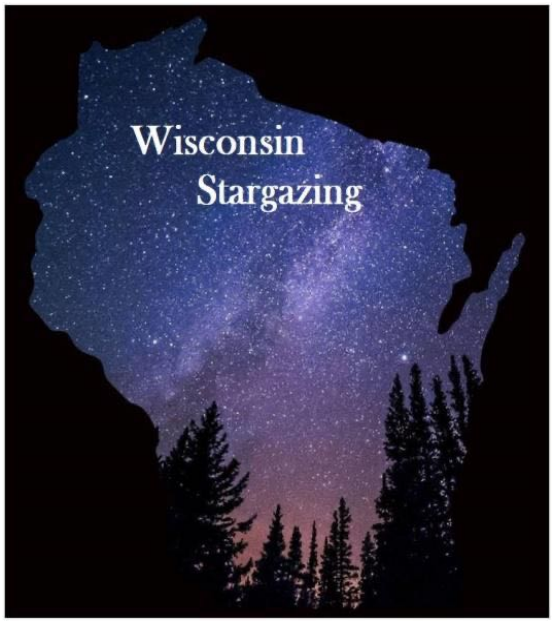
Survey Sign 1

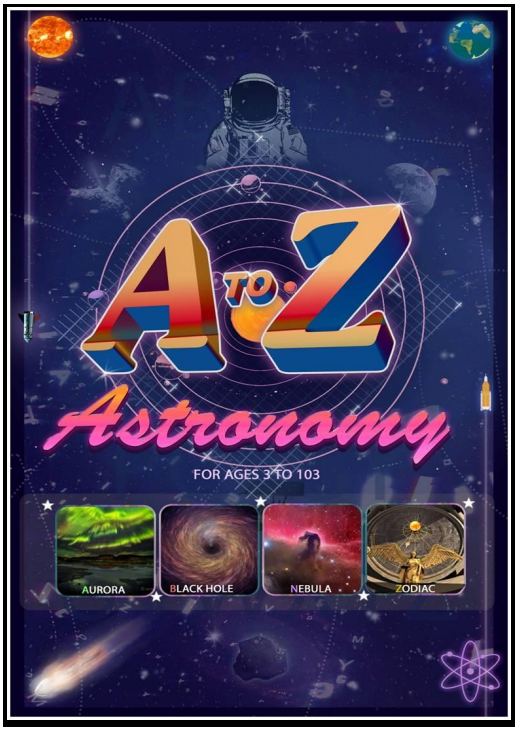
Survey Sign 2

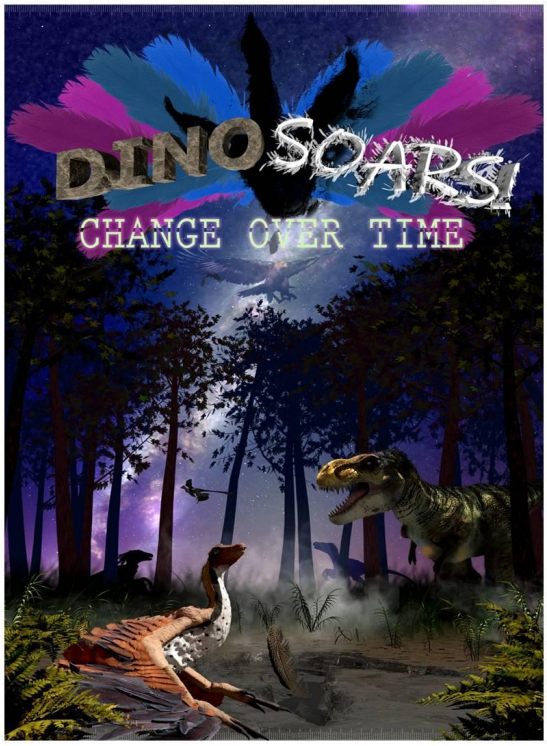
People don't have much times these days. And we all seem to be getting more impatient. So we made our survey very short and sweet—only taking 1 to 2 minutes to fill out.

We had 197 people fill out the survey. There were 80 kids, 45 young adults and 72 wise adults.

We asked people to fill out surveys after watching after each of our 3 planetarium shows in July 2022. They were Wisconsin Stargazing, Dino Soars, and A to Z Astronomy.







We decided to do only 10 questions. Any more might scare people off. See below for all the questions.


Daniel M. Soref
PLANETARIUM
mpm

Short & Fun Planetarium Survey

Please answer 10 questions about space!

Soref Survey

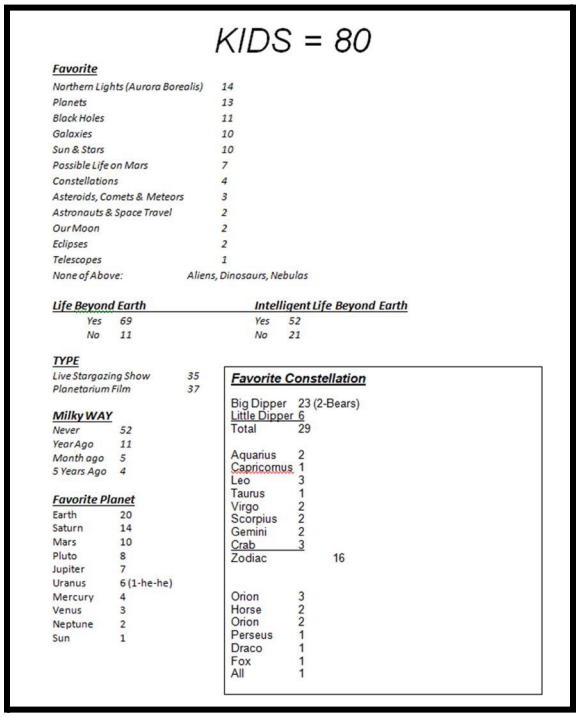
What Did We Learn?

I made a top ten list of what we learned from our survey. Please see below.

10. Pluto still a big deal.
9. Not many kids see the Milky Way. Planetariums are essential.
8. Northern Lights are #1 favorite. Why?
7. People still like a big… good mystery. Thanks universe.
6. Live vs. Recorded Planetarium Show? Still a tie game.
5. Life beyond Earth? Intelligent Space Aliens? Oh yeah! (According to Pew Research Center America 2021: 89% (Life) 75% (Intelligent) 65% (Intelligent)
4. Visitors know the wildest things about space.
3. Dippers & Zodiac
2. Saturn
1. People still love the Earth. But enough?

Complete Survey Results

The following images show the complete results of the survey.



KIDS = 80

Favorite

Northern Lights (Aurora Borealis)	14
Planets	13
Black Holes	11
Galaxies	10
Sun & Stars	10
Possible Life on Mars	7
Constellations	4
Asteroids, Comets & Meteors	3
Astronauts & Space Travel	2
Our Moon	2
Eclipses	2
Telescopes	1
None of Above:	Aliens, Dinosaurs, Nebulas

Life Beyond Earth

Yes	69
No	11

Intelligent Life Beyond Earth

Yes	52
No	21

TYPE

Live Stargazing Show	35
Planetarium Film	37

Milky WAY

Never	52
Year Ago	11
Month ago	5
5 Years Ago	4

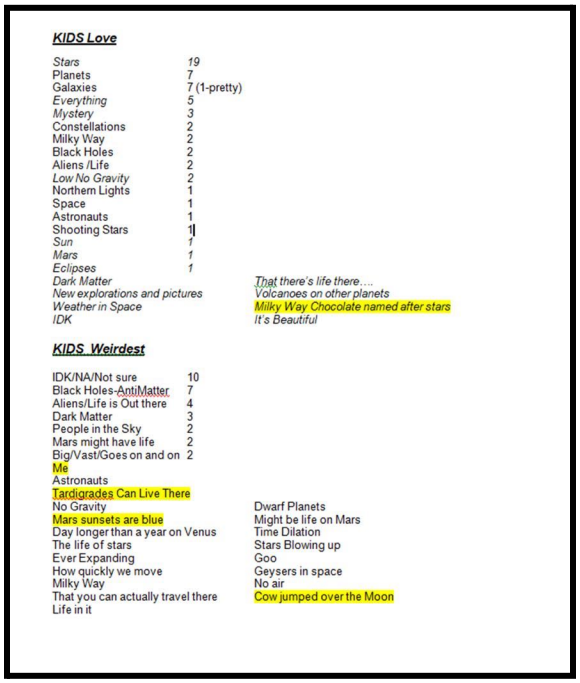
Favorite Planet

Earth	20
Saturn	14
Mars	10
Pluto	8
Jupiter	7
Uranus	6 (1-he-he)
Mercury	4
Venus	3
Neptune	2
Sun	1

Favorite Constellation

Big Dipper	23 (2-Bears)
Little Dipper	6
Total	29
Aquarius	2
Capricornus	1
Leo	3
Taurus	1
Virgo	2
Scorpius	2
Gemini	2
Crab	3
Zodiac	16
Orion	3
Horse	2
Orion	2
Perseus	1
Draco	1
Fox	1
All	1

Kids Answers 1



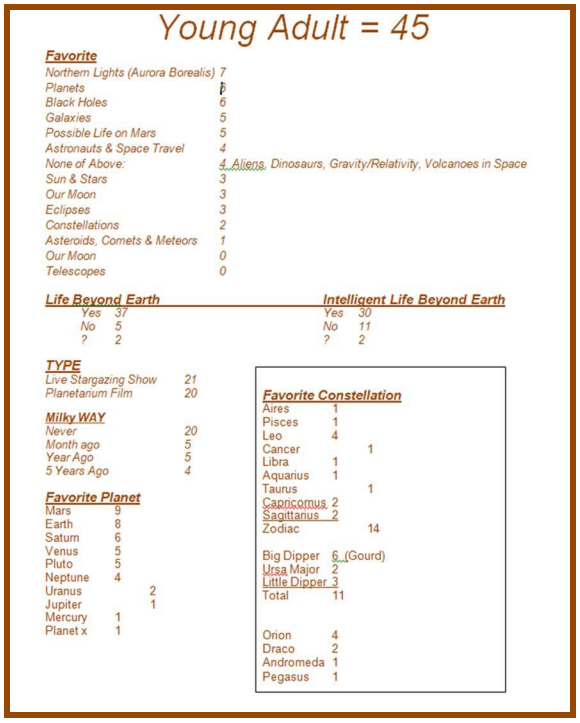
KIDS Love

Stars	19
Planets	7
Galaxies	7 (1-pretty)
Everything	5
Mystery	3
Constellations	2
Milky Way	2
Black Holes	2
Aliens /Life	2
Low No Gravity	2
Northern Lights	1
Space	1
Astronauts	1
Shooting Stars	1
Sun	1
Mars	1
Eclipses	1
Dark Matter	That there's life there….
New explorations and pictures	Volcanoes on other planets
Weather in Space	Milky Way Chocolate named after stars
IDK	It's Beautiful

KIDS Weirdest

IDK/NA/Not sure	10
Black Holes-AntiMatter	7
Aliens/Life is Out there	4
Dark Matter	3
People in the Sky	2
Mars might have life	2
Big/Vast/Goes on and on	2
Me	
Astronauts	
Tardigrades Can Live There	
No Gravity	Dwarf Planets
Mars sunsets are blue	Might be life on Mars
Day longer than a year on Venus	Time Dilation
The life of stars	Stars Blowing up
Ever Expanding	Goo
How quickly we move	Geysers in space
Milky Way	No air
That you can actually travel there	Cow jumped over the Moon
Life in it	

Kids Answers 2



Young Adult = 45

Favorite

Northern Lights (Aurora Borealis)	7
Planets	7
Black Holes	6
Galaxies	5
Possible Life on Mars	5
Astronauts & Space Travel	4
None of Above:	4 Aliens, Dinosaurs, Gravity/Relativity, Volcanoes in Space
Sun & Stars	3
Our Moon	3
Eclipses	3
Constellations	2
Asteroids, Comets & Meteors	1
Our Moon	0
Telescopes	0

Life Beyond Earth

Yes	37
No	5
?	2

Intelligent Life Beyond Earth

Yes	30
No	11
?	2

TYPE

Live Stargazing Show	21
Planetarium Film	20

Milky WAY

Never	20
Month ago	5
Year Ago	5
5 Years Ago	4

Favorite Planet

Mars	9
Earth	8
Saturn	6
Venus	5
Pluto	5
Neptune	4
Uranus	2
Jupiter	1
Mercury	1
Planet x	1

Favorite Constellation

Aires	1
Pisces	1
Leo	4
Cancer	1
Libra	1
Aquarius	1
Taurus	1
Capricornus	2
Sagittarius	2
Zodiac	14
Big Dipper	6 (Gourd)
Ursa Major	2
Little Dipper	3
Total	11
Orion	4
Draco	2
Andromeda	1
Pegasus	1

Young Adults Answers 1

Young Adult: What Do You Love Most About Space?

Unknown/Mystery/ Complexity	7
Stars	6
Big/Far	6 (we're small)
Planets	5 (water on Mars)
There's always more to learn	2
I love how much we don't know	2
Beautifulness/Cool	5 (1-The Pictures)
Eclipses	1
Constellations	1
Everything	1
Never discover all of it	1
Black Holes	1
Emptiest	1
No sound—no one to hear you scream	1
Galaxies	1
Idea of Aliens	1
Planet Made of Diamonds	1
Microorganisms that survive—(extremophiles)	1

Young Adult: Whis is the Weirdest Thing We Discovered About Space?

Black Holes	5
IDK/Not sure/Hard to Choose	5
Pluto is not a Planet—why?	3

Birds are dinosaurs
Ancient Structures--Pyramids
So many constellations
Not being able to breathe
Planets Orbiting 2 stars
Plasma
No sound in space
Milky Way
Saturn's Rings
Oport Cloud
Sun makes a bubble around Solar System
How much we don't know
The universe cloud
Water on Mars a long time ago
Everything

Young Adults Answers 2

Love

So vast, so big, much to explore/endless/infinity	18
Mysteriousness/Unknown/Endless Possibilities	12
Beautiful—pretty/Awe inspiring	7
All-Everything	4
Stars	4
Inspiration to keep exploring/So Much to Learn	3
How much we don't know/left to discover	3
Learning New Things All the Time	2
Galaxies	2
Constellations	1
Aliens	1
Astronauts	1
Physics of Space	1
It's there!	1
Surprises	1
Relaxing	1
Humans haven't screwed it up yet	1
Black Holes	1

Weirdest

Black Holes/Time Stops?	16 (No one knows where they go)
Size/ vastness/Never-ending	8
Dark Matter	6 (strange matter)
Pluto's Status	3

Uranus Spins Sideways
Spacetime
Pluto Not a Planet
It doesn't stop
That Aliens are real
Einstein's Theory of Relativity
The Big Bang Was Wrong
Zero G
Nothing
Everything
Big Bang
Smells Like Raspberries
Elements in Asteroids
Haven't discovered it yet
Pulsars are more accurate than watches
You take far too much liberty presenting this fact to us!! It is not true. Too many assumptions.

Wise Adults Answers 2

WISE ADULT = 72

Favorite

Northern Lights (Aurora Borealis)	*18*
Planets	*12*
Black Holes	*10*
Galaxies	*8*
Constellations	*8*
Sun & Stars	*4*
Astronauts & Space Travel	*4*
Possible Life on Mars	*3*
Our Moon	*2*
None of Above:	*2 Aliens, Dinosaurs*
Eclipses	*1*
Telescopes	*0*
Asteroids, Comets & Meteors	*0*

Life Beyond Earth

Yes	*64*
No	*3*
?	*4*
Yes—God	

Intelligent Life Beyond Earth

Yes	*50*
No	*12*
?	*8*
Yes—God—sorry, no aliens	

TYPE

Live Stargazing Show	*29*
Planetarium Film	*33*
Both the Same	*2*

Milky WAY

Never	*23*
Over 5 Years Ago	*23*
Year Ago	*11*
Month ago	*9*

Favorite Planet

Earth	24
Saturn	15
Mars	9
Venus	6
Pluto	6
Neptune	4
Jupiter	3
Mercury	0

Favorite Constellation

Little Dipper	4
Big Dipper	10
Ursa Major	6
Total	20
Orion	20
Sagittarius	2
Aquarius	1
Aries	2
Virgo	2
Capricornus	1
Pisces	1
Libra	1
Leo	1
Zodiac	11
Cassiopeia	3
Seven Sisters	2
Milky Way	2
Bootes	1
Horsehead	1
Draco	1

Wise Adults Answers 1

THEATER WITHIN THE PLANETARIUM: TURNING YOUR PLANETARIUM INTO A PERFORMING ARTS VENUE

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Over the past three years, the Culp Planetarium has worked with the theater and music departments on campus to host different levels of performing arts events: from a student-led reading to an original play written by a theater professor to the premiere of the first opera conceived for a planetarium. This paper will share the different ways the planetarium was used in each event and the levels of involvement required, as well as the key points to consider when looking to host a performing arts event in your planetarium - a space not designed with these performances in mind.

Introduction

A planetarium is essentially a sky or space theater, right? While the focus is on presenting important scientific concepts, it's also important to be entertaining and put on a show for those in attendance. So, it seems almost natural that an actual theater production could take place here as well—except for the fact that a planetarium is not designed for this type of theater at all. For a planetarium show, all focus is on the dome, and the speaker is more or less a disembodied voice ringing throughout the space. For a theater production, it's important to be able to see the actors that are speaking and engaging with each other.

Even though there are hurdles that need to be crossed, holding a theater performance within the planetarium is not impossible. This type of event continues to express the idea that the line between art and science is fluid, not solid. It breaks the bounds of what we think theater should be, while also offering a different interdisciplinary experience for your usual visitors.

Different Types of Events

In our planetarium, we have held three different types of theatrical performances over the past three years. Each of these performances had a different goal with using the planetarium space/dome itself, and how they wanted the audience to experience the space in relation to the performance. These ranged from a theatrical reading of a play to an original play written by one of the theater faculty to the first opera conceived for a planetarium that was written specifically (and exclusively) to be performed in a planetarium.

The first event was a dramatic reading of the play *Copenhagen* by Michael Fray, and was directed by a theater student. This play features scientists Heisenberg, Bohr, and Bohr's wife, who meet after their deaths to debate the motivations and outcomes of their attendance at a 1941 meeting in Copenhagen to discuss nuclear power. The planetarium was used primarily as an interesting thematic location to hold a theatrical production related to physics and did not require anything on the dome.

The second type of theater event we held was an original play written and directed by one of the theater professors on our campus; this turned into a series of performances after reworking the original script, and took place over two years. It was designed to be an immersive experience of attending a wedding in the planetarium, with audience members filling the roles of wedding guests; in the last version, there were also pre-show and post-show events related to a wedding, such as seeing members of the wedding party getting ready and a post-ceremony reception. The planetarium was the main venue for this production where the

structure, rather than the dome content, was the main focus, creating a site-specific theater event.

The last and most recent event we held was the premiere of a new opera called *Galaxies In Her Eyes*. This opera focuses on women in STEM, highlighting several famous female scientists throughout history and their groundbreaking discoveries. The main character (patterned after Dr. Mae Jemison) is a young girl named Eden, who dreams of being the first person to land on Mars and wonders if the constellations would look the same. After unexpectedly losing her mom, Eden travels across time and space, weaving together the stories of these female scientists whose work helped make the journey to Mars possible. This opera was written, directed, and performed (encompassing both opera singers and symphony orchestra members) by outside professionals who were using

Figure 1: Copenhagen student actors in the planetarium.

Overall, this was the easiest theater event to accomplish since it did not require much from the planetarium or for rehearsals. All that was needed were our microphones and just one of the ChromaCove LED ring settings as the main source of light in the space. There was a short rehearsal timeframe in the planetarium itself (since the actors didn't have to memorize lines, nor were they moving much around the space), and there was no scenery or additional lighting brought in. The most complex part of this event was one scene where an actor was speaking from behind the dome; this was quick and easy to accommodate on our end since it simply consisted of flipping on the main worklights behind the dome to be able to see them (as seen in the figure below).

our planetarium space. Without the use of a planetarium, the performance of the opera would not be the same, nor possible overall.

There are several advantages to holding a theater event in your planetarium, to create an enhanced and unique experience. There are, however, a few things to keep in mind to help set your project up for success from the start.

Copenhagen

For the theatrical reading of the play *Copenhagen*, the planetarium was primarily used for its location rather than planetarium system itself. It was a similar experience to theater being performed outdoors, where the location helped create the atmosphere for these characters without using traditional scenery. Holding this reading in the planetarium helped contextualize these physicists meeting outside of time to discuss their decisions.

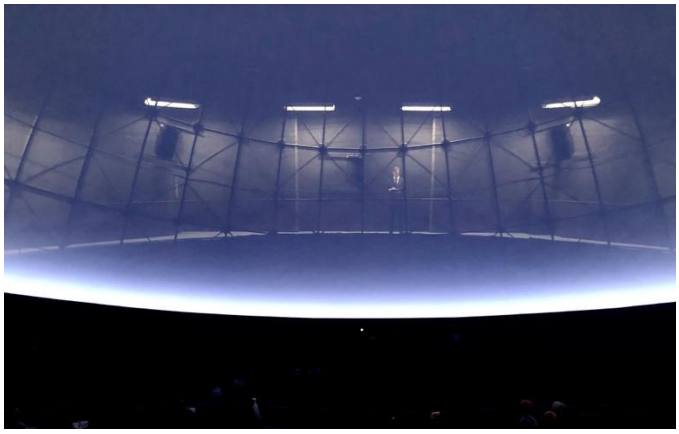

Figure 2: Copenhagen student actor behind the dome.

While the rehearsal and performance use of the planetarium was rather simple, the ideas and concepts that we learned from this experience carried over and helped prepare us for the other two (more intricate) events we held. The most significant takeaway from this experience was that the choice of performer location matters, to consider the sight lines throughout the performance. In this case, since the actors were down on the lowest level (and we have a tilted dome with raked seats), it was hard to see them. Audience members had to lean forward in their seats to have a clear view of the performers. This experience eventually led to the creation and installation of a front platform in this bottom space, which is still up today.

Taking this beyond the scope of our own dome, a major factor you should think about when holding an event is the layout of your dome. Is it concentric or unilateral? Tilted or not tilted? Where are your projectors located? Based on all these factors, where should the performers be positioned to best be seen by the audience? Is there any way your space can be adapted to help make this better? Beyond installing a platform, these accommodations might look like simply removing a portion of your seating or designating one specific seating area for audiences under the dome.

TIME LIKE WATER

The second type of theater performance we held in our planetarium was an original play written by one of our university professors called *Time,* which then ultimately became *TIME LIKE WATER*. There were three different iterations of this concept: the first performances, the revised workshop performance, and the final iteration with major reworks of the script and scenes. In each version, the concept of promenade theater was applied to create "behind the scenes" experiences of a wedding using other spaces in our building leading up to the actual performance/wedding itself within the planetarium. There were also specific flashback scenes within the production where the characters reflect on when they were all in astronomy class, while literally in the same planetarium the audience was sitting in.

Although there were scene and dialogue changes from each run of the production, the overall use of the planetarium's structure, rather than the dome itself, remained a key component. During *Time* (the first iteration), the story relied heavily on the use of color to help differentiate periods of time, which also tied in different exaggerated star fields; this was supplemented by using different structural levels behind the dome to distinguish periods of time (as seen below).

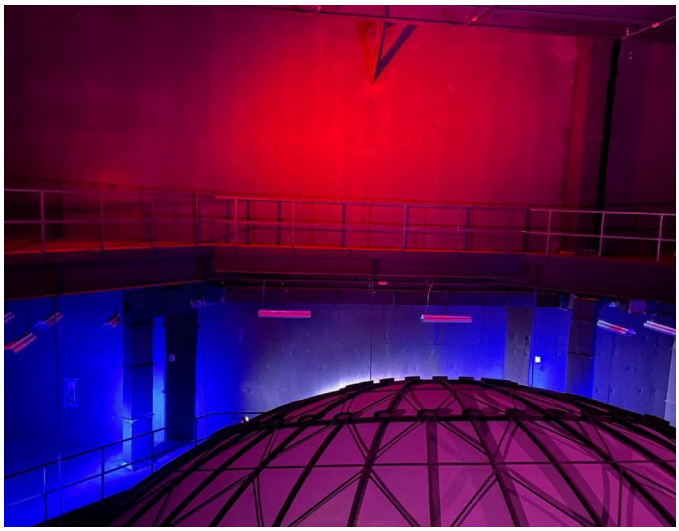

Figure 3: colored theater lights behind the dome for 'Time'

The latter two versions of the production (a revision and then full rework resulting in *TIME LIKE WATER*) still used the different levels behind the dome, however it was a less rigid breakdown of the space. Characters in the present time were able to be on any level behind the dome to emphasize their physical and mental distance from each other. Additionally, specific colors were no longer assigned to different periods of time.

Figure 4: Use of the levels behind the dome in 'TIME LIKE WATER'

In all three versions of the play, the dome was used to create some of the backdrops for the scenes but was by no means a prominent feature. Outside of the star fields and ChromaCove lighting, there were just two instances when the dome was used to show short 1-2 min visual shows related to the astronomy professor's monologue about theories of time.

Figure 5: actors in front of an exaggerated star field.

While I created these short pieces, the rest of the dome visuals were pulled into sequence by one of the technical theater students. I was able to train two different students (one for each of the two years that this production ran) on the basic operations of our system. This was primarily related to the ChromaCove system to create the different LED rings and how to use our scripting software to add to or edit the script they used during the performances to control the dome.

Each student was sufficiently trained within two one-hour sessions; this not only allowed them to take ownership in creating the look for the scene, but also meant that one of the planetarium staff did not have to be there for the final tech runs. Having a student know how to control the basics of the system also meant that they were able to add in the timing and cue calling system that the theater world uses. While this isn't too hard to learn, it's much easier to have the student operator add in the calling methods since they will be operating the system for all the performances.

Having this level of performance did require more rehearsal time in the planetarium, but it did not require our interference until the tech rehearsals closest to the performance dates. Overall, there was about a month of rehearsals within the space during the evening since this coincided best with the theater students' class schedules. Out of that month, technical rehearsals were the last week and a half.

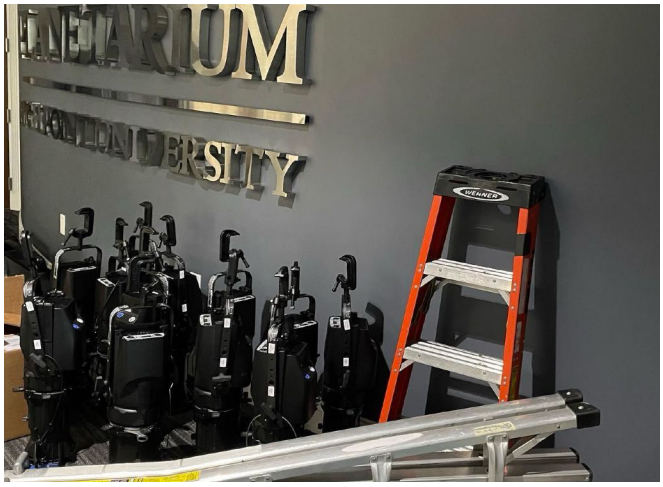

Figure 6: theater lights that were brought into the planetarium.

From the various iterations of this production, there were several things that we learned. The most prominent being that theater equipment will need to be incorporated into the planetarium space. External theater lights will need to be brought in to help illuminate the performers (in our case, under the dome as well as behind the dome) so that they can be clearly seen by the audience. Therefore, these lighting booms and arms will need to be in a location inside the planetarium where they are able to stay for the duration of tech rehearsals through the final performances. Ideally, these will be locations where the planetarium can still be operational during those weeks.

In a similar vein, the theater group will need a reliable audio system to use since all the performers will need to have a microphone on. If possible, they would be able to tap into your existing audio system within the planetarium, so there are not additional pieces of equipment that need to take up space within your dome.

With these considerations in mind, the default should be planning for more tech set up and testing time, before the actual tech rehearsals, than anticipated. This is a new space for the theater group that is very different from their normal performance venues, so there will be hiccups no matter how well they try to avoid them. Allowing for more time will also make sure the tech rehearsals can solely be dedicated to finding the desired look of each scene, rather than troubleshooting technical difficulties.

One of the best takeaways from this production was that theater students really enjoy the experience and challenge of performing in an atypical venue. From the performers to technical theater students, they all had a great time learning how to operate in a nontraditional theater space. This was also a great experience to add to their resume to highlight their flexibility and adaptability.

Galaxies In Her Eyes

Galaxies In Her Eyes is an opera that was conceived and developed fully during the pandemic, a time where performers were unable to exist in their normal spaces and could not be in front of audiences. A few professionals from the opera world came together during that time to create something that had never been done before—design an opera to specifically be performed within a planetarium. In this way, the role of the planetarium dome is equally as important to the plot as the musicians and the opera singers are.

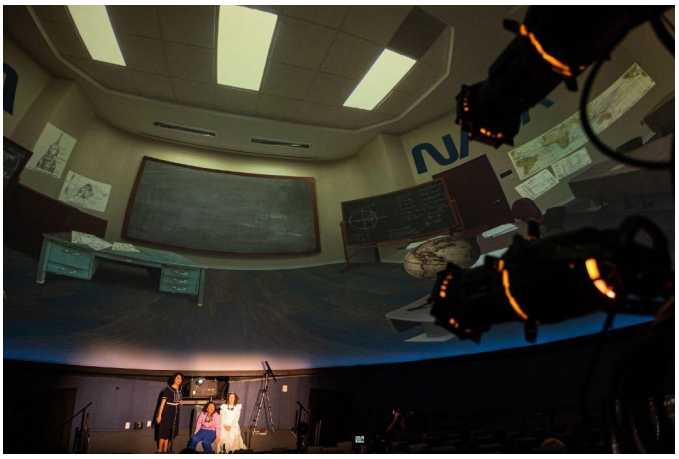

Figure 7: one of the scene backgrounds in 'Galaxies In Her Eyes'.

Since the dome was used for creating each scene, the audience itself was brought into the story with the performers; this was not an intentional immersion like *TIME LIKE WATER*, but by being surrounded by the experience of the dome, the audience inherently became a part of the story. The singers were also dynamically interacting with content on the dome throughout the performance, where their motions and actions affected the graphics or the location/scenery. For example, when singing about the equations coming together perfectly to get the flying machine working, with the wave of a hand they are rearranged into the shape of a plane and then become a fully rendered flying machine. This type of real-time interaction added another layer of magic to the experience.

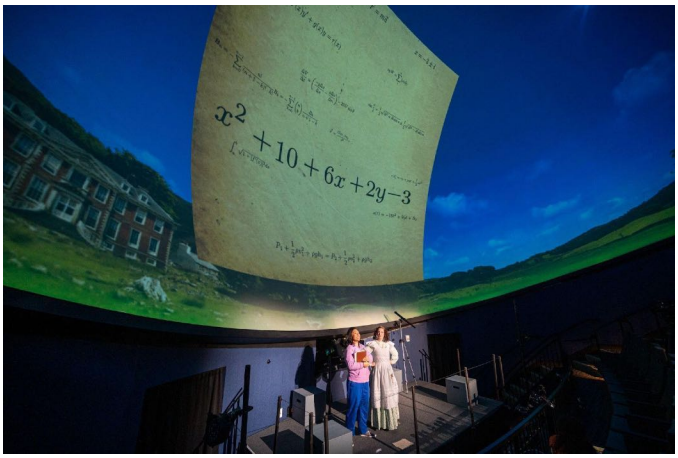

Figure 8: example of an "interactive" graphic on the dome.

For this opera, our planetarium director was involved from the initial development (reading the libretto and correcting the science) through the final performances where he operated the system each time. He created the show script on our system that controlled all the changes on the dome for the entire opera, blending the astronomy software on our system with the graphics that were developed by a professional. Due to the intricacy of this work and the precise timing that was needed, it required a considerable amount of development time to create the dome content; so, it was not possible to train a student from scratch to adequately operate the system and be able to develop the high level of content that was needed.

Outside of dome content development times, it was also necessary to schedule times to meet with the graphics designer and director. Having check-ins with them while building the show allowed everything to be adjusted along the way, so notes could be made and those edits applied separately. It was especially important to work with the graphics designer to make sure what they were making was compatible in resolution and file size for our dome. Building the visuals this way allowed for fine tuning during the designer run and tech rehearsals, rather than making major edits.

This opera was made possible by having a full integration of theater technology with the planetarium system: from the various external lights

to the changing content on the dome to external audio or sound effects. The stage manager was stationed next to and worked alongside our director to make sure the light changes and the cue calling was timed correctly related to the score. The ChromaCove lighting was especially useful to help soften the shutter cuts from the external theater lights that were used to highlight the singers at the front of the dome. It was also used for clever effects such as lightning during a storm, the burn of a spacecraft as it enters the atmosphere, and to show the hydrogen spectra of a star.

Figure 9: theater equipment operating next to our planetarium control system.

Similar to the theater production, the planetarium was used for rehearsals to get the performers comfortable with the space for several weeks; it was not necessary for the planetarium dome to be used until the tech rehearsals closest to the performances. Once it came time to bring in the external equipment and lights, there was already a general plan of where these should be in the planetarium based on our previous experience with the theater production. However, since those lights are so bright, smaller light "birdies" were brought in and attached to the front railing that allowed a dimmer light to be shown on the singers during darker scenes to avoid washing out the content on the dome.

The most challenging aspect was figuring out how to bring in the live quartet to play the score of the opera. Since there is not a lot of space down in the front of our planetarium (and that was where the opera singers were performing), we had to place the musicians and conductor behind our dome up on the third level. And since the conductor and the singers were not within the same space, as they normally are within an operatic theater, we had to use a camera and monitor system behind the dome and in front of the platform to make sure everyone was in sync and on time.

Figure 10: conductor and musicians setup behind the dome.

Additionally, the musicians had to have their instruments hooked up to a microphone that played through our sound system so they were able to play at a lower volume. Initially, when they were playing at their loudest so the audience below could hear them, the conductor could not hear the opera singers. Since opera singers are loud in nature, they didn't need a microphone to be heard clearly by the audience. Having microphones on the instruments allowed the players to play softer and the conductor was able to hear all the musicians/singers involved without compromising the quality of the sound.

While creating the dome content for the opera was similar to developing and creating a traditional planetarium show, it required a much longer timescale. Something that helped plan and organize this process, as well as lay out the majority of the cue timings upfront, was using a chart system (also known as a cue sheet). These are pretty standard practice for theater productions, where the production is broken down into scenes and sometimes lines with what exactly should be happening—from the lighting to the scenery (or here, dome content) to sound effects. Seeing this layout helped determine the best method to create the script, such as when pauses should be added to hold a scene or to precisely time out rapid visual changes. Doing this intensive development in the beginning made it easier to quickly make adjustments later on in the run through. Any way

you cut it, there is no instance of working with any theater production where you can just hit play on a script and watch it run all the way through. Strategic pauses help account for any rushing or lagging by singers and/or musicians.

Apart from working within the dome and using the planetarium system, there are a few other logistically important items. While the planetarium is the primary location for rehearsals and performances, there will also need to be additional spaces *outside* of the planetarium for the cast and crew to use. The cast will need space for a dressing room not only to get into costume, but as a safe place to leave their things during a performance. For a larger cast, there also might need to be a green room for actors to wait in while they are off stage. There will also need to be spaces to store things between rehearsals and performances, such as props, costumes (on racks), microphones, audio and lighting boards.

An odd but incredibly useful thing we learned is that you should always have gaffer's tape on hand. It leaves no residue behind, so it's safe to use on just about all surfaces in the planetarium (excluding the dome and projectors), while still having a strong hold like duct tape. Since it's made of a non-reflective cloth and is more resistant to heat, gaff tape can help solve many problems: taping down cables, covering LEDs on equipment (or surfaces you just discovered are reflective), marking spots for props or performers, putting up signs or reminders on walls, and the list goes on. As the director or person overseeing the use of the planetarium, these outside groups will turn to you to help solve any issues that pop up within the space in general.

Conclusion

From a basic performance to the most elaborate production, bringing theater into the planetarium is overall an exciting experience for everyone involved: from the theater group to the planetarium staff to the attending audience. While there will be obstacles to overcome at any level, it is entirely possible to work through them to turn your planetarium into a functioning performing arts venue.

Looking back at these experiences where we learned a lot along the way, it's clear how influential each event was in shaping the outlook of our planetarium and the role it can serve beyond the sciences. We planetarians all know that art and science work well together (since it takes a level of performing to give a good planetarium show and an artistic eye to put one together), but holding a theater event in the planetarium can really bring a spotlight to this intersection while also creating a new, unique experience.

WHO ARE WE MISSING, AND NOW WHAT?

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As part of a NASA grant, the Bell Museum collected data from seven planetarium member/visitor email lists (one per planetarium regional organization in the United States), as well as online survey panel data from residents in each area, to describe and compare those who do and do not visit planetariums. The results confirmed broad patterns found in studies of other informal learning institutions in that planetarium visitors were likely to be affluent, highly educated, and white. How can we expand these results to foster welcoming environments for a wide range of community members?

Introduction

This paper is based on an article in the September 2022 issue of The Planetarian, "Who are We Missing, and Now What?" by Catalyst Consulting group, and Sally Brummel and Holly Menninger of the Bell Museum.

In 2018 the Bell Museum team was preparing to apply for a NASA Teams Engaging Affiliated Museums and Informal Institutions (TEAM II) grant. We partnered with Catalyst Consulting Group for the evaluation. NASA's solicitation requested specific demographic information about the communities that would be reached through the proposed project, as well as benchmarks related to those groups. The Bell does not have an internal evaluation team that collects data on visitors, and only limited demographic information based on school groups served and member lists. This is not enough to provide benchmarks. We looked to the literature to see if there were any national trends we could use. There is information available about other informal science institutions (ISIs), but we found nothing focusing on planetarium visitors. This supports a claim from IMERSA that data describing planetarium visitors does not exist (Sumners, 2016). We added an objective to our proposal: facilitate an independent evaluation to fill a critical knowledge-gap about audiences through a demographic study.

In December 2019 NASA awarded us funding for our project, A Charge Forward: Activating the Nation's Planetariums to Excite the Public About Human Space Exploration of the Moon and Beyond. The award period runs from July 2020-June 2023. We are creating a recorded fulldome production and toolkit of associated activities focused on how to keep humans healthy, safe, and motivated during long distance space travel to Mars. Both will be available at no license fee to planetariums nationwide. The planetarium show, Mars: The Ultimate Voyage (figure 1), opens at the Bell Museum in December 2022. Both the show and the activities will be available for distribution in the second half of 2023.

Figure 1: Mars: The Ultimate Voyage

Method

When we wrote the proposal, we intended to survey audiences in five planetariums from each of the seven

regional planetariums in person. Due to the pandemic, we changed it to an online survey with one planetarium from each region, and we also purchased responses from SurveyMonkey Audience to serve as a comparison group for each region.

Our intent was to include a variety of planetarium types: those in K-12 districts, colleges and universities, associated with an informal learning institution, and stand-alone. We ran into many challenges when selecting the planetariums. We contacted the planetariums in early 2021. Many were not open, or had lowered staff capacity due to layoffs, and declined to work with us. Some planetariums that were interested in working with us but are in smaller markets or do not do daily public shows, do not have a sufficient member list or any at all. So we were not successful in getting a variety of planetarium types.

For the GLPA region we surveyed the Bell's email list, to make sure we got the kinks out! The other selected planetariums were:

- OtterBox Digital Dome Theater, Fort Collins Museum of Discovery, Fort Collins CO (RMPA)
- Arvin Gottlieb Planetarium, Union Station, Kansas City MO (GPPA)
- Science Dome, Pierce College, Lakewood WA (PPA)
- Burke Baker Planetarium, Houston Museum of Natural Science, Houston TX (SWAP)
- Raritan Valley Community College Planetarium, Branchburg NJ (MAPS)
- BlueCross BlueShield Planetarium, South Carolina State Museum, Columbia SC (SEPA)

In the survey we asked participants for demographic information, what kinds of cultural institutions they visit, a rating of their interest in science, and information about their attitudes toward visiting with regards to Covid.

16,419 people from the seven institutions received an invitation to complete the survey and we received complete surveys from 1,811 people, for a response rate of 11%. Responses from 100 participants from the cities of each planetarium were purchased from SurveyMonkey Audience, and we received 672 complete responses.

Research Question 1

What is the demographic makeup of both planetarium visitors and those who do not visit the planetarium?

The vast majority of the sample completing both surveys was female, white, with moderate to high income, and at least a college degree. Looking just at the race and ethnicity results, not surprisingly the planetarium community shows a lack of inclusion in who was on the planetarium email lists (table 1). The number of white planetarium visitors who completed the survey is far higher than the adult population. The Catalyst authors also note that "the community panel is above the national average and so our comparison sample is a skewed sample as well (which can happen with panel samples)."

	Adult Population	Planetarium Email lists	Market Research Participants
White	63%	**81%**	**72%**
Hispanic or Latino/a/x	16%	**5%**	**7%**
Black or African American	12%	**2%**	**7%**
Asian or Asian American	6%	**2%**	**6%**
American Indian or Alaska Native	1%	**<1%**	**<1%**
Native Hawaiian or Pacific Islander		**1%**	**<1%**
More than one race	2%	**<1%**	**1%**
Other		**1%**	**<1%**
Prefer not to say		**4%**	**1%**

Table 1: Demographic sample description of race/ethnicity, based on recruitment strategy

For the analysis of this research question, we broke it down to two basic categories: visitors and non-visitors, combining the planetarium email lists and market research participants (table 2).

52% of all respondents had visited a planetarium in 2019 and/or 2020. There were few differences in attendance based on race and ethnicity categories. Slightly more than 50% of white respondents were visitors, slightly less than 50% of the respondents in other categories were visitors.

As income rose, people were more likely to be visitors. Less than half of people in three lowest categories of education level were visitors, more than half in three highest education level categories were visitors. Both results replicate results from other informal learning contexts.

Variable Features		n	non-visitors	visitors
Race/ ethnicity	Asian or Asian American	75	60%	40%
	Hispanic or Latina/o/x	124	56%	44%
	Black or African American	85	54%	46%
	White	1728	46%	54%
Education	Some high school	17	76%	24%
	High school degree	141	78%	22%
	Some college	303	63%	37%
	College degree	690	46%	54%
	Some graduate work	159	49%	51%
	Graduate degree	852	37%	63%
Income	Under $25,000	121	79%	21%
	$25,000 - $49,999	220	64%	36%
	$50,000 - $74,999	386	53%	47%
	$75,000 - $149,999	733	44%	56%
	$150,000 - $199,999	247	35%	65%
	$200,000 - $249,999	113	36%	64%
	$250,000 - $300,000	49	37%	63%
	More than $300,000	77	30%	70%

Table 2: Basic demographics of planetarium non-visitors and visitors

Planetarium email lists respondents, naturally, had a higher rate of having visited the planetarium recently than the market research respondents. The market research participants visited the other informal learning environments--art museums, natural history museums, science and technology museums, zoos, and aquariums—at a similar rate as is reported nationally (table 3). Interestingly, in the market research sample, only 18% had visited planetariums, and double to triple that percentage had visited the other types of institutions. For planetariums, we hope that is an underestimate of the overall population who visits planetariums, due to pandemic conditions.

Institution visited in 2019 or 2020	Planetarium Email lists n=1,519	Market Research Participants n=672
Planetarium	68%	18%
Museum or gallery	69%	44%
Natural history museum	68%	38%
Science or technology museum	72%	36%
Zoo or aquarium	80%	57%

Table 3: Institutions visited in 2019 and/or 2020

Research Question 2

What patterns emerge when looking through the lens of intersectionality?

The Planetarian article provides an overview of intersectionality.

> Intersectionality is the idea that human characteristics such as race and/or ethnicity, gender, socioeconomic status, education, age, etc. are not mutually exclusive within a person, but rather work in concert with (and sometimes against) one another and should be treated as such (Crenshaw, 2017)….The advice provided in the contemporary literature regarding intersectional studies is to be very intentional when conducting this type of research, and to plan for this kind of analysis from the beginning by oversampling from key groups of interest (Christoffersen, 2017).

We did not set out to do an intersectional analysis, so we did not follow these practices. As such, we present the demographics of planetarium visitors and non-visitors as viewed through descriptive analysis only. This allows us to begin exploring data in

intersectional ways in new studies, as opposed to using this study to highlight definitive trends.

We chose eight intersectional groups to study (table 4). Each had sample sizes of over 20 and included characteristics ISIs prioritize when trying to broaden their audiences. Of the eight groups, five are more likely to be non-visitors.

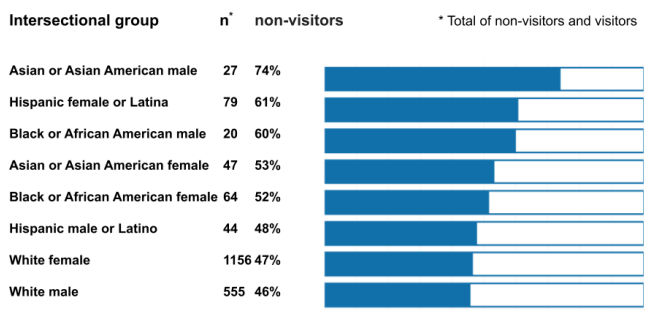

Table 4: Intersectional demographics of non-visitors and visitors: Gender and race/ethnicity

We do not intend these results to be instructions for planetariums to determine what communities to focus on, neither for the broader field nor the seven planetariums in the study. For most of them, there were not significant sample sizes of any group in their regional responses. Instead, the Planetarian article describes how an institution might approach such a study.

> The intersectional results help narrow the focus more to consider patterns among community members who are not visiting the planetarium.
>
> The combination of gender and race/ethnicity presented here begin to identify specific groups of community members that planetariums might partner with to learn more about non-visitors. For example, the planetariums in our sample might want to understand more about why most Asian men do not visit the planetarium. Similarly, they might want to learn more about why most Hispanic men choose to visit while most Hispanic women do not.

Additional Results

One result that provides hope is that planetarium members and community members alike are interested in science.

All groups reported on a scale from 0 to 10 at least some interest in science, which seems a positive starting point for planetariums who are interested in attracting non-visitors.

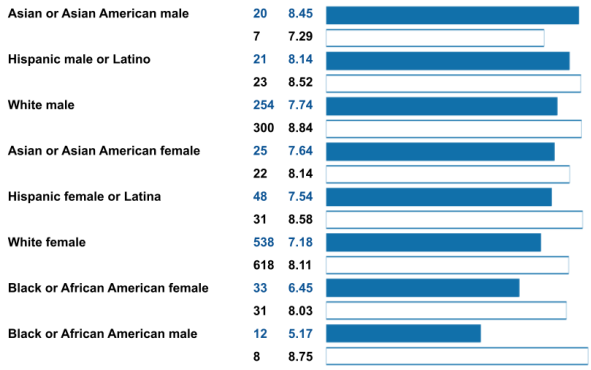

Table 5: Intersectional interest in science ratings of non-visitors and Visitors: Gender and race/ethnicity, on a scale from 0 to 10

Now what?

How will we, the Bell Museum, find out who is not coming. and why?

We are using our Diversity, Equity, Access, and Inclusion action plan as, well as this study, inform future actions. Our DEAI action plan lists our commitments to:

- Understanding and acknowledging the history and current practices of museums, science, and education, and revealing where systemic racism and ongoing discrimination make these fields inaccessible and less safe for all people to participate in and contribute to
- Auditing and improving our public engagement and research programs to ensure they are grounded in equity and amplify the voices of those whose contributions have not been valued or heard
- Creating an inclusive environment for staff, student employees, volunteers, advisors, visitors, donors, collaborators, program participants, and all others who intersect with the museum

- Continually examining and challenging our own assumptions, biases, actions, and policies that prevent our positive contributions to a more just and equitable world.

Each department creates action items on a yearly basis. One action for my department, Public Engagement and Science Learning, is to collect and analyze data about race and gender identities of museum visitors and public program attendees. We want to gain a better understanding of who is coming and not coming to the museum and our programs, with the goal of better serving BIPOC and LGBTQIA constituents.

An additional action that we share with our Statewide Engagement department to start is to be intentional of who we are visiting, the groups we are going out to. We are also fortunate to have a variety of diverse groups reach out to us for partnerships.
Recently I worked with students from a STEM camp on the Fond du Lac reservation to create a planetarium show. It was funded by NSF's Advancing Informal STEM Learning program. One objective was to develop a collaboration of University of Minnesota researchers, Bell Museum program developers, and camp teachers to support student engagement. Another objective was to provide a model for reciprocal relationships between a youth-focused culturally-responsive program and a large public outreach museum. The grant period has ended, but we must see it as merely the opening of the door to this relationship, and continue to partner with and support this group, for the project to be a success.

To be honest, we do not have it all figured out. This is hard work, and it has required commitment from our administration, as well as significant and time and financial investment museum-wide.

Please see the September 2022 issue of the Planetarian for the full article or read the excerpted article here. https://z.umn.edu/peterman

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ASTRONOMY EDUCATION APPROACH AT THE BUFFALO MUSEUM OF SCIENCE

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Abstract Over the past two years, the Buffalo Museum of Science has employed various methods to approaching post-Covid education in Astronomy. The audience is a full range of ages, and with assistance from our volunteers and partners from the Buffalo Astronomical Association we are working toward our goal within the Buffalo Eclipse Consortium for 2024. We focus mainly on our usage of the Kellogg Observatory and the Zygmunt Planetarium.

PART 1: THE KELLOGG OBSERVATORY

1.1 Background

At the Buffalo Museum of Science, our astronomy programming has been revitalized following the renovation of the roof deck and the Kellogg Observatory in 2018. From activities at the Kellogg Observatory, to internal and outreach programs using the portable Zygmunt Planetarium, our focus has been to bring astronomy to Western New York in association with our affiliates. Since 2015, we have been planning for our largest upcoming activity, the 2024 total solar eclipse. As part of the Buffalo Eclipse Consortium (BEC), it has been a priority to include as much information as possible to bring awareness to the event.

The Kellogg Observatory opened in 1930, when the newly constructed building was given a rooftop exhibit with leftover funds and a donation from the Kellogg family in Buffalo. With a 1929, 10-foot, 8”-lens Lundin refractor, the Observatory has been used for almost 100 years to bring the universe to a steadily brightening urban environment. In 1999, the observatory was closed to the public due to the dilapidated condition of the wood-framed observatory which damaged the Lundin telescope. It took until 2018 when the restoration of the Lundin telescope was completed, the dome was replaced by a 20’ stainless steel structure, and an accessible entry was placed on the roof. With this construction came two new telescopes for the roof deck: a refractor donated in the memory of Theodore Bistany, and a Hydrogen-Alpha Lunt Solar Telescope on a dual-saddle Astrophysics Mount. On September 28, 2019, the Lundin telescope was renamed in honor of long-time astronomer, former museum director, and Buffalo icon Ernst Both. In August 2022, the observatory’s first Schmidt-Cassegrain telescope was donated in the memory of Peter Taylor. Currently, all these instruments make up the core array of the Kellogg Observatory.

While in an urban setting, the observatory, at its original construction, included a naturally darker sky than today. The Kensington Expressway that currently connects traffic from Buffalo’s airport to downtown runs just past the museum, and was built in the late 1950’s. Now adorned with moderate highway lighting, there is some interference from below inhibiting some detail in photography and viewing experiences at night.

1.2 Seasonal Considerations:

Our biggest challenge to any of our outdoor observatory events is being the third cloudiest city in

the United States due to the meteorological effects of Lake Erie. As a result, our outdoor programming is constrained by the weather. With a relatively high degree of variation day-to-day, it is necessary to adjust programming on the day of the event, which presents a strategic threat to programming consistency. For all programs, the Kellogg Observatory Astronomer is responsible for making a daily weather call for the event. This entails looking at weather patterns, reading Sky Charts, and also (when necessary), tapping resources of local meteorologists at the local NOAA office.

1.3 Program offerings

Our most common program is the Solar Saturday event which opens the rooftop to visitors from noon-3:00 PM between the beginning of April until the end of October. By using resources such as spaceweather.com and the National Solar Observatory network, museum staff can be prepared for the day on what is likely to be seen in both of our rooftop telescopes. Mitigating sunless days for three hours is not an overwhelming challenge. We also offer our iSpy activity which allows families to search for architectural or natural landmarks using binoculars. Not only is the city of Buffalo visible from the roof of the museum, but visitors can also catch a glimpse of Niagara Falls, NY and Niagara Falls, ON. Even on cloudy programming days, it is possible to point the Both Telescope toward the Skylon Tower in Canada. Using the digital camera and our 42" monitor, we can observe its exterior elevators ascending and descending with passengers. And, on days when humidity is relatively low, mist from the Falls is plainly visible on the horizon.

During the evening, our original programming was tailored to reservation access on Wednesday nights to the 6-person capacity limit of the observatory. At 10:00 AM on Wednesday following the weather call, the museum would open registration for the evening program with timeslots dependent upon variations in sunset. So, for example, many more time slots were available in January than in June. However, while it seemed difficult to fill the timeslots for winter months, more than expected came out to see M42, M1, or a planet or two.

Our 2022 season opened on April 16th to a cold day, but one that (even for Buffalo weather standards) began a stretch that resulted in solar visibility and no precipitation on every Saturday this season. Our evening programs were restarted in July 2022 with our newest program: Twilight at the Museum. There will be more on this later, but it was designed to allow patrons to visit the museum in the evening and utilize the Kellogg observatory.

1.4 We are not alone

Our Saturday programs include assistance from volunteers that dedicate themselves to the roof experience and to learning more about solar activity; as well as lending a hand in educating the public. Additionally, our major assistance comes from the affiliation with the Buffalo Astronomical Association (BAA). This year alone we have had a very high participation rate from their leadership and membership and adding their knowledge to our programs has been invaluable. On many occasions, the BAA has staffed a table in our Buffalo in Space exhibit. Able to network with other amateur astronomers, there is an opportunity to expand their membership base in Western New York. In reciprocation, staff and volunteers from the Museum of Science travel to the Beaver Meadow Observatory in North Java, NY to assist with the BAA public nights in a much more rural setting and in turn attract more patrons to come to the museum.

During the pandemic, the BAA and several members of the BEC gathered to create an online program forum through the use of YouTube and Facebook to present Looking Up!, a program utilizing live telescope views and various studio topics for a two hour tour of the night sky. This provided us an avenue to present to a wider audience. During the pandemic, our following was strong, seeing viewers from as far away as South America who just wanted to "see a different part of the sky".

In between live views of planets, nebulae, galaxies or a crescent moon, studio topics include live JWST updates, Hubble events, special guest speakers, meteorite findings and a sky tour using Stellarium. It is a great way to expand our reach to those who are unable to find their way to one of the many institutions around the area.

PART 2: THE ZYGMUNT PLANETARIM AND TWILIGHT AT THE MUSEUM

The Museum received its new 5-meter Digital Starlab in July of 2018. The planetarium opened in tandem

with the reopening of the Kellogg Observatory, welcoming an additional new tool for astronomy programming. The purchase of the new dome was funded by Dr. Cora Musial, who grew up attending classes and other educational programs offered by the museum. She dedicated the planetarium to Mr. Richard Zygmunt, a long-time member of the museum's educational staff, whose teachings started her lifelong love of astronomy. Mr. Zygmunt was able to visit his namesake planetarium multiple times before his passing in 2020.

The Zygmunt Planetarium is a portable model, and much of its activity takes place offsite during outreach programs. The dome has traveled as far as 70 miles for school day programs, all-ages evening events, summer and day camps, community outreach, and career exploration events. Since introducing offsite planetarium programming in early 2019, the Zygmunt planetarium has hosted over 3,000 visitors during outreach alone.

In addition to outreach, the planetarium can be set up inside the museum itself for onsite programming opportunities. The dome has been used for our own day camps, birthday parties, scout programs, ticketed public shows, homeschool classes, adults-only and all-ages themed events, staff and volunteer engagement, and other special events. Those visiting the museum for a field trip have the option to add planetarium shows for an extra charge. The BMS is also physically and programmatically linked with the Charles Drew Science Magnet School, in the Buffalo city school district. Museum education staff meet with grades pre-K to 8 throughout the school year to provide informal, hands-on educational experiences that coordinate with topics the students are learning in the classroom, including visits to the planetarium.

Unfortunately, the museum site does not currently possess a designated space for planetarium use. While there are a handful of areas in the building that accommodate the size and shape of the dome, these spaces are meant primarily for other activities, so accessibility and practicality vary. As a result, opportunities for onsite planetarium use are always short-term. The museum balcony atrium provides enough floor space and height clearance for the planetarium footprint. However, the high ceiling causes echoes, and the atrium is where hundreds of excited students may gather during a field trip, so the ambient noise created here can drown out a presenter's voice quite easily. Our Temporary Exhibits Gallery has ample space, lots of egress and high ceilings. It is also occupied by large traveling exhibitions or special installations for most of the year. During the summer of 2019, the museum was able to offer public ticketed shows twice a week in an area of the gallery that was sectioned off from a separate, small installation. Conditions have not provided this opportunity since. Lastly, the space on the museum auditorium stage provides a location where there is no background noise, and the ample seating makes it easy to orient an audience and conduct introductions prior to entering the dome. However, a few stairs lead up to the stage and there is no ramp currently available, so this presents an accessibility challenge.

When using the dome's Starry Night software to its full potential, the planetarium becomes perhaps the most immersive and versatile teaching tool in the museum. The BMS has used the Zygmunt planetarium to discuss dozens of topics in-depth, including: mythology, navigation, space exploration, lunar and solar eclipses, terrestrial and astronomical coordinate systems, daily and yearly patterns in the sky, composition and surface characteristics of solar system objects, units of distance and time, and many others. We are still early in the '22-'23 school year, but so far the most popular booking for schools has been with the planetarium. A close second is an assembly program that involves liquid nitrogen. More on that on Thursday.

The latest museum astronomy offering is our new event, Twilight at the Museum. This past summer saw three tests of a program model dedicated to casual nighttime observing. Twilight events took place one Friday during the months of July, August and September. From 8-11 PM, the entire museum was open for exploring, including the Kellogg Observatory and the roof deck. Under clouds or stars, guests could visit the roof and join Museum astronomy staff and volunteers from the Buffalo Astronomical Association, or BAA. BAA volunteers brought their own scopes to add to our own equipment, so a visitor to the roof deck would have 6 or more scopes of different designs and degrees of magnifications to choose from. In the event of precipitation, all astronomers would set up around the museum galleries and show and tell about their equipment, chat about astronomy and space science, and generally engage with the audience.

This event was designed to create a casual, free-flowing astronomy experience for as many people as possible. Tripling and sometimes quadrupling the number of available telescopes on the roof meant that patrons would never have to wait for more than a few minutes to get a view of the skies, and an astronomer was always present to answer questions and point out other details along the way. If clouds obscured the view, astronomers would instead connect guests with free or low-cost astronomy apps and resources, and share their tips for which equipment to buy or where to travel for dark skies. In the event the roof deck became too crowded, guests would be able to take a break and explore the other museum galleries. Lastly, the cost for admission was the same as during our regular hours. If weather did not permit access to the roof, the entire set of permanent museum offerings was already available. The Buffalo Museum of Science has a large member base, so many visitors paid no extra to enjoy the astronomy content.

Each Twilight at the Museum event welcomed over 275 visitors, despite 30-50 percent cloud cover each evening. Of these visitors, many were repeat attendees, having come to two or more events. Comments received by museum staff and volunteers were overwhelmingly positive. A sentiment expressed by dozens of visitors was that there was seemingly no opportunity to access the museum roof deck at night in previous years, and they were somewhat correct. While our initial evening roof access model had a strictly limited capacity, extra cost, and could easily be ruined by weather changes, Twilight at the Museum instead offered an easy, accessible and largely weatherproof treat for larger and more diverse groups. Plans are currently being made to expand our Twilight at the Museum event offerings for the 2023 season.

HOW WE CAN INCORPORATE MORE DESIGN THINKING IN OUR WORK AND BEYOND

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We attended the *Teaching and Learning Studio (TLS) Workshop* on design thinking hosted by the Hasso Plattner Institute of Design (a.k.a. d.school) at Stanford University. Design in this case is a verb used to define problems, solve problems, identify knowledge and skills, work with others, innovate, learn, and shape the future. We can all use this framework no matter what we do in our field. We will focus on some best practices for learning and problem solving both at work and in general.

Introduction

In 2020, we began to connect our collaborative work to the goals of the Lubar Entrepreneurship Center (LEC) at the University of Wisconsin-Milwaukee. The LEC offered us funding support to engage in professional development activities related to curriculum design. We found it empowering to operate outside our immediate departments, and we highly recommend that you find something similar near you. If you work on a campus, search for an innovation or entrepreneurship center. It might be a stand-alone entity or part of your business or engineering school. If you are not affiliated with a university or campus, these centers typically want to work with external partners as well. Following this suggestion might have the longest lasting impact on your work satisfaction and career.

In what follows, we highlight specific ideas and practices from the TLS Workshop that we found surprising and useful.

Developing community and culture

Our first day was centered around community and culture. The importance of building a community and developing a culture of curiosity and safety was emphasized by discussing the four important **contexts for learning**:

(1) We learn when things have relevance to us[1,2]
(2) We learn when we are actively engaged in and reflect on what we are doing[3,4]
(3) We learn when we engage our emotions[2,3,5]
(4) We learn from and with others[6,7]

Even if we are aware of these requirements, how can we implement them in our professional setting for richer learning? Below are some practical approaches.

(1) *We learn when things have relevance to us.* One of the difficulties of teaching astronomy is that many people feel that learning about the universe is not **relevant** to them. How do we address that? In the class Jean teaches this semester, *Search for Life in the Cosmos*, she was about to discuss the Drake Equation, an approach to estimating the number of communicative civilizations in the Milky Way. Based on her insights from the workshop, she paused the curriculum and asked her students what they do for

[1] How People Learn II: Learners, Contexts, and Cultures by the National Academies of Sciences (2018)
[2] The Neuroscience of Joyful Education by Judy Willis
[3] The Art of Changing the Brain: Enriching the Practice of Teaching by Exploring the Biology of the Learning by James E. Zull (2012)
[4] How We Learn: Why Brains Learn Better Than Any Machine…for Now by Stanislas Dehaene (2020)
[5] Emotions, Learning and the Brain: Exploring the Educational Implications of Affective Neuroscience by Immordino-Yang, M.H. (2015)
[6] Social Learning Theory by Albert Bandura (1977)
[7] A Social Theory of Learning, and Communities of Practice: Learning, meaning and identity by Etienne Wenger (2018)

their physical and mental health. The students discussed various strategies. Jean then resumed discussing the Drake Equation and the students were in a better position to discuss the value they would give to the different parameters in the Drake Equation. Why did this work? Students had a chance to talk about what was on their mind and how they cope. This group discussion might have gotten them in a more resilient frame of mind and more willing to discuss the astronomical topic at hand.

(2) *We learn when we are actively engaged in and reflect on what we are doing.* Most of us work within teams. How can we ensure that **everyone is engaged** when we have meetings? Jean finds this a particularly challenging issue with her 10-15 student staff, who work few, scattered hours and have many other obligations. To make matters worse, many of them work on completely independent projects and feel that they don't have things to contribute especially if they are introverts. Jean, for years, has involved her students in decisions about the planetarium. Now, she leverages the voices of all her student staff by having project-based meetings of small groups.

(3) *We learn when we engage our emotions.* Although we can all agree that it is better to learn while experiencing positive emotions, Jean had never thought of emotions as levers that can steer decisions. We heard at the workshop that "**Emotions are the highlighter of learning.**" What does that mean? One salient aspect of the workshop was how ubiquitous music was. Clearly, music can lift the mood and create an emotional response. As a result, Jean asked her students in her current class to contribute their favorite two songs that make them feel home and alert, which she now plays before class begins.

(4) *We learn from and with others.* To build better learning conditions, facilitators of the workshop talked about (a) modifying spaces, (b) enabling participants to feel safe sharing their opinions, and (c) encouraging everyone to bring their authentic self.

(a) How many of us have had the experience of going to a talk and learning something more important from a private conversation with another member of the audience? To ensure that students learn more comfortably from each other, Jean requested a classroom in which **students could sit in pods and face each other**. This arrangement has improved interactions among the students.

(b) It is also healthy to ask the team you are working with to help solve an issue. Questions such as "What if we tried…" can open possibilities and encourage suggestions. These conversations can teach team members to treat every opinion as an offer or a gift. It is best to build on an idea rather than shoot it down by using "yes, AND" rather than "no" or even "yes, but." It is also important to address the blocks or concerns that teammates have because those concerns might improve the solution. Things that affect the quality of a team include psychological safety, dependability, clarity of tasks and goals, and the notion that your work matters. Psychological safety is worth emphasizing: How many times does a person you work with feel that they don't belong in the group and, therefore, that it is best not to say anything? How do we address the issue of belonging[8,9]?

(c) Part of building a community is to **bring our authentic selves**. Some ways to do that include the Paseo Protocol and the describe yourself activity. In the Paseo Protocol[10], each person thinks of all the ways they identify themselves (e.g., female, astronomer, Greek). The facilitator gives a prompt, such as "With which descriptors do you identify most strongly? Why is that?" and everyone takes 1 minute to consider their answer, which they share with a partner. We worked with four prompts and were astonished at how quickly conversations became engaging and profound when contemplating our identity. We focused on our values and what really matters to us. Another great activity is to describe yourself without mentioning your title or role, the activities you engage in, or anything that hints at your socioeconomic status. This sharing activity was done while walking in pairs. Try it for yourself. Focus on who you are and not what you do. At first it is challenging, but ultimately it is freeing.

[8] What We Know About Belonging from Scientific Research by Carissa Romero (2015)

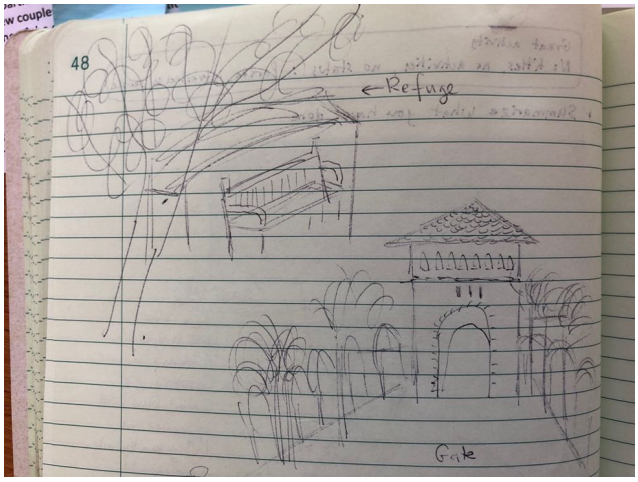
[9] Whistling Vivaldi: How Stereotypes Affect Us and What We Can Do by Claude M. Steele (2010)

[10] https://www.schoolreforminitiative.org/download/the-paseo-or-circles-of-identity/

Finding and scoping problems

One of the most important aspects of addressing a problem is seeing it from a different perspective to get at the essence of the problem and possible solutions. In the workshop, we engaged in several activities related to noticing ourselves, our environment, and putting ourselves in others' place. These activities included: taking on new identities, challenging our built-in assumptions, and being mindful of the language we use.

An eye-opening activity was to walk around the Stanford campus with assigned **new identities**. Jean was assigned to be an architect. That gave her permission to really look at buildings and sketch any buildings that caught her eye. She felt liberated to ignore her limited drafting ability (see below) to thoroughly enjoy being present and look at things with fresh eyes.



Another productive way to change perspectives is to examine our **built-in assumptions**. For this exercise, we worked in pairs. Upon learning our partners' expertise, we made a list of assumptions about them. For example, Jean was paired with a marketing professor. Jean's list of built-in assumptions included that her partner is experienced working with people, is result driven, is good with statistics and afraid of math, and has a corporate attitude. Jean chose one of the assumptions and formed a particular kind of inquiry: "In my experience, people in marketing are afraid of math and science. What's your reaction to that?" To Jean's surprise, she found that her partner was a trained engineer and that she loved math. Meanwhile, Robin assumed that the professor at a military college was logical, rule bound, and not interested in the arts. She was surprised to find him engaged with the arts and interested in using storytelling with his leadership team. These experiences remind us that our assumptions can be limiting and wrong. Let's not allow them to mislead us.[9]

When we are framing a question or problem, **the words we use are important**; we don't want to be too specific or prescriptive. For example, what you draw in response to the prompt "draw a vase" can be very different than what you draw in response to the prompt "draw a way to appreciate your flowers in your home." Jean tried this approach with her undergraduate students. Previously, she would ask them to draw a night sky on dark paper with white pencils; now, she asks them to draw themselves enjoying stargazing. The pictures now include the students admiring the sky and buildings in their neighborhood—the pictures are much more grounded.

Putting these ideas in practice

The culmination of the workshop involved considering how to improve one of the following areas: how you work, collaborate with others, guide your students to learn, or advance some other goal or idea. After we identified an area for improvement, we were encouraged to pick a small starting point—something that doesn't require a lot of resources or permission from others and that can be started soon and completed fast.

Here is how to start: Look at the first thing on your schedule when you return to work. Is it a one-on-one meeting, a group meeting, a class session, or something else? What is the ideal outcome of the interaction? Choose one of the following "levers" to tweak for the result that you hope for: activities, space (as in the environment you work in), artifacts (as in prototypes for a solution that requires an object), shared behaviors and rituals, or language and communication.

Robin found not needing a complete plan liberating. She scheduled a meeting with a senior member of the LEC on how to advance her dream of introducing storytelling in many courses across campus. Meanwhile, Jean wanted to improve her interactions with her student staff. On her first day back in the office, Jean met a student staff member who produces planetarium shows. Her goal was to empower the student to feel that she has artistic agency and the freedom to ask for clarification about the science. Jean chose language and communication as the lever.

Jean's language is not always understood by her staff; thus, she modelled rephrasing what the student said so that it was clear that communication had taken place. Jean also encouraged the student to share her vision so she can feel heard. This simple first step has changed the culture of our interactions and has shifted how our one-on-one meetings work.

We also plan to revise the curriculum of our collaboratively taught course, *Stories of the Stars*, based on the workshop. We will connect the course to investigations in conjunction with the LEC that will impact our planetarium programming and overall teaching on campus. In closing, we again encourage you to reach out to your local entrepreneurship center to see what you can offer them and what they can offer you.

Acknowledgments
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STELLAR STARS: BRING THEM BACK AGAIN AND AGAIN

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A common struggle among planetariums is getting audiences back into the dome after they have seen a show once or twice. Lake Erie Nature & Science Center has one solution to this problem with our show, Stellar Stars. Stellar Stars targets children ages 3 to 7 years old and takes them on a tour of the solar system over the course of 12 weeks. At the end of every show, they collect a sticker on their Stellar Stars Passport. The show topic rotates weekly, and currently families have 4 chances a week to catch the show. While we do not get thousands of visitors coming back for all twelve shows, we do get anywhere from five to thirty families completing their passport every year. In this paper I will discuss our show content and format for the pre-K/K age range, as well as our passport program and the successor to Stellar Stars: Mini Missions.

Blast off and travel through space as you visit different destinations in the solar system and learn about constellations in the night sky! That one little sentence is all we advertise for a 12-week adventure that keeps people coming back to the planetarium again and again. Our Stellar Stars program was developed before I started teaching at the Center 10 years ago, and it will continue to be a crowd favorite long after I have moved on. The goal of Stellar Stars is simple, to educate young children and their families about the objects in our solar system in a fun and exciting way that is age appropriate for 3-7 year-olds and keeps families coming back.

The format of the show is always the same. We get adapted to being in a planetarium, talk about what the solar system is and is not, locate the Earth (wave hi!) and buckle those pretend seat belts, put on our pretend space helmets, and blast off! Using our current software, Uniview. After we learn our planet facts, we head back home to planet Earth and land on the surface in our location to watch the sun set in the west and then we find the constellation of the day. We hear an age-appropriate constellation story and end with sunrise. On their way out the door kids pick up coloring pictures of the planet and constellation of the day, and get a sticker for their passport.

When we blast off to the planet of the day, Uniview flies us dramatically to an up-close view of the planet model and as we slowly rotate around it, we learn the age-appropriate details using models and real images from NASA missions. We always try to compare the planet to Earth, deciding if it has air we could breathe, water we could drink, or an appropriate temperature. We learn what makes the planet unique and different from the rest of the solar system too. Size comparisons are made too. To aid in the size comparisons, we have a display of 1 million zeros on our planetarium wall the children can look at before and after the show. This display comes in handy when discussing the sun and the gas giants. We talk about if the Earth was the size of one of the zeros on the wall, how big the sun/Jupiter/Saturn would be. After the show is over many families approach the wall taking a closer look at the tiny zeros.

Each week the introduction to the planetarium and solar system takes about 5-8 minutes. We are buckling our seatbelts at about 10 minutes after start time. We spend 10-15 minutes learning about the planet, depending on audience interest and staff enthusiasm.

The final 5 minutes are spent on the night stars and locating the constellation of the day. We hear an age-appropriate story about the constellation, and then the sun rises to end the program. When it comes to the constellation of the day, we try to introduce kids to as many different constellations as possible. They are always in the current night sky. Sometimes the constellation is a very famous one and other times it is so obscure and faint the kids actually question if we made it up on the spot. The point is exposure to any and all constellations. If we can't find an appropriate story, or if the constellation doesn't have a good story, we challenge the kids to come up with a story of their own while they are coloring their picture at home.

On the way out the door kids get a sticker on their passport. (It was recently discovered that the stickers we use are no longer manufactured, so when we run out we will switch to stamps.) We do the same planet for the whole week, with shows on Monday, Wednesday, Friday and Saturday, and switch to the new planet on Monday. When we get to the end of the solar system, we go back to the beginning. While we mostly focus on the planets, there are 12 show topics included in the regular line up: Sun, Mercury, Venus, Earth, Mars, Asteroids, Jupiter, Saturn, Uranus, Neptune, Dwarf Planets, and Comets. Once a year on the day after Thanksgiving, traditionally called Black Friday, we celebrate Black Hole Friday, and all of our shows focus on black holes.

When a child completes their passport with all 12 stickers, they get a little prize bag. It is usually a logo wear backpack left over from our summer camps, filled with star crayons, NASA stickers and lithographs, temporary tattoos, book marks, posters, and whatever we can get our hands on from NASA and our part-timer employee that is also a Solar System Ambassador. We used to get many more free items from NASA, but we have hung on to enough that we are still using those materials to stuff our bags. Children get an extra prize on top of that if they attend the Black Hole Friday show and complete their passport. Most recently we found some old Galileo scope kits in our storage room, and those have been the bonus prize for attending all 13 unique shows.

We tally up how many prize bags we hand out, and the numbers have been pretty steady. We started tracking in 2014 when we reopened our newly renovated planetarium. We have one year of missing data, but it was during covid, so it would have been an outlier anyway. Fiscal year 2018-2019 (July 1-June 30) was our highest rate of completion, with 30 kids finishing their passports. The fiscal year of the height of covid (2019-2020) saw our lowest number with 4 completions. And last year, 2021-2022 we rebounded nicely to have 15 finished passports. Once children complete Stellar Stars and get their prize bags, some opt to get a new passport and begin again. Other children move on to our next show, Mini Missions for children 7 and up. More on Mini Missions next time.

In the grand scheme of things, it might not sound like much to have 15 friends visit for 12 shows out of the thousands we get a year, but Stellar Stars is by far our most popular show, with people calling every week to check what planet it is so they can stay on track. Families have taken years to finish their passports or completed it in only 12 weeks. However they do it, children and families are having fun coming back to the same format with new information every week.

DOMECASTING IS FOR THE BIRDS!

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What began as a canceled 2020 birdwatching talk at Staerkel Planetarium in Champaign evolved into a successful live domecast shared with audiences in two domes. We plan to do it again, and to invite more domes to join in next time. Find out how you can join in, or how you can transform your dome into amore localized birding event.

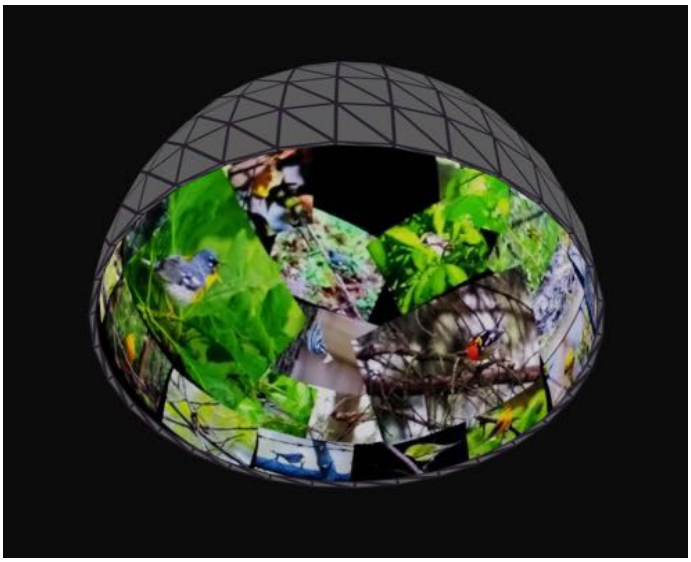
Introduction

Last spring, we hosted a fun live lecture event on Birdwatching, using terrain flyovers of various central Illinois locations for finding a wide variety of midwestern U.S birds. For each of these locations, anywhere from 6 to 24 bird images were shown, all taken by the speaker, Jeff Bryant, who had stories to share about the birds. The visuals and audio were domecast to the Cernan Earth and Space Center at Triton College in River Grove, IL. In Champaign, Waylena McCully ran the controls, while in River Grove, Wayne Foster hosted their guests and monitored the program.

WarblerDome!

For decades, the William M. Staerkel Planetarium has hosted a monthly lecture series featuring experts and interesting speakers on a variety of science-related topics. Originally called the "World of Science Lecture Series," it was eventually renamed to the "James B. Kaler Lecture Series" in honor of Dr. Jim Kaler, whom several of you here may recall as a long time member of our GLPA community and the original Astronomy Update Speaker.

For several years, they had been trying to get Waylena's husband, Jeff Bryant to speak on the topic of birdwatching and bird photography. He declined at first because he didn't feel like an expert and was concerned that someone from the local Audubon Society might attend and be disappointed. A few years later, after he presented AT a meeting of the local Audubon Society, he finally agreed. So in 2019, as Director Dave Leake prepared to retire, he booked Jeff as a speaker for the April 2020 Kaler Lecture.



Instead of a simple power point, they wanted to do something more immersive, so in playing around Waylena copied every warbler picture Jeff wanted to

potentially use, and posted it to her planetarium friends as WarblerDome!

Alas, the closure of the planetarium in March 2020 resulted in the cancellation of the talk, so they didn't get to develop the dome version of Jeff's talk.

They did schedule Jeff for a birdwatching talk in the 2020-2021 entirely online version of the Kaler Lecture series, and it was easily the best-attended of the Staerkel Planetarium online live presentations.

Domecasting Dreams

In domecasting, the content (scripts, interface, digital media) is packaged and downloaded to participating systems, and is then controlled by the host dome.

Plans for testing at the Staerkel Planetarium in early 2020 with other domes were put on hold, just like everything else that year, but they still wanted to give it a try. After all, Jeff and Waylena had been attending wonderful dome cast events for a few years at the Dome Planetarium in Peoria.

Meanwhile, at the Cernan Earth and Space Center at Triton College, Director Kris McCall had also been wanting to start up some domecasting with their Digistar 6 system and was seeking partners to work with. There seemed to be a growing perception that domecast events were for the larger, more dominant planetariums, but Kris saw potential for relatively smaller domes to build such programming as well.

Wayne Foster joined Cernan Earth and Space Center in 2020 just as everything was closing, and built a very nice regular YouTube series for the planetarium that continued even after the reopening in 2021.

Wayne had to meet Waylena and Jeff online when all meetings were virtual, but it didn't take long to find out that Wayne is an active birder.

Bird Talk 2022

The Spring Kaler Lecture series was already scheduled, but the staff decided to put together a version of the original immersive birding talk. A date was chosen for early March 2022, to encourage people to go out an find birds for themselves as the migration season moved into full-swing. The date also closely followed a Kaler lecture, providing an opportunity to promote it to the local fans of science lectures.

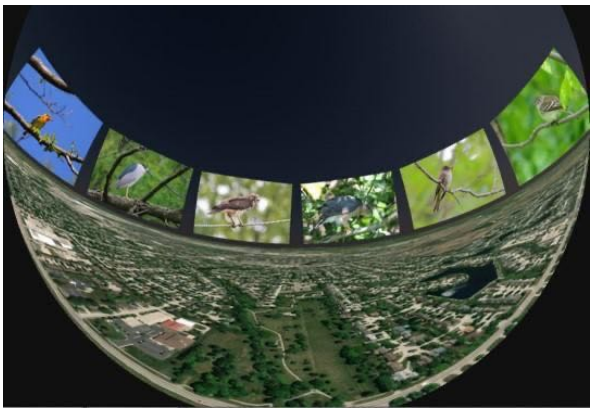
Waylena told her planetarium friends, several of whom had become more interested in birds over the previous two years, and Kris McCall responded asking if we could all try it as a domecast.

Staerkel Director Erik Johnson was immediately on board. Both Waylena and Jeff decided to give it a shot, knowing that if the unproven technology failed us, Wayne was more than capable of leading a discussion of the featured birds to the audience at Triton.

Programing for Multiple Domes

Basic idea is simple: a live program is set up. The interface, scripts, 3d models and digital media files are all uploaded and distributed to participating domes. During the domecast, the receiving domes are controlled by the presenting dome.

Waylena and Jeff decided to use Digistar terrain to fly to some of the birdwatching locations. Jeff narrowed it down to 18 locations and chose at least 6 bird photos from each location.

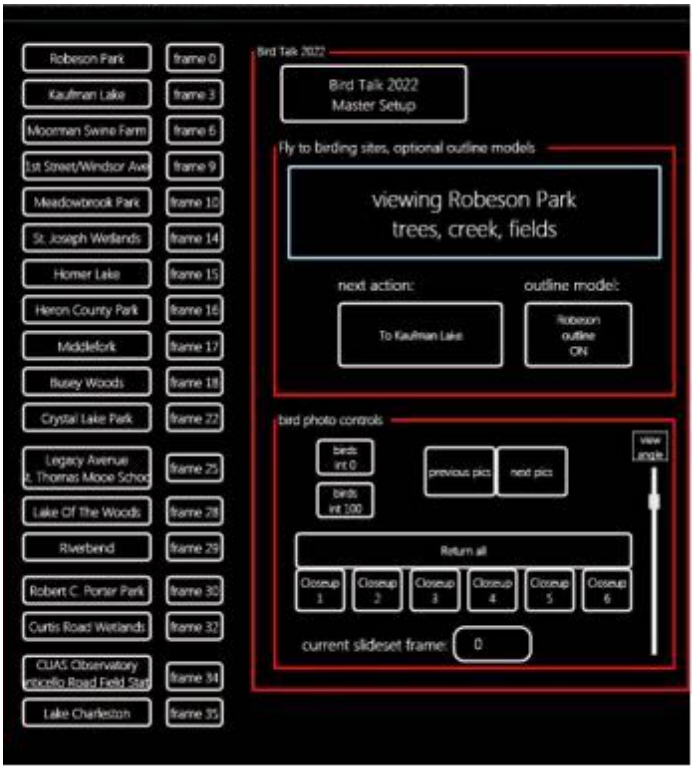


The dome at Cernan Earth and Space Center is tilted, while the Staerkel dome is not, so the viewing angles were a bit different than what the Staerkel Planetarium would usually use. The audience at Staerkel didn't seem to mind.

Because the remote audience would not see the presenter's laser pointer, Waylena created 3D model outlines in Blender

Each bird photo could be enlarged as a callout for showing a more detailed view.

Waylena set up the controls so that she could operate them following cues from Jeff. Additional controls were set up in case locations or images required revisiting during Q & A.



Testing

Waylena and Wayne ran several test sessions to figure out what worked and what didn't.

The biggest issue was audio. The ideal situation would be for both audiences to hear Jeff describe the birds and the birding locations, while also having both audiences able to hear from Waylena and Wayne, who could get microphones to audience members for asking questions.

An early workaround used a private Zoom session just for audio. Both facilities had some experience using Zoom with planetarium audio systems. It sounded really good at both ends, and there was no noticeable lag. In fact, it sounded so good and performed so well in testing, that we decided to use it for the event.

The Event
WarblerDome 2: Birding Boogaloo

We are doing it again! And this time we are inviting more domes to participate.

Jeff has agreed to present once more, but only if Waylena lets him replace some of the photos with new ones he has taken since the last presentation. (Jeff's photos are available on his Flickr page: www.flickr.com/photos/jeff-m-bryant)

We know that we can make it work for Digistar 6 domes, and we are working on how to get it to work with Digistar 7. There will be testing sessions and we may need to simplify the programming setup, but it will be worth it.

Beyond 2023, we hope to continue birding-oriented domecasts, perhaps with Wayne leading the talk.

Beyond Birding

And we hope to encourage other planetariums with domecasting capability to give it a shot. Many topics with local appeal are of interest beyond our usual geographic spaces.

Thank You!

LIVING IN BALANCE: A COLLABORATIVE PLANETARIUM SHOW ON ANISHINAABE STAR KNOWLEDGE

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The Abrams Planetarium collaborated with Dr. Beth LaPensée to create a planetarium show on Anishinaabe Star Knowledge. The script and art was created by Dr. LaPensée and the show heavily features the Eastern dialect of Anishinaabemowin. It was narrated, reviewed, and approved by Anishinaabe elders and community members including Alphonse Pitawanakwat, Aarin Dokum, and Dr. Annette Lee. Abrams translated the assets into a show using Gimp and Digistar 6 programming. We took the information from Dr. LaPensée to develop an educator guide that accompanies the show. We are distributing it for free or low cost for anyone who is interested.

Introduction

The Abrams Planetarium worked with local Indigenous people to create a new planetarium show called "Living in Balance: Anishinaabe Star Knowledge." The project was mostly driven by Indigenous folks and heavily features Ansihinaabemowin, the Anishinaabe language. It covers Anishinaabe constellations throughout the seasons, some stories as appropriate to share in a planetarium show, and the names of the moons that are based on observations of the surrounding environment. Due to Climate Change, the names of the moons have been shifting in relation to the western calendar and this is discussed in the show as well. There is also an educational guide that includes an Anishinaabemowin glossary and additional information about the constellations.

The show was produced using Digistar 6 programming to overlay original art over the constellations and to highlight the stars. Additional art was shown on the dome to highlight the changes through the seasons. The art was created by and the show was written by Dr. Beth LaPensée. Dr. LaPensée works in the gaming industry and was formerly faculty at the Michigan State University College of Communication Arts and Sciences. She is Irish, Anishinaabe, and Métis. She created a virtual reality game called "Along the River of Spacetime" from which the show was based.

The show was narrated and reviewed by Aarin Dokum who is Anishinaabe from Wiikwemkoong First Nation and a speaker of Anishinaabemowin, the Anishinaabe language. Alphonse Pitawanakwat is an elder of the Wiikwemkoong First Nation in Ontario and a fluent first language speaker of Anishinaabemowin and reviewed all the language in the show. And Dr. Annette Lee, who is Lakota living in Ojibwe communities, reviewed the star knowledge in the show as Director and Founder of Native Skywatchers. Additionally, JP Chalykoff, who is Anishinaabe from Michipicoten First Nation recorded the sound for the show and Jordan Thomas, also known as Exquisite Ghost, who is from Peguis First Nation wrote the music in the show.

The show production model was that of co-creation. The story and review was done by our Indigenous collaborators while Abrams took on the role of steward. The Abrams Planetarium took the assets and

used them in a way that made sense for dome environments and did the programming within Digistar. We also reviewed the script to suggest some shifts in the narrative beats for better flow within the dome. We are also distributing the show for free to low cost to anyone who is interested.

Initial Collaboration and Funding

This project came about through conversations between Dr. Shannon Schmoll and Dr. LaPensée about wanting to create a planetarium show on Anishinaabe Star Knowledge. Dr. LaPensée and Dr. Schmoll collaborated on a display on Ojibwe constellations in the lobby through a class where students created new exhibits. Dr. LaPensée had created the game "Along the River of Spacetime." This meant the art was largely already created and we just need to turn that into a planetarium show narrative. We began to look for funding.

Dr. LaPensée decided to pursue funding via the Michigan Space Grant Consortium for the amount of $5000. Her college at MSU provided an additional $5000 in cost share. Dr. LaPensée and Dr. Schmoll provided their time as part of the cost share while the $10,000 we used covered honorariums for our advisors, Aarin Dokum, Alphonse Pitawanakwat, and Dr. Lee as well as time for our production staff, John French. Since everything was done using overlays of custom art from Dr. LaPensée in Digistar we were able to do this for relatively little money.

Figure 1: Examples of art from Dr. Beth LaPensée that were used in the show.

Narrative

The narrative of the show itself shares Anishinaabe teachings of Mina-Madzaawin, or living a good life, and living in balance with the environment and how climate change makes that more difficult. It goes through the seasonal constellations and the names of the moons at different times of the year as well as discusses practices and observations of the environment during those times of the year.

The Eastern dialect of Anishinaabemowin is centered through the narration as well. While it is primarily in English the names of the moons and constellations are always shown and spoken in Anishinaabemowin and if an English name is provided it is always secondary.

The show also does not discuss the Anishinaabe constellations in relation to the Western European constellations. The IAU constellations are never once mentioned in the show. The constellations are presented specifically as a valid method of scientific observations that stand alone.

Figure 2: A circle that was used to represent stars. These were animated in Digistar six to offer a dynamic element to the show

Production

Most of the production was done by John French using the Digistar 6 programming system. The majority of the visuals are static images. The artwork for the constellations was created by Dr. LaPensée. She also created small donut shaped graphics for the stars that were to be overlaid on the constellation art. This made it easy to align the art with the starfield. The text on the dome consists of transparent .png images created using a combination of Microsoft Powerpoint and GIMP.

The narration was done by Aarin Dokum and recorded by John-Paul Chalykoff. The music was composed and recorded by Exquisite Ghost, a.k.a. Jordan Thomas. The music and narration were supplied to Abrams Planetarium as a series of .mp3 files. The narration was given to Abrams Planetarium as a single 12 minute audio file that was then edited to allow for pauses and create a 25 minute long show. Each paragraph of narration was a separate file. John French then used an audio editor to assemble the clips into one soundtrack.

Figure 3: A screenshot from the show featuring several elements of the narrative and art.

Project Timeline and Response

Overall the project took about a year to complete from the time we were informed of funding being granted to the first shows for indigenous groups. The bulk of the work took about 6 months from writing the initial script to the programming of the final version of the show. Art and audio assets were provided to the Abrams Planetarium and there were approximately 3 iterations of the show produced. A draft, followed by significant additions to the art shown, and final tweaks. Dr. LaPensée reviewed it at those different iterations. We invited Aarin Dokum and Alphonse Pitawankwat, being the most local partners, to review and offer their approval.

The show was then shown to Indigenous community members in late winter/early spring of 2022 free and we were open to feedback. The response was overwhelmingly positive. Several people expressed to us that it was powerful to see their knowledge presented in a science institution. Others noted they were not aware or didn't know there was star knowledge and were happy to learn more and expected to continue to learn more through programs like Dr. Lee's Native Skywatchers. Most poignantly, there were Indigenous women present who had grown up interested in star knowledge and felt a gap because of a lack of a show like "Living in Balance." They felt especially fulfilled by watching the show with their children, who they expressed will grow up with new opportunities and understanding that they didn't have in their generation.

Distribution

This show is available for free or for a small fee to cover the cost of a harddrive and shipping if frames are needed that way. For Digistar planetariums we will send the scripts instead as it does run more smoothly that way. For those who are not Digistar planetariums, we are happy to provide the frames instead. We also provide an educator guide and a poster with the show.

The show is released under a creative commons—no derivatives license. You are free to charge for tickets to the show though we do ask that if you show it to Indigenous communities you do that for free. That license also means you are not allowed to change the show in any way. Though we would be open to new versions of the script and narration in other dialects of Anishinaabemowin. Please contact us before pursuing those potential changes.

IPS 2024 IN BERLIN AND JENA

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Abstract This paper is to update the membership on the International Planetarium Society conference in 2024 that will take place in Berlin and Jena, Germany. IPS 2024 will be the first in person IPS conference since IPS 2018, and it is happening in the middle of the Centennial of the Planetarium! There will be many exciting opportunities for planetarians at IPS 2024 and GLPAns won't want to miss out!

The International Planetarium Society (IPS) Conference in 2024 will be held in Berlin, Germany with Pre-Conference Activities occurring in Jena, Germany. Jena is the birthplace of the projection planetarium, and Berlin is the capitol of Germany with three permanent planetariums, two mobile domes, and two observatories. IPS 2024 will be the first in person IPS conference since IPS 2018, and it is happening in the middle of the Centennial of the Planetarium! There will be many exciting opportunities for planetarians at IPS 2024 and GLPAns won't want to miss out!

We understand what an exciting and important IPS conference this will be, and because of this we are trying to keep the conference as affordable as possible so that planetarians can attend! The bid documents can be viewed at https://www.planetarium.berlin/ips2024 for more details (plans are subject to change).

INTERGENERATIONAL INSPIRATION: SAFE SOLAR VIEWING, ASTRONOMY SLAM, & MORE

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As planetarians and educators, it is our mission to share our passion for space with our guests and support them in their journeys of lifelong learning in order to inspire the next generation of explorers. At the Charles W. Brown Planetarium, Ball State students engage the public with a new solar telescope purchased through support from the Institute of Museum and Library Services (IMLS), present an annual Astronomy Slam! where students share a piece of the universe through a friendly competition, and broadcast a virtual Constellation Crew live series to YouTube. This presentation is made possible by the IMLS.

Introduction

Planetariums are versatile spaces designed to encourage curiosity and wonder. As planetarians, it is our mission to share our passion for space with the public, supporting lifelong learning and inspiring the next generation of explorers. But we know our inspiration doesn't stop there. We attend professional conferences to share and acquire knowledge, and we share our experiences and talents with those in our own institutions. In fact, workplaces typically include generations of experience, coming from young professionals as well as seasoned workers, which make it easy for intergenerational learning and inspiration to occur.

At the Charles W. Brown Planetarium, we strive to inspire our guests—and our fellow team members—in all that we do. To achieve intergenerational inspiration, we need workers from a variety of backgrounds on our team. Students are of different ages and are at different points in their academic careers. They range from graduate and undergraduate students to high schoolers. Together, alongside professional staff and faculty, we make up a team. The entire planetarium team shares ideas and opinions through peer review, planning sessions, team meetings, and simply through working closely together during projects and events. This workplace dynamic promotes discussion and encourages creativity.

To better engage students in this environment, we encourage their involvement in all that we do. Student workers are essential to making sure our weekend public programs are successful, working as crowd

facilitators, exploring STEM concepts at a hands-on activity station with guests, or helping people see celestial objects through telescopes. During weekday school group visits, trained student assistants can also present educational content in the dome. These positions give student workers a range of opportunities to acquire experience in science communication, and to help impact and improve future planetarium programming. Their work is influenced by those before them, and their additions help influence the next generation in their efforts.

To give students even more creative freedom in their work, we have two student-centered projects: Astronomy Slam! and Constellation Crew. These projects put the students front-and-center and afford them the opportunity to lead the design of their work from start to finish. These events add to the breadth of opportunities we offer not only our community, but our student workers, really empowering the next generation of science communicators and enthusiasts.

To better serve our community, and to expand our current offerings, we submitted a proposal to the Institute of Museum and Library Services (IMLS) Inspire! Grants for Small Museums initiative. The grant was funded and has enabled us to purchase new planetarium shows, create and install lobby wall exhibits, and obtain a new Coronado SolarMax III 90mm solar telescope for public events. To further support the IMLS grant project, we purchased a Meade 8" f/10 LX85 ACF Optical Tube for evening observing and a Meade LX85 Computerized GoTo Telescope Mount with AudioStar, which will also be used for observing with the Coronado solar telescope. The IMLS grant supported this paper and travel to the 2022 Great Lakes Planetarium Association Annual Conference.

Safe Solar Viewing

The Charles W. Brown Planetarium is located at Ball State University in Muncie, IN, which lies inside the path of totality for the upcoming total solar eclipse in April 2024. This eclipse will be a fantastic opportunity to educate and prepare the public on how to safely view the Sun during eclipses and at all other times. Reaching an entire community, along with visitors traveling from out of town, with the resources and supplies needed to safely view a solar eclipse is no easy task. We are starting now and are using the help of our student staff to support this endeavor. To prepare for these events, we have been running the Sudekum Planetarium's Eclipse: The Sun Revealed fulldome show to help guests not only learn about what solar eclipses are and how to safely view them, but to inspire and excite them about the unique opportunity that Muncie has to see a total solar eclipse in 2024, right at home. Our student workers are peaking guests' curiosity before the shows by facilitating hands-on activity stations that explore solar eclipses.

To further involve our students, planetarium staff and faculty astronomers have been hosting telescope viewings during public events. Moving forward, students will not only lead nighttime viewings, but also daytime solar viewings with the new Coronado SolarMax III 90mm telescope purchased in September through the grant funded by the IMLS. As student assistants are trained by leadership to host safe solar viewings leading up to the eclipse, they will share their knowledge and inspire the public, serving as solar eclipse ambassadors. Before the 2024 eclipse, our team of students will join the large network of local educators and community members that are prepared to provide safe, educational opportunities for nearly everyone to view the eclipse safely.

The Constellation Crew

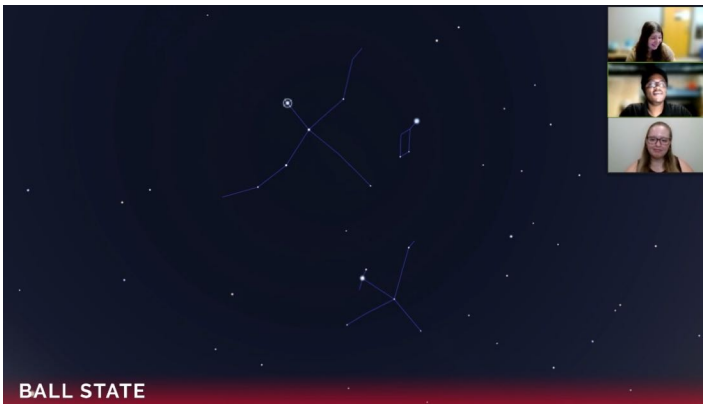

Figure 1. "Goodbye to the Summer Sky" screenshot with the Constellation Crew - September 2022

Constellation Crew was originally developed and led by Planetarium Director, Dayna Thompson, in response to closures caused by the COVID-19

pandemic but has since evolved into a student-led project. During *Constellation Crew* episodes, student presenters discuss how to find constellations in the sky, the mythology behind them, and what celestial objects lie within them. Presenters also give updates on current missions and space news for viewers to learn about. You can watch the latest *Constellation Crew* episodes on the planetarium's YouTube channel, or learn more about the series on the planetarium's website.

As the planetarium slowly reopened to the public after being closed due to COVID-19, *Constellation Crew* continued. The show transitioned to a student-led project to give students more agency in the projects they bring to the team. By design, the show has an informal and conversational feel, but the episodes do require some planning and direction from professional staff. The crew of students and staff meets before each episode to brainstorm a theme or constellation for the next episode. From there, the outline process begins on a shared GoogleDoc, where students collaborate on ideas and add notes. Once a general outline is created, students choose topics to research and present on for the episode.

Through their work on *Constellation Crew*, students learn from one another and produce an educational and entertaining series for viewers of all ages. The show has amassed some supporters over the past few years, like the daughter of one viewer, who wrote to us stating, "My daughter is 8 and watches the *Constellation Crew* every chance she gets." The series even inspires beyond its intended audience, keeping planetarium staff involved in the process, introducing them to science topics or concepts they may not have heard of before, while helping students refine their science communication techniques.

Astronomy Slam!

Figure 2. Astronomy Slam! at the Charles W. Brown Planetarium

For the past three years, we have put on the annual Astronomy Slam! at the Charles W. Brown Planetarium. Student presenters select an astronomy topic of their choice and create a 10-minute presentation to share in the dome in front of a live audience in the most creative way they can. For many of our students, preparing and presenting a talk on their own is a unique experience. They lead the design of their presentations with support from planetarium leadership, and planetarium visuals are created for them to use during their talks to form a fulldome planetarium experience for the audience. Students are given a space to share their passion for astronomy in a creative and non-threatening atmosphere, while having the opportunity to educate and inspire the young learners and families who attend the event.

Like all our programs, audience participation is essential to the success of the event. At the Astronomy Slam!, awards are voted on by the attendees in real time at the end of the presentations. Questions are asked to the presenters during the tallying of votes. The selected Astronomy Slam Champion receives the Best Overall Presentation award, and every student is recognized and awarded with a trophy and certificate. The other awards are: Most Thought-Provoking Presentation, Most Visually Engaging Presentation, and Best Energy. The students can use these presentations and awards to help strengthen their professional resumes for future endeavors.

To keep the conversations going after the presentations in the dome, there is a reception in the

lobby with food and drink, allowing guests to meet and speak with the presenters. At last year's Astronomy Slam!, we were joined by a staff member from Ball State University Foundation, who sent us and her colleagues a kind note stating, "It was so well done; my friends were thrilled I introduced this gem to them. If you are looking to impress your friends, family, or donors, take them to the Astronomy Slam…" This goes to show that students have much passion to share with the world, inspiring anyone from young children to adults, including our professional staff. In fact, some Astronomy Slam! content has been used in public shows after the event, like visuals on nuclear fusion created for graduate student, Greg Gallagher's 2021 presentation, Stars: A Lego Factory. Learn more about the Astronomy Slam! on the planetarium's website.

Beyond Astronomy: Arts in the dome

Planetariums are creative spaces that have the ability to inspire beyond astronomy. In addition to the two student-led astronomy projects we offer each year, we are hosting a special arts celebration this year, or *Dome Party*, in honor of award-winning writer and physicist Dr. Janna Levin's visit to Ball State University. A team of faculty and staff invited Ball State students to submit original pieces of art, poetry, short writings, film and music that celebrates the Webb telescope and team, and the human propensity to ask deep, difficult questions while gazing at the stars. Pieces were chosen by a team of faculty and students to be performed at the *Dome Party* during this unique event. The performance is followed by a Q&A with Dr. Levin about her career and efforts to bridge the perceived gaps between art and science.

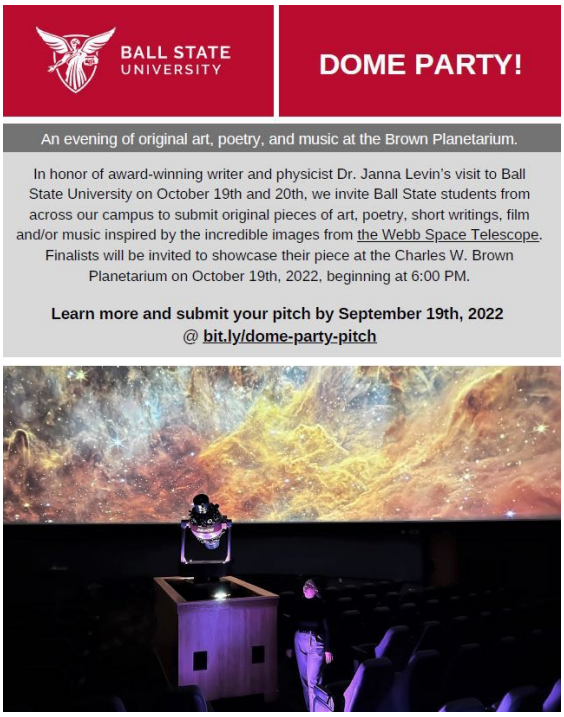

Figure 3. Dome Party call for pitch submissions flyer.

To support this event, a poetry workshop titled, Poems in the Dome was held in the planetarium the month prior to the *Dome Party*, motivating students to create and share their work. Attendees were guided through a series of writing exercises inspired by the Webb Telescope by Planetarium Director, Dayna Thompson, and Creative Writing Professor, Katy Didden. This workshop inspired one of our Department of Physics & Astronomy Graduate Assistants to submit a series of her own poems to present at the *Dome Party*.

Conclusion

Our students' contributions to the team through these student-centered projects inspire more than just our guests. They inspire new content for professional staff to bring to the dome for public and private shows, keeping our presentations dynamic and evolving. Supporting our team of students provides them opportunities to strengthen their skills, and also promotes discussion among the entire Charles W. Brown Planetarium team to keep progressing in our mission, "to encourage scientific literacy and advancement through inspiring educational programming, innovative research, and service to our community."

DIY ASTRONOMY THEMED INTERACTIVE EXHIBITS

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Does your planetarium lobby or museum gallery need a little more interactivity? Folks of all ages benefit from hands on learning experiences. Learn about some low to high effort do-it-yourself interactive and kid friendly exhibit elements that the Peoria Riverfront Museum used in our Moon and Mars exhibitions, and how you may be able to adapt them for your purposes.

In the past three years, the Peoria Riverfront Museum has created three different astronomy themed exhibitions, two on the Moon and one on Mars. These were self-curated, meaning we wrote the content, borrowed or acquired the objects, and created our own interactive elements. Interactive exhibits in museums or planetarium lobbies can be engaging to visitors of all ages. The elements we created are outlined below, in hopes that they may be helpful to others.

Low Effort Interactive Exhibit Elements

Some interactive exhibit elements are very low effort, and still enjoyable for visitors. People of all ages enjoy being able to participate in an exhibit or display. For MOON, we asked guests to think about what would be different on Earth if there were no Moon. We printed this question on vinyl at a local sign shop, and put the knock-out letters on the wall. Then we simply had a table with pencils and colorful sticky notes underneath, and visitors wrote their responses on the notes and added them to the wall (Figure 1).

Figure 2– Visitors sharing what would be different on Earth if there were no Moon, using post-it notes

This question and answer element could be done for any topic. The colorful notes on the dark background looked nice. Gallery just needed to remove a few impolite words or drawings now and again, but overall, people enjoyed the ability to add to the exhibit. You could do this same sort of interactive where guests answer a question on a computer screen, and a display scrolls through answers. In our experience, guests respond better to the simpler screen-free option.

For our moon themed exhibitions, we also had some interactive elements for our very young visitors. We purchased dress up astronaut clothing, with hard space helmets. Plastic hats or helmets do not have concerns about head lice as cloth ones might. We included a few Galileoscopes with these. Young visitors loved to dress up as an astronaut, and to point the simple telescope at Luke Jerram's Moon artwork (Figure 2).

*Figure SEQ Figure * ARABIC 1– Young visitors dressing up in imaginative play with the Moon.*

Parents loved taking the little ones' picture dressed up! Dress up is an excellent form of imaginative play, which encourages creative thinking and communication skills.

In all of our exhibitions we include a little sitting area for people to rest, and read books related to the topic. Including books for children gives another nice activity for families to do together while they are spending the day at the museum. A book corner would be a nice addition to any planetarium lobby as well, with picture books for children and adults.

In addition to picture books, simple toys related to the exhibit or theme of your space can help little ones have more fun. For our Moon themed exhibitions, we included plastic rocket toys that were fairly accurate in design to the Apollo spacecraft, toy astronauts in pressure suits, and a moon buggy. We also found some wooden blocks with Moon phases on them. Purchasing the educational toys related to the exhibit was very low effort, but again, very popular with guests. Children can play with the toys while their accompanying adults read labels and looked at the objects. The toys can help facilitate a conversation between the children and grownups about the topic – a rocket toy can be used to talk about escaping gravity, a pressure suit astronaut can be a good demo for talking about the Moon's lack of atmosphere, and so on.

Finally, in our MARS exhibition, we added a space with tables, chairs, and bins of LEGO bricks. Guests were provided with examples of proposed Mars habitats, and an explanation of the dangers of the Mars environment that a habitat would need to protect a visitor from. They were given prompts to design and build their own Martian habitat. While some guests built entirely unrelated creations, many built small miniature living structures. This type of activity would also work well as a classroom activity, lobby cart activity, or corner of a planetarium lobby space. We have a ton of LEGO available, so this addition was free to us. The same activity could be done with K'nex, or any building toy.

Medium Effort Interactive Exhibit Elements

At the Peoria Riverfront Museum, we have also created some interactive exhibit elements that require a little more technology, carpentry, or space. These medium effort level exhibit elements have been popular and nicely interactive.

NASA/JPL has created several Solar System Treks. These online, browser-based portals allow a user to explore the surface features of many worlds using real data. They are an exhibit already created in themselves, but the danger with any web-based exhibit component is that the visitor will navigate away from the page and put something unwanted up on the screen. To overcome that challenge, we purchased the KioWare lite software, which restricts browser access and controls pop-ups, and has many other controls. This software allows us to display the interactive website without being concerned that users will do their own browsing (Figure 3).

Figure 4– Mars Trek on a locked down touch screen.

Our MARS exhibit features two full sized rover models on loan from NASA/JPL-Caltech. We wanted to give visitors a chance to drive some small robots, so they could think about all the difficulties in navigating a robot on a world far away, with a significant light delay. We already owned some Dash robots, and small tablets used to control them. Our exhibit preparator created a little maze for the robot (Figure 4).

Figure 3– "Dash" robots on a robot maze. A visitor pilots with a tablet.

Guests were encouraged to try to drive the robots through the maze. When they found it challenging, it was a good talking point for how difficult controlling robots on another planet would be. This interactive exhibit element required more effort to create – you need to have a person who is good at woodworking to create the maze. To lock the tablets down so that people couldn't get to any app except the app used to control the robots, we used several layers of parental controls. The browser is completely blocked, as are searches, purchases, and communications.

High Effort Interactive Exhibit Elements

Some of the interactive elements the museum created for our astronomy themed exhibits required quite a bit of time and effort to create. These are ones that will be useful for a long time, and were the most popular parts of the exhibit, but if you are interested in recreating them, you should be aware of the time sink required.

We wanted visitors to understand a little about Mars' atmosphere by seeing the current weather report on Mars, and being able to listen to the sounds on Mars, produced by NASA (Figure 5).

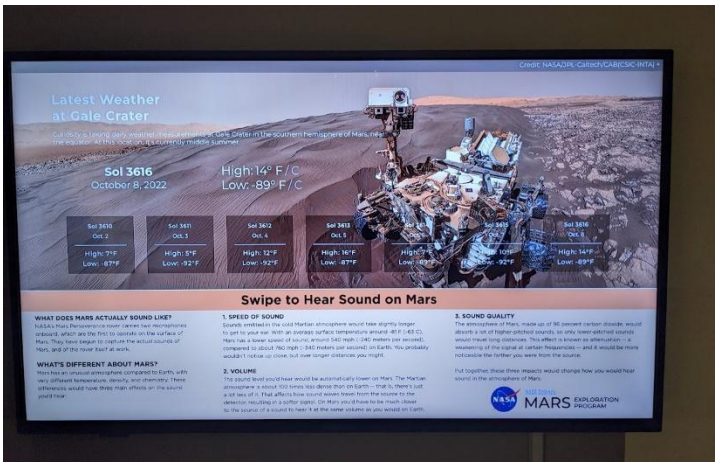

Figure 5– An interactive presentation using a BrightSign and smart TV.

The IT department at the museum helped me create an interactive station using a smart TV, with BrightSign LS524 and BrightAuthor:connected. The top half of the TV connects to the NASA web page that displays the weather from Curiosity. The BrightAuthor software allows you to create zones on your screen, and embed a website in a presentation. Because it is wifi enabled, it just displays the NASA widget and updates when it updates. We connected a Nexmosphere XT-EF650 to the TV, which uses a magnetic field to allow a visitor's gestures to control the content on the screen (Figure 6).

Figure 6– The Nextmosphere sensor reads visitor gestures to control the content.

As you swipe through the magnetic field, your hand creates a disturbance that it can read a signal. In this way, guests can swipe through a playlist we downloaded from the NASA website of sounds recorded on Mars, or a comparison of sounds on Mars vs sounds on Earth. This content could be presented on a touch screen, or a looping video as well. But the

swipe technology is neat, and allows the visitor to interact with it in a different way.

We also wanted visitors to have a physical way to think about elevation on Mars. You can create your own augmented reality sandbox, if you purchase the equipment, and build the box. There are tutorials available online. We considered building it ourselves, but were pressed for time. Instead, we purchased a sandbox from Idea Fab Labs in California. Immediately upon installing it, visitors were exploring Mars' elevation with the sand and changing elevation lines. As a user changes the shape of the sand, building a mountain, or creating a valley, the projected topographical map changes as well (Figure 7).

Figure 7– An augmented reality sandbox can be made by yourself, or purchased.

We have a Mars elevation map nearby, and text encouraging visitors to recreate a Martian landscape.

Finally, during our MOON exhibition, we wanted little people to feel like they could land on the Moon. We worked with a local artist to create a "LEM simulator". Using some suggestions of equipment from Steve Burkland, and photos of the interior of the lunar module, the local artist created a switch board with LED lights, knobs, buttons, and switches. Above it, we included a TV screen mounted at an angle, that looped footage of landing on the Moon from Apollo 15, from the perspective of inside the LEM. The buttons and switches did not control anything except some LED lights, but our little guests loved it (Figure 8).

Figure 8Young Kerrigans enjoy the LEM simulator exhibit made by a local artist.

We intend to reinstall the piece in our planetarium lobby, now that MOON has ended.

I hope this explanation of the interactive parts of the exhibitions we created may be helpful to others with gallery space, a lobby, or even as use in classroom activities. Providing a different method of learning is helpful to people of all ages, and interactivity adds more fun to your space.

WHAT NOW?
THE POST-PANDEMIC PLANETARIUM UNIVERSE

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During the pandemic, Planetarians used their creativity and resourcefulness to remain connected and valued to their different audiences. Many of their methods involved virtual programming, both live and recorded. As we reopen our facilities to in-person experiences, many are finding that the future is not so much about a "return to normal" but instead an evolution into a new recipe of community engagement. In this presentation, we'll explore what a new balance might look like.

The Delta College Planetarium reopened in late 2021 to eager crowds and surprisingly high attendance numbers. While we were happy with the turnout, we also realized that there was no such thing as a "return to normal." During the 17 months our doors were closed, we found creative ways to connect with audiences of all types. While many of these here may not sound unusual or unique to most planetariums (including ours), the difference is that we stepped up the depth and variety in these areas.

Greater Social Media Presence

- Many people turned to social media during the pandemic
- It's not just posting more often
- Encourage feedback – be social!
- Use engaging imagery
- Always provide a call to action (a link)

Virtual Presentations

Virtual programs allowed us to reach a much wider audience. This helped build awareness of the planetarium's existence. It also became a crucial way of staying connected with the school system. It also served as a way to reach many schools that could never visit the planetarium in person.

YouTube Productions

- We produced over 30 mini-productions, each running between 5-10 minutes (research indicated many people don't watch past about 8 minutes).
- A comprehensive series on the constellations
- Hot topics and current events
- Built a following of nearly 3,000 subscribers
- Posted recordings of our live virtual events here. Binocular Astronomy video has 30,000 views.

Radio Programs

- Expanding more into radio did a lot to reach new audiences
- Contact stations to get on their interview shows
- Offer a short astronomy spot for your local NPR affiliate

Podcasts

- Our radio spots automatically go into podcasts, but you can easily create your own.
- They do not need to be very long. My "Backyard Astronomer" podcast is only 2 minutes long.
- Promote them to get more followers

E-news

- This became an important vehicle for alerting people to our online offerings and special events.
- Include a personal "Monthly Message"

- What's in the sky
- Exhibits and displays
- Resources for online exploration

Supply online learning activities to schools and the general public

- We did a lot of research to find resources for home and classroom hands-on activities!
- A much more complete list is on the Planetarian Network.

Underserved Audiences

- Outreach – Right before the pandemic, we started bringing more outreach programs to schools, libraries, and special events. These were very popular. While coming back into demand, we've had to be careful because the pandemic is still a concern for our staff.
- We will continue, on a limited basis, virtual field trips in cases where we can't come out in person.

The "BUS" Scholarship Program

- Min 40% students in free lunch program
- Or the class is ESL/ELL or special needs
- Max reimbursement of $100
- Requires bus company invoice
- Funded by the Delta College Foundation, Optimist Club and "Round Up" donations

Online Ticketing System

- Seized the opportunity to install online ticketing.
- Found a solution that includes point-of-sale.
- Gave us new ways to advertise and build awareness.
- An efficient way to handle donations such as the BUS scholarship program.
- Expected an initial sales rate of 20% online – instead got 35-50%.

A Re-Evaluation of Theater Programs

- Quality is king! Yes, there are a lot of low or no cost programs out there, but evaluate them carefully so they will meet audience expectations.
- Live specials on hot topics and current events.
- Multi-disciplinary programming. As part of a college, we are exploring methods for bringing other classes into the planetarium for immersive lab-like experiences. Digital now makes that easier (less time-intensive production).

How do you maintain all this?

You can't! At least not to the same level. Adapt, evaluate, and re-prioritize. The building of face-to-face relationships is more important than ever. And speaking of building relationships, reengagement within the planetarium community is important too! Conferences and state meetings are vital for revitalizing yourself, spurring new ideas and forging collaborations. Electronic communication in planetarium newsgroups seems to have dropped off too. Use the new Planetarian Network at https://ipshub.mn.co/

LANIAKEA: TELLING THE CAPTIVATING STORY

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The discovery of our local supercluster, Laniakea, is a story of epic proportions, considerable effort, and is conceptually complex. This paper describes an approach, using simple visual steps, to introduce Laniakea to your audiences that builds a step-by-step story line, leading up to a grand view of our local universe that is both captivating, visually magnificent, and compelling. Beginning with our own Milky Way, we convey the greater distribution of galaxies in a way that becomes familiar. Carefully selected motions maintain a constant sight-line that prevents losing your audience in complexity and wraps with a new cosmic perspective.

Most people in this audience are familiar with showing the large-scale structure of the universe. A sky full of galaxies, that is breathtaking in its scale.

But unpacking the story of what is embedded in this distribution is quite complex and a lot harder to do. When we look at the large-scale structure of the universe, we often simply explain that all of these galaxies are moving away from us – the Hubble expansion, or Hubble Flow. Distant galaxies expand with the universe at 72 km/s/Mpc.

There are, however, subtle things happening to motions of galaxies that deviate from that overall flow. These so-called peculiar velocities tell a magnificent story.

The challenge for us is in attempting to describe this to planetarium audiences. To do so requires some simple visual steps that carry your audiences view along for a compelling story.

Let's begin our journey with the local group of galaxies.

It turns out our local group has a little bit of structure to itself. It is like a flat pancake.

Figure 1 and 2 shows the view face on, and if you rotate through 90 degrees you can show that it's quite a thick disk.

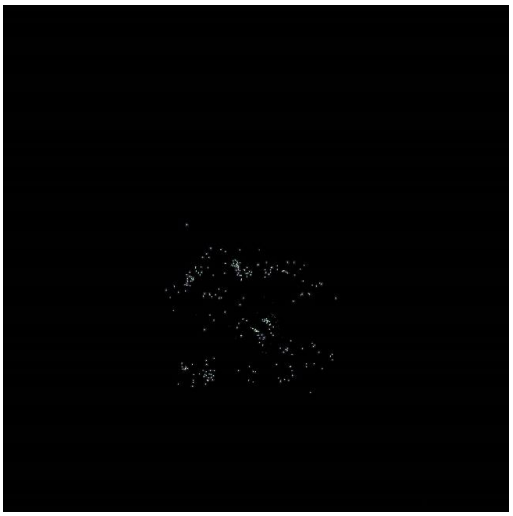

Figure 1: A view of our local group looking down on the plane. Our Milky Way us near the center of this distribution.

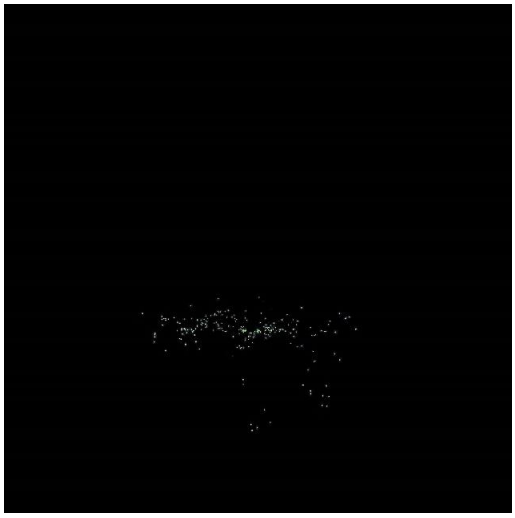

Figure 2: A view of our local group looking edge on to the thick disk of our Local Group.

What's perhaps not so well known is when you are edge-on to this disk and extend a line through that disk, you find that it points to the Virgo cluster. (Figure 3). That's not an accident but I won't go into those details in this paper.

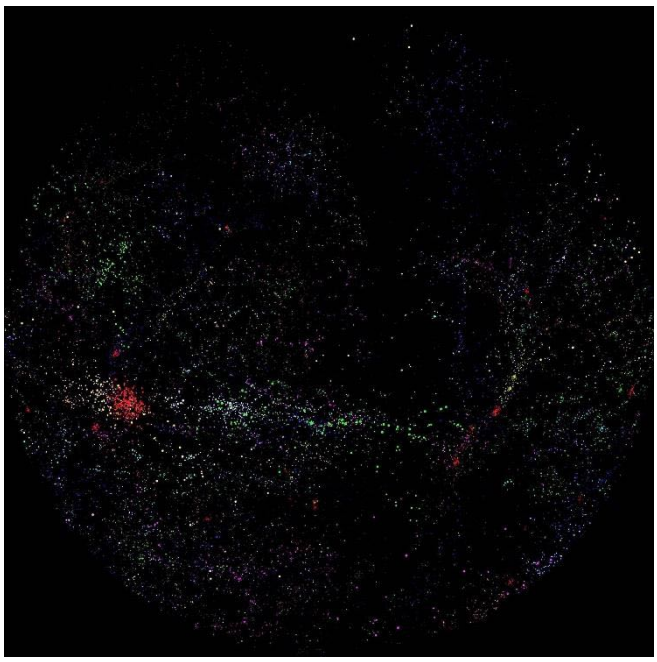

Figure 3. The Local group in green is shown edge on and how it aligns with the Virgo Supercluster 64 million light years away.

What we do now is back away while keeping that reference line in mind. We see the larger scale distribution of galaxies and some more distant superclusters. This plane is defining a plane in the local universe and it's called the supergalactic plane. (Figure 5).

If you position the view carefully, you also see the zone of avoidance caused by the plane of our Milky Way blocking our view if distant galaxies. It lies perpendicular to our supergalactic plane, and visually echoes a reference for the orientation of our own Milky Way. It gives us a useful visual reference around which we can turn and reveal the structure of the local universe to our audiences.

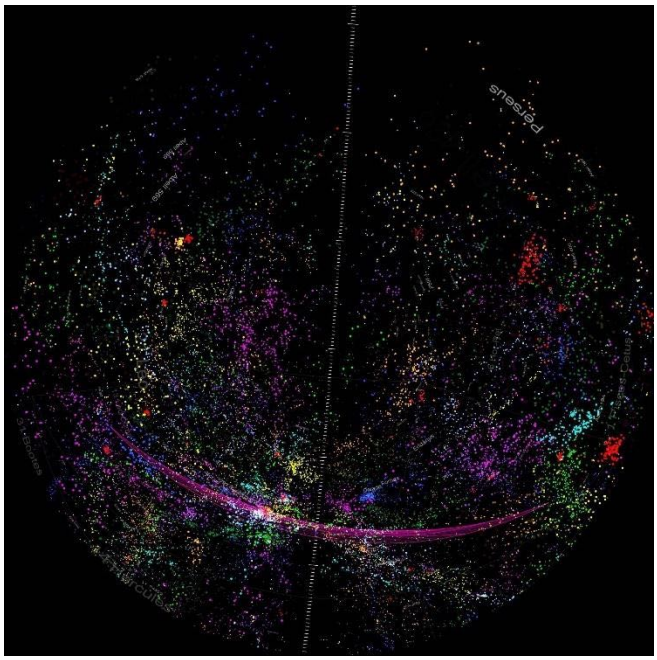

Figure 4. The Supergalactic Plane, which aligns with our Local Group through the Virgo Supercluster. The vertical line shows the zone of avoidance, the plane of our Milky way galaxy, and acts as a useful visual reference for your audience.

Now I want to introduce peculiar velocities of galaxies, and to do so we come back to Earth and look at a mountain range.

On Earth rain falls vertically downwards but when it encounters large masses like mountains, they divert the overall flow of water. If we tracked the motion of raindrops we could reconstruct the terrain map even if it was dark.

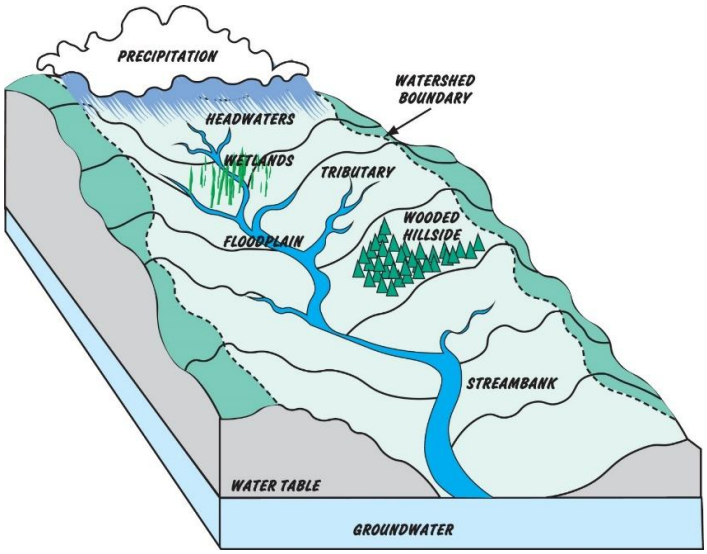

Figure 5.
A watershed. Rainfall drops vertically onto Earth and local mountains redirects water causing it to flow along the terrain, from higher elevations to lower elevations in streams and rivers.

Likewise in the large-scale distribution of galaxies we have the overall Hubble flow, the general expansion of the universe, but some of these galaxies are being diverted slightly away from that overall motion due to the large gravitational pull of some major superclusters of galaxies at large distances.

By using high precision measurements of redshift, a team of astronomers led by Helene Courtois in France, and Brent Tully in Hawaii, and others, they have mapped out the subtle deviations from the Hubble Flow (peculiar velocities), thus mapping out our local watershed, and identifying where major masses in our local universe are influencing out motion. The research reveals that we are a member of a huge supercluster called Laniakea.

The following rich regions are included in Laniakea: The Virgo Supercluster, the Hydra-Centaurus Supercluster including the Great Attractor, Antlia Wall, the Pavo-Indus Supercluster, and the Southern Supercluster (Fornax, Doradus and Eridanus clouds).

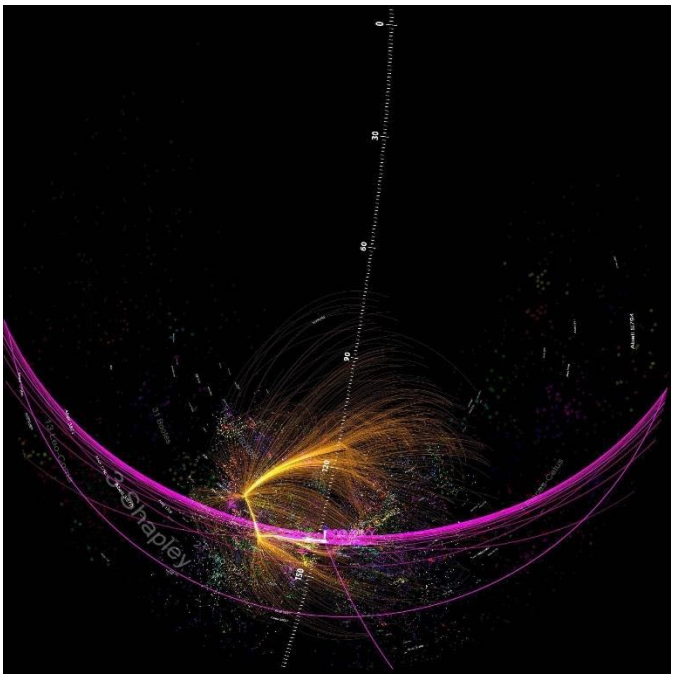

Figure 6. The Laniakea Supercluster (watershed) shown in a dome view, with reference lines of the Supergalactic Plane, the Plane of the Milky Way, and local superclusters. In the center is a 3-axis pointer aligned to the supergalactic plane that we use as a visual reference for the location of the Milky Way. Such references are best seen with orbital motion so relative distances are maintained in the viewers' mind. The moment motion stops, the audience loses this valuable perspective. The Laniakea watershed showing how our Milky Way and Virgo, center, are being gravitationally "pulled" along with thousands of other galaxies towards a large attractive mass. The following rich regions are included in Laniakea: The Virgo Supercluster, the Hydra-Centaurus Supercluster including the Great Attractor, Antlia Wall, the Pavo-Indus Supercluster, and the Southern Supercluster (Fornax, Doradus and Eridanus clouds).

We can now rotate about the vertical (z) axis. Steeping through each scene, we see Laniakea from four orthogonal points of view. Rotating the view live presents difficulties because of the normal axes of rotation in digital planetarium systems. I used ShowBuilder in Digistar to capture each of these views. Showbuilder captures each visual stepping-stone or frame with a simple click of a button, and automatically draws a smooth navigation through the universe to maintain the visual cues important for the audience to follow the story and understand the structure.

When we rotate around the supergalactic plane, it becomes evident that there is a larger quantity of galaxies on one side on one side of the Milky Way compared to the other side. The watershed flow lines depicted by the Laniakea model tells us where

deviations from the Hubble flow is occurring and why – due to large superclusters beyond Virgo. Virgo dominates the Milky Way's motion but even Virgo is being affected my larger clusters on a bigger scale.

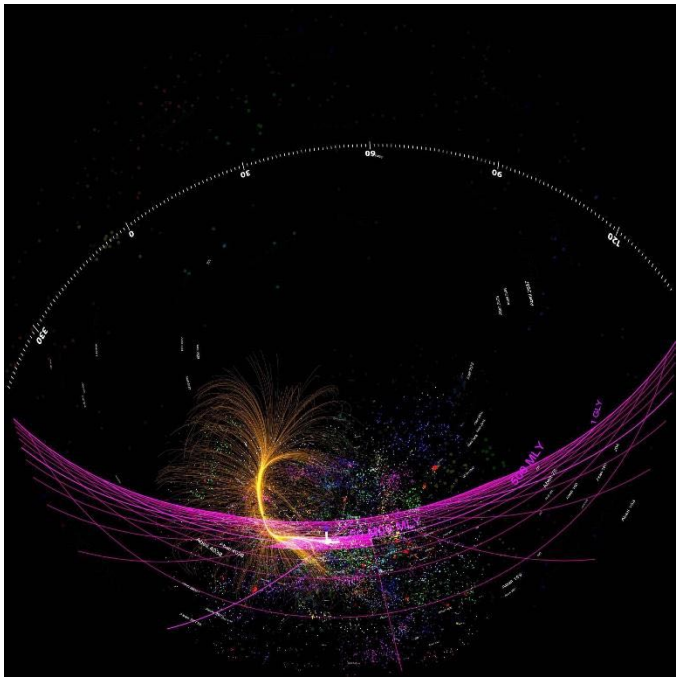

Figure 7. The Laniakea Supercluster rotated 90 degrees from Figure 6, shown in a dome view, with reference lines of the Supergalactic Plane, the Plane of the Milky Way, and local superclusters.

Finally, we introduce a direct observation - the definitive measurement of our motion through the universe, produced by measurements of the Cosmic Microwave Background (CMB). For your audience, it's useful to connect this to how a distant horizon looks from a speeding car – it's the Milky Way's horizon reference point against which we can measure our own motion. The CMB dipole reveals that we are moving at 552 km per second in the direction of Virgo.

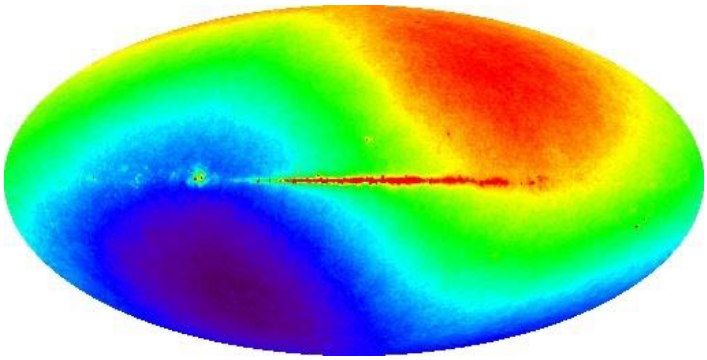

Figure 8: The CMB dipole, showing the relative motion of our Milky Way with reference to the CMB. The plane of the Milky Way runs horizontally across this projection. Red indicates warmer, and shows the direction of motion, generally towards the constellation of Hydra. Blue indicates cooler.

We can now bring all this together. We have three components: The CMB dipole; the galaxy distribution; and Laniakea. Laniakea and the CMB Dipole line up beautifully, indicating some very large masses are affecting our motion in our little provincial Local Group and the visual map of galaxies.

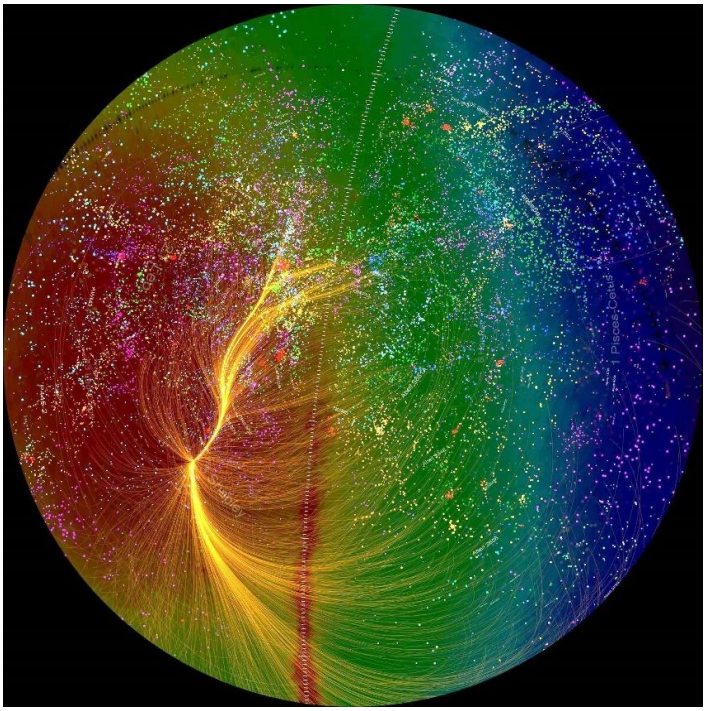

Figure 9. A static image of Laniakea with reference to the CMB dipole and distribution of galaxies. When this scene is in motion, the clear distribution, or large clusters of galaxies to the left of the dome compared with the right side of the dome is very evident.

When we add the CMB dipole we find that that also matches the observations in the local universe of what direction we're moving. You'll see here in this final image that the sky which is one of many galaxies in the universe. is sort of divided from the left-hand side towards which we're moving which shows a very large quantity of galaxies and clusters and the right-hand side which is relatively sparse.

A final word for teachers: For reference, education standards for teaching include the following: ESS1. A. Earth and its solar system are part of the Milky Way galaxy and is one of many galaxies in the universe.

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Tully, R., Courtois, H., Hoffman, Y. et al. The Laniakea supercluster of galaxies. Nature 513, 71–73 (2014). https://doi.org/10.1038/nature13674 (behind a paywall - use the video link above for technical description).

ENGAGING STUDENTS IN SOUNDTRACK COMPOSITION IN THE DOME

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Have you ever watched a movie without a soundtrack? Probably not. Music is used to enhance the story and compliment the visuals. This is true for movies, television shows, commercials, and planetarium shows. Using this fundamental idea, we worked with middle school girls (grades 4-8) in our Full STEAHM Ahead Summer Workshop to compose a soundtrack for a short planetarium show.

Project:
To engage middle school girls in soundtrack composition. To teach them the impact of music in creating a story.

Audience:
Middle School girls, grades 4-8 participating in the Full STEAHM Ahead Summer Workshop

Methods:
We hosted two weeklong workshops on campus- one for grades 4-5 and the other for grades 6-7. Each program had 30 girls. As they entered the dome, Professor Will Wickham did a brief lesson on composition and its use in telling a story.

The girls listened to a variety of music and shared what came to mind- feelings, thoughts, images, etc. We then watched a short show without music. The show was created in Digistar using show builder. It starts in the midafternoon with sun and clouds overhead. The sun then sets. From there we rise off the planet, watch Earth from space, and finally end in the middle of an aurora.

The students were divided into groups and assigned scenes. Each group was given a collection of audio clips preloaded on a tablet with the mixing software. Professor Wickham composted the audio clips. Professor Wickham also explained to them how to use the software. After mixing the music for their scene the groups then came together to work on the transitions between their scenes. Once all the groups were happy with their mix, we merged the projects and added them to the show. The girls then watched the show with their music and made final edits until they were happy with the outcome. The final mix was added to the show in show builder.

Results:
The results exceeded our expectations. The final product was shared with the public before our regularly schedule weekend shows. Several of the girls came back with their families to see the show.

What's next?
Based on this initial success we have expanded the project to CCC students in a music composition class. These students are writing their own pieces for a 20-minute full dome meditation show

THE PLANET THAT SHALL NOT BE NAMED

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242 years after its discovery, our Solar System's seventh planet has become an afterthought in the planetarium world; a joke ceded to snickering middle schoolers. But at what cost? In the past year, the Planetary Science Decadal Survey decreed that a Flagship mission to this world is its highest priority. It's time to get reacquainted with Uranus and reconnect your audiences with the mysteries of the outer Solar System.

Think about the last time you talked about our Solar System's seventh planet in a planetarium show. Have you ever done so? If not, I'm not faulting you. I've always focused on encouraging audiences to find bright, easily-visible objects in the night sky. Skirting the edge of naked-eye visibility (averages around magnitude 5.5), Uranus has never fit in that category. Couple that with an embarrassing pronunciation, and it's no surprise that we often omit this planet from our discussions. But by doing so, what are we missing? Uranus is a wonderland of mysterious phenomena.

In 2012, the results of the 2013-2022 Planetary Science and Astrobiology Decadal Survey were released. A mission to Uranus finished third, behind a couple missions you may have heard of: Perseverance, and the Europa Clipper.

In April 2022, the results of the 2023-2032 Planetary Science and Astrobiology Decadal Survey were released. This survey recommends science missions and targets for NASA, NSF, and other government agencies for the next ten years. The highest priority for a Flagship mission was given to a Uranus Orbiter and Probe (UOP). This craft would launch in 2031, reach Uranus in 2044, and spend the rest of that decade traversing the Uranian system, flying by the major moons, and launching a probe into Uranus' atmosphere. Think the Cassini mission, but for Uranus.

So what's so cool about Uranus; why is it so important to probe this distant icy world? As it turns out, there's an awful lot we don't know about it. Uranus and Neptune are ice giants, the only class of planet that we haven't studied closely with spacecraft. Also, most of the exoplanets we've discovered are ice giant-sized, which makes learning about these planets even more important.

The UOP will also attempt to determine where Uranus formed in the Solar Nebula, and when. A detailed survey of its physical composition may help to confirm current theories of planetary migration, like the Nice model, or present a new wrinkle.

It appears that Uranus has much less internal heat than the other planets. Some have suggested that a colliding body could've stripped away that heat early in the planet's existence (and may also be responsible for it's extreme axial tilt). Others suggest there may be some sort of atmospheric barrier to that heat transfer. But when we look at the planet, we can't see many clouds or atmospheric details. The Uranus Orbiter and Probe (UOP) will help us thoroughly uncover the atmospheric structure and map the circulation of Uranus.

Uranus' magnetic field is completely bonkers. It doesn't originate at the planet's core, and it's tilted by almost 60 degrees, off the planet's already 98 degree axial tilt. Once every Uranian day (17 hours), the alignment allows solar wind through the magnetosphere, bombarding the planet. Later, the alignment 'closes' redirecting the particles away from the planet, like our magnetosphere on Earth. Measuring the magnetosphere, processes that produce it, auroral emissions and its interactions with solar wind are all on the list to be studied by the UOP.

Uranus is surrounded by nine exceptionally narrow rings, and over a dozen small moons. Over time, those ring particles should have spread out away from the planet, but they haven't. Those moons also orbit so

closely that there should have been some collisions within the time period of the Solar System's history. Studying this potentially dynamic, young system will answer those questions about the processes that shaped the rings and small moons into their current positions.

The Uranian moons are also the only regular satellite system not already intensely studied by a spacecraft. Given our current understanding of the potential for astrobiology discoveries on icy moons, UOP will help us determine whether any of the Uranian satellites contain habitable environments. It will also detect both the surface composition and internal structures of those satellites including items like internal heat sources or liquid oceans.

This has been a quick overview of the potential new discoveries to come from the UOP; I look forward to hearing more at #GLPA2045.

INDEPENDENT STUDIES IN MYTH AND MUSIC

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In the past year, I have supervised independent studies in myth and music. The myth study focused on Inuit mythology. The first music study led to an honors senior recital of an original composition on the nearest stars. The second music study is in progress and involves a composition on the planets.

Myth

Last spring I supervised a student (Logan Sanders) doing an independent study on mythology that focused on the Inuit of eastern Canada and Greenland. The Inuit had only 16 constellations compared to our 88 and only 33 stars. The Arctic Circle divided the Inuit land; some communities were north of the Circle and some were south of it.

The Inuit had an animistic belief system and thought the stars were alive. They believed in Nanook who was the Great Polar Bear Spirit and thought of him as both a god and an ancestor. The legend of Nanook has him being chased by hunter dogs and no matter what he did he could not shake off the dogs. After running a long time, they came to the edge of the world but did not notice the cliff and ran into the starry sky and became the Pleiades.

They also worshipped the Sun as it gave them life and light. The goddess of the Sun was Seqinek and she had a brother Tatqim who was a hunter. Tatqim liked to chase his sister and during the night, Seqinek would rest in the dwelling place that was shared with her brother in Udlormiut, which is where the highest celestial spirits lived. One night a mysterious person got into Seqinek's bed and had sex with her. She realized it was her brother and escaped while he tried to pursue her. Each carried a torch but the brother's is partly blown out, which explains why the Moon is fainter than the Sun. Even with this horrible story, Tatqim is important to reincarnation as he is the one who brings souls back to Earth, which explains the Moon's absence on nights near new moon.

Other fairy tales and nursery rhymes also connect with the sky. One well-known nursery rhyme is "Jack and Jill," based on a Scandinavian story about two children who were kidnapped by Mani, the moon. We imagine Jack as the right half of the moon and Jill as the left half. When the moon is waxing, Jack is the first one we see. When the moon is full, we see both Jack and Jill, when they are at the top of the hill. When the moon is waning, Jack disappears first, falling down the hill, and then Jill disappears.

A well-known fairy tale is "Sun, Moon, and Talia," better known as "The Sleeping Beauty." When Talia was born, wise men and astrologers predicted something would happen to her because of a splinter of flax. Many years later, she finds a woman spinning flax; wanting to help, she pricks her finger and falls to the ground unconscious. Her father puts her in one of his estates in the woods. A king who is out hunting enters the estate, finds Talia, is unable to wake her, finds her beautiful, and rapes her. Nine months later, still asleep, Talia gives birth to a set of twins. One of the twins starts sucking on her mother's finger, dislodging the splinter, and Talia wakes up. Talia names her children the Sun and the Moon. Then the king comes back, takes Talia to his castle where the queen finds them and tries to have Talia and the children killed. But the king saves them and marries Talia. Somewhat different from the Walt Disney version!

Music: the temple of immensity

Last year I supervised a student (Stephen Naylor) doing a music composition "the temple of immensity" fall and spring semesters. The piece was ultimately about looking at the universe with wonder, awe, and reverence. After a prologue, the piece set astronomical data to music, beginning at the Earth and then traveling outward through the 50 nearest stars.

For each star, there is a corresponding musical event, placed in a specific temporal spot with music between them corresponding to distance between the stars.

The composition was performed as a 28-minute senior honors recital with a 16-member choir and electronics. The music focused on the primeval colossal nature of the closest stars and the vast distances between them. The electronic sounds expanded the choir's sonic palette and inspired ideas of massive objects and large spaces.

The prologue evokes the emotions surrounding the work. In the second movement, multiple types of astronomical data concerning the stars nearest Earth are used to determine different musical elements. A central tenet is that the distance from Earth and the music's temporal aspects would be equivalent. The fifteen light years to the most distant star used was broken into hundredths of a light year and each hundredth corresponded to one beat of the music at the pace of 60 beats a minute for a duration of 25 minutes.

The duration of each star event was determined by the star's luminosity using a logarithmic scale to accommodate luminosities ranging from 0.00004 to 25.4 solar luminosities. This yielded durations between four and 120 beats.

The musical dynamics were determined by each star's radius, again using a logarithmic scale to assign a star a dynamic between fff and pp.

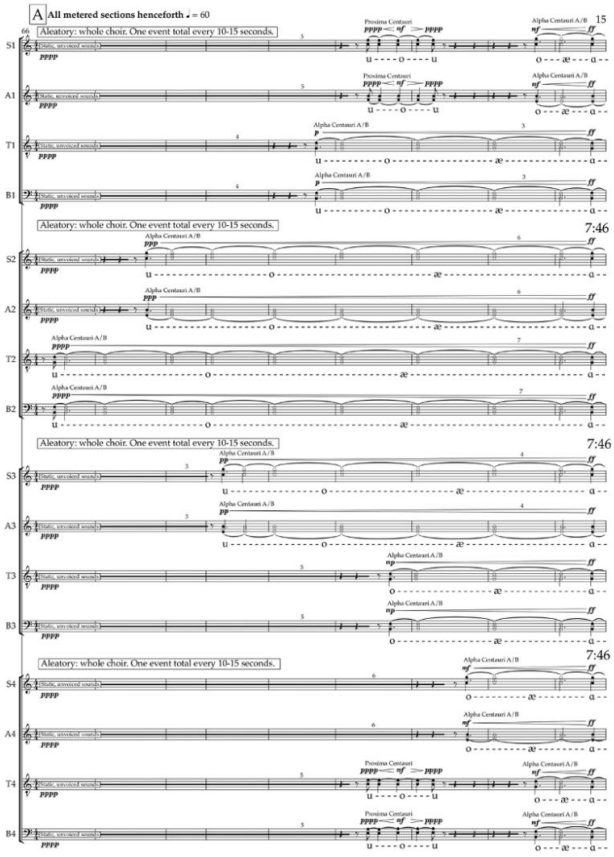
Pitch harmonically follows a trend of dissonance to consonance. For the first stars, the singers select notes independently but by the end, pitches are solely from the key of D major.

Due to the distance between stars, the choir sings for 7.5 minutes (during stars) and is silent for 17.5 minutes (between stars). To avoid underuse of the choir, another layer of choral activity was added consisting of select consonants that each singer voiced depending on what they heard around them. This aleatoric music was voiced less at the beginning and more at the end.

The electronics are a constant element humming under the choir's star and aleatoric events. Numerous layers comprise each composite sound to give different textures.

The Temple of Immensity strives to give listeners and performers the opportunity to pause and reflect on their place in the world and the stars. The composition encourages introspection about humans being so small, yet actively contributing to the universe somehow. The music allows them to be at peace with space's gigantic scope, and to feel wonder and awe at the daily opportunity to observe the incredible universe. Music makes such topics far more accessible than charts of data can.

Here is a sample of the musical score around the star Alpha Centaur



Music: the planets

This spring and fall I have been supervising a second music project based on the planets. It is inspired by Holst's *The Planets* but is based on astronomy, not astrology as Holst's work was. The student involved (Kaitlyn Wincup) has learned about the planets, commissioned a composer to create the work that conveys a 21st century model of the planets, and formed an ensemble to perform it.

The project began with Kaitlyn's realization that Holst's work is based on astrology. It was composed in 1916 when our knowledge of the planets was rudimentary. Instead, she wanted to commission a work rooted in factual science, a contemporary piece that is a closer representation to the physical properties of the planets. For example, Holst had Mars as the hot-headed god of war, whereas in fact Mars is a cold planet. Kaitlyn prepared a table of key physical properties of the planets that should be conveyed in the music.

Mercury	Venus	Mars	Jupiter	Saturn	Uranus	Neptune
- Little/no atmosphere - Hot and cold (bipolar) - "Boring"	- Thick atmosphere - Extremely hot - Earth parallel	- Rocky - Rusty - Ice water	- Clear contrast (of themes?) - Major storm - Empty grandness - Beyond imagination	- Thin, visible rings - Floating	- On its side - No internal heat source - Less weather patterns	- Coldest - Minor storm that disappeared

The duration of each movement is approximately proportional to the radius of the planet. Mercury, with the shortest radius, is about 58 seconds. Venus, about the size of the Earth, sits at 2 minutes and 28 seconds. Jupiter was going to be about half an hour, but the composer cut it to six minutes, still making the point that Jupiter is extremely large.

Each of the movements includes musical quotes from other works. Holst's themes are quoted throughout. Various quotes from Wagner's Ring cycle are referenced in Saturn and Uranus because of the planets' rings. As Venus used to be much like the Earth, the theme from Dvořák's Ninth Symphony, *Largo*, is a central theme throughout as it undergoes transformations. Just as Venus went through a runaway greenhouse effect to transform the planet into a deadly hot place, this theme develops into chaos by the end of the movement. Uranus was discovered by organist and astronomer William Herschel, so this movement includes a quote from his *Full Organ Pieces*. Uranus feels somewhat more lopsided as its axis tilts the planet on its side, and it leads to a feeling of "wild abandon" that is unique compared to other planets.

A couple of the movements utilize pitch to represent a distinct planetary property. In Mars, all the pitches are set higher in each instrument's range to represent the thin atmosphere and cold climate of the planet. For Mercury, both high and low pitches are utilized throughout the movement to parallel Mercury's bipolar temperatures due to a rotation the length of 58 Earth days, where the surface can heat or cool for an extended period of time, and a lack of atmosphere that, on other planets, traps heat and controls the climate.

Jupiter's contrast in cloud bands is a very important part of that planet's environment. The different colors represent the rising or sinking of gas. The music has two main sections that sound distinct from each other; just as these sections sound different, the environment on Jupiter is different under each of the main cloud bands.

Some of these properties can readily be expressed in music, but others cannot. Kaitlyn notes that putting science into music is more abstract than she originally realized, but can be executed in many ways. She will prepare program notes to connect the tangible aspects of science to the intangible musical properties and will give a short (~5 minutes) lecture to help the audience connect her research to the performance.

The work will be performed by a small ensemble including Kaitlyn on saxophone in additional to a clarinet, trombone, percussion, cello, and piano. The composer envisioned different tones and timbres he could draw from these instruments.

The order of the planets is different from Holst's in that the order is increasing distance from Earth: Venus, Mars, Mercury, Jupiter, Saturn, Uranus, and Neptune.

Kaitlyn hopes this piece will become a new resource between the physical sciences and music.

USING GODOT GAME ENGINE TO CREATE A PLANETARIUM LIGHTING ENGINE

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I used the open-source Godot Game Engine to create an independent lighting engine, called Helios, for planetariums. This talk will briefly discuss how most planetarium lighting systems work before detailing how I used Godot to create Helios. I will discuss its current capabilities and limitations, and my hopes for what may come of it in the future. Information will be provided for anyone who wishes to use Godot to create their own lighting engine as well.

Virtually all modern planetarium lighting systems utilize UDP encoded DMX signals sent over Art-Net devices to control lighting fixtures. A typical planetarium hardware layout includes several independent but connected components. The two most obvious components are the computer (or server cluster) running the planetarium software itself, and often a separate computer that runs the lighting software. Connected to the lighting computer via ethernet cables are one or more Art-Net Universe controller devices, which is then connected to the planetarium's cove lights and other lighting hardware. The lighting software sends a the UDP encoded DMX signal to the Art-Net Universe controller, which interprets the signal and sends an appropriate raw DMX signal to each connected device, allowing easy user control of dozens or hundreds of individual lights at once through a simple user interface. The planetarium software computer and the lighting software computer are often on the same network and UDP signals are sent between them so that the user can control the planetarium lighting by using the planetarium software directly, without need of operating two computers and separate interfaces.

So focusing on what is required of the computer controlling the planetarium's lighting system, all that is needed from the lighting software is to be able to communicate, via UDP signals, with the Art-Net controller as well as communicate, also via UDP signals, with the computer running the planetarium software. This means any software capable of sending customizable UDP signals can potentially operate as a lighting control software for planetarium settings.

The Godot Game Engine, a free and open-source game engine primarily intended for the development of indie video games, has built in classes for UDP communication as well as robust features for developing a custom user interface. This positions Godot nicely as a tool anyone could use to develop a custom lighting engine. In the past year I've used Godot to produce Helios, a custom lighting engine for my planetarium which has base functionality that's been tested to work in my planetarium.

One concern to consider when creating a lighting engine, assuming you want it to be functional for planetariums besides your own, is that each planetarium lighting system is unique to the planetarium. There will be a differing number of cove lights, handrail lighting, entry and exit lighting, spotlights, and many other peripherals based on the size of the dome and the needs of the facility. Compounding this difficulty is the fact that there is no standardization for the channel count or functionality for DMX controlled devices.

The way Helios handles this is by checking for a site configuration file on opening, and if it doesn't find one, prompting the user for information about the specific facility it's being run in. After the first prompt, this information is saved so that future users don't need to know anything specific about their facility's hardware. However this does mean that the first time Helios runs, someone at the organization will need to know the following information about the lighting hardware.

- How many Art-Net Universe controllers there

are, and the IP address for each controller
- The number of DMX channels per cove light (Helios includes a tester to figure it out)
- The starting channel for the string of cove lights (normally 1)
- How many cove light fixtures are in the planetarium
- Which channels represent which colors for the specific cove lights fixtures in the planetarium (Helios includes a tester to figure it out)
- Each of the auxiliary fixtures in the planetarium including
    - The starting DMX channel for that fixture
    - The total number of DMX channels used by that fixture

Helios is currently able to create and save custom lighting scenes through the use of simple control buttons, has a customizable page to move and create those buttons, and is able to be controlled from the planetarium software. The control of auxiliary fixtures has been planned for but is still being implemented. Additional features that are planned for include the ability to layer colors on top of each other withing a scene using a variety of blending methods, to allow the user to create a "show" file which is a string of scenes played back at specified intervals, and the ability to export show files in a universal format so that lighting cues can be more easily shared between planetariums then is currently possible.

Finally, for anyone who would like to utilize Godot to create their own lighting engine, below are the basic steps for setting up the core of a lighting engine in the software.

1. Define variables within Godot to hold the IP addresses for each of the Art-Net Universe controllers.

2. Create a unique PacketPeerUDP node (a built in Godot class) for each universe.

3. Connect each PacketPeerUDP node to the matching universe IP Address using the .connect_to_host() function. Strictly speaking UDP is a connectionless format so this isn't entirely necessary but it keeps you from having to specify the IP Address each time you send a packet.

4. Create array variables to use as your UDP encoded DMX signals. These take the format of var dmxSignal = [65, 114, 116, 45, 78, 101, 116, 0, 0, 80, 0, 14, 1, 0, 1, 0, 2, 0, #,…,#], The array has a total of 530 values, the first 18 values do not change as that is the part of the signal that identifies it as an Art-Net signal. The one exception being the 16th value, which is the universe number. The other 512 values in the array, abbreviated here as #,…,# are the 512 DMX signal values each universe is capable of communicating.

5. Create methods to constantly update the DMX signals being sent out to the universes. This is the difficult part and is not detailed in this paper.

6. Constantly (under a _process(delta) function) send the updated DMX signals to the universe controllers.

LANDSCAPES OF THE SOLAR SYSTEM

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For the last decade the California Academy of Sciences has been exploring the ever-increasing capability of planetarium software to use high-resolution terrain data for the Earth and other worlds. In our latest live program for our Hohfeld Hall panoramic theater leverages the open source OpenSpace platform to take audiences on a new tour comparing and contrasting some of the most dramatic terrain features on Earth with their analogues elsewhere in the Solar System. The selection of sites and techniques to assemble this program will be examined, as well as additional tips for how anyone can use this data to create compelling stories or explore on their own.

OpenSpace Background

As one of the Informal Science Institution Partners on the OpenSpace Project Grant, the California Academy of Sciences is always looking for new ways to bring presentations driven by the OpenSpace software to our visitors. We've progressed in our use of the software from the initial one-off demonstrations that began in 2015 through our first uses for speciality programs and lectures in 2018 and '19. In late 2019 and early 2020 we began to use it for regular planetarium programs in Morrison Planetarium and during our closure throughout 2020 due to the COVID-19 Pandemic it became a regular feature of our Cosmic Conversations and Tour of the Outer Space livestream programs. In 2021 and 2022 OpenSpace returned in Morrison Planetarium, where was used for daily Tour of the Universe programs, and provided a live update to our newest rendered production, Living Worlds.

Pleased with the increasing reliability and usefulness of the software in the planetarium and for streaming applications, we decided it was time to expand its use into additional venues at the Academy. In addition to Morrison Planetarium, the California Academy of Sciences has two other immersive venues: the Hearst 3D Forum and Hohfeld Hall. The Hearst Forum is currently dedicated for use as a temporary exhibit space, making Hohfeld Hall our ideal target for the next OpenSpace install.

Venue Background

Historically at the Academy, Hohfeld Hall was a space science exhibition hall. Following the 2008 renovation of the Academy, it became the pre-show area for Morrison Planetarium, where guests waiting for a planetarium program could adapt their eyes and get ready for the show while watching astronomy-themed content across the panoramic display on the curved wall of the theater. The display is currently 3 HD projectors side-by-side, creating a window into the Universe often compared to the feel of "Ten Forward" on Star Trek: The Next Generation.

In addition to pre-show queuing using rendered video loops, for most of the last decade Hohfeld Hall has also been used as an interactive program presentation space. The venue has supported Sky-Skan's DigitalSky2 and Sciss's Uniview 2.0, functioning as a space where planetarium staff can develop short astronomy-themed programs, while the smaller venue provides more direct engagement with guests. The layout of Hohfeld Hall has easily lends itself to multi-screen slideshow-style presentations, although we have always worked to increase the utilization of realtime 3D content to accentuate the feeling of being on a starship traveling through space.

Program Concept and Features

As we discussed options for an OpenSpace show in Hohfeld we specifically wanted to lean into making the best use of this environment. As we brainstormed ideas our team were all intrigued by a concept that

began as “National Parks of the Solar System.” In brief, the pitch was to compare the dramatic landscapes of Earth with analogues around the Solar System. This program concept would leverage our specific experience working with high resolution imagery and elevation data for the other worlds of our Solar System with OpenSpace’s robust “globebrowsing” terrain engine to allow us to explore these landscapes in detail while turning Hohfeld Hall into a spaceship able to smoothly transport the audience between the planetary (and interplanetary) scales, down to human (or near-human) scales available with current imagery.

With the seed of the concept, Planetarium Programs Specialist Mary Holt and the planetarium presenter team began to identify what landforms and features would best drive the show. We landed on four features to compare: mountains, canyons, volcanoes and glaciers.

For mountains, we would compare Earth’s highest peaks, the Himalaya, with the Moon’s Apennine Mountains. The rugged peaks of the Apennines, although not as tall as the Himalaya, are a prominent and easily observable feature. They provided a valuable contrast between the orogenic processes of the two bodies. On Earth, the Himalaya are relatively recently formed mountains, raised up by the collision and subduction of the Indian tectonic plate under the Eurasian plate. On the Moon the Apennines sit at the rim of the Mare Imbrium, one of the Moon’s basaltic plains that was likely formed from a protoplanetary impact with the Moon during the late heavy bombardment 3.9 billion years ago. Ejected rock and surface material created these mountains ringing the edge of the basin. As presenters traverse the landscape they can discuss the effects of weathering and erosion on Earth, where young mountains are sharp, rugged and craggy. The Moon lacks the atmospheric and hydrological weathering features of the Earth, but attention can still be called to the soft, rounded nature of the Apennines (and even the historical expectation of astronomers and geologists that without weathering the Moon’s mountains would be tall, sharp peaks), which we now know is caused by the billions of years of meteoritic impacts on the Moon providing their own erosive activity, slowly wearing down the Moon’s sharpest features and leaving the surface coated in dusty regolith. OpenSpace allows us to merge and layer global Moon imagery from Japan’s Kaguya spacecraft or the Wide Angle Camera on the Lunar Reconnaissance Orbiter with more detailed imagery such as LRO’s Narrow Angle Camera, or even composite photography from the Apollo missions to step down to the human scale at Hadley Rille to visit the Apollo 15 landing site (complete with a model of the Lunar Excursion Module Falcon).

Canyons provide an obvious comparison between the Earth and our neighboring planet, Mars. On Earth we dive down over northern Arizona and cruise over the dramatic terrain of the Grand Canyon, passing over the National Park’s visitor center, giving the audience the unique experience of flying into the canyon. Traveling over to Mars, the audience is instantly greeted with the enormous feature of the Valles Marineris. From orbit, we compare the scale of these features, projecting a to-scale map of the United States (and highlighting the Grand Canyon) over the Valles. The features are contextualized in their differing formation: the Grand Canyon primarily an erosional feature as the Colorado River spent millenia carving its way down through layers of rock at the edge of the Colorado Plateau; Valles Marineris however is generally believed to have initially formed as a tectonic crack in the Martian crust as the volcanoes of the nearby Tharsis Plateau formed, thickening that part of the crust and causing collapse of bordering terrain. Flow features indicate that the Valles were then widened and shaped by liquid water present on Mars’ surface earlier in its history. We connect the audience to our exploration with a quick stop to the Mars Reconnaissance Orbiter (with an orbit over the Canyon selected) to discuss how we obtain such high-resolution imagery, then dive down into the Valles themselves, flying along the Valley and bringing in data from MRO’s CTX Context camera and HiRISE camera to see the details of the landslides along the valley walls and deposits and formations on the valley floor that are more relatable in scale to geologic features we experience here on Earth.

We wanted to explore a variety of bodies in the Solar System; since we went to Mars for canyons, we wanted another location to feature volcanoes–there was almost no question we’d visit the most volcanically active body we know of: Jupiter’s moon Io. On Earth we drop down from planetary scale to look at Mauna Kea on the island of Hawai’i. Bringing

in bathymetric data we can see how the motion of the tectonic plates over the Hawai'ian magma hotspot has formed this chain of volcanoes over millions of years. This hotspot volcanism can then be compared with volcanism resulting from plate subduction by highlighting both all known and all active volcanoes on Earth, many of which ring the Pacific plate as it is subducted under bordering plates on all sides. Traveling to the Jupiter system, we root our visit with the Juno spacecraft, taking advantage of an upcoming planned flyby of Io in 2023 to create a dramatic view across the screen. Departing the Juno probe we orbit Io and discuss the extreme volcanism there, which results from different processes than on Earth–the entire moon is flexed and squeezed by the gravitational pull of Jupiter and the other three massive Galilean Moons, keeping its insides hot and molten, and bringing molten rock to the surface as lava flows or explosive eruptions. A long-term goal for the program as the software improves will be to include time-series eruption data from Imke de Pater and Katherine Kleer at the University of California Berkeley, whose infrared observations of Io have classified individual eruptive features across the moon.

For our final feature, we turn from the fire of volcanoes to the ice of glaciers. On Earth we bring our audience to Alaska to explore the glaciers tucked into the valleys around Anchorage. Audiences are reminded how glacial melt is one of our strongest indicators of climate change and global warming here on Earth, and how the retreat of glaciers over recent decades can be visually observed, while remote sensing with satellites like NASA's GRavity Recovery and Climate Experiment (GRACE) show how we are losing ice & water mass in regions like this, as glaciers melt and their waters flow to join the oceans (contributing to rising sea levels). The analogue feature we chose on another world took us to the outer edges of the Solar System to visit the vast ice plain of Sputnik Planitia on Pluto. We updated and leveraged assets from one of OpenSpace's early demonstrations for the New Horizons flyby in 2015 to start off at the New Horizons probe as it flew over the dwarf planet, with Charon hanging at the background. We then descend onto Pluto, where the detailed imagery is merged with elevation data of Pluto to make this icy world a textured, dynamic landscape. Sputnik Planitia is the western lobe of the larger heart-shaped Tombaugh Regio. On its western fringe it's bordered by tall sharp mountains of water ice, which in the deep cold of Pluto doesn't flow like the glaciers of Earth, but is hard as rock. The wide basin of Tombaugh Regio is filled with nitrogen ice, which has a consistency similar to toothpaste. Able to flow slightly, the ices show geometric patterns likely caused by convective flow from heat inside Pluto. Astronomers, such as Mike Brown, have proposed that Sputnik Planitia may effectively be Pluto's "ice cap"--but given the dwarf planet is tipped over on its side, the ice cap is forming along the equator rather than at a pole. Similarly as Pluto is currently on its century-and-a-quarter-long trip to aphelion where it will be furthest from the Sun, it may be the case that that the ices of Sputnik Plantia are Pluto's thin atmosphere, solidifying as the dwarf planet cools down heading towards the distant parts of its orbit.

Technology and Development

Storyline development went in parallel with the development of the program in the software. At Morrison Planetarium we've done a variety of programs driven by high-resolution terrain data for years. An early demonstration was Geology of Other Worlds presented in the Hearst 3D Forum in DigitalSky2. We continued to explore these capabilities in Uniview, through a variety of lectures and speciality programs, ultimately building our own Web Map Service (WMS) server to ingest and host additional data not available through public services. The ability to utilize these data has become an essential part of many programs presented at the Academy. OpenSpace was specifically developed and designed with this kind of high resolution data in mind, and it swiftly and robustly handles it for easy, smooth presentation.

Although it can run on a variety of platforms and has become more stable with each release, we've still found that OpenSpace benefits from powerful hardware to support it. In late 2021 and early 2022 we worked with the OpenSpace development team to spec out a new render cluster for Morrison Planetarium that would be optimized for OpenSpace. Although much of the software relies on the graphics processor unit, map tile download and ingest is a more

intensive process on the central processing unit, so we selected one of the faster processors available on the market at the time, Intel's i9 10900x, which we've found we can comfortably run at over 4Ghz without heat issues to maximize smooth loading of terrain tiles. Graphics processing was provided by a donation from the NVidia Corporation of their RTX A6000 cards.

Coincidentally, over the summer of 2022, the render server that powered Hohfeld Hall's displays experienced a power supply failure. This unit used a server power supply and a replacement unit was no longer manufactured, so we seized the opportunity to rebuild Hohfeld to the same hardware specifications as Morrison which we knew would comfortably and smoothly run OpenSpace.

For all OpenSpace programs at the Academy we try to make the experience for the presenter as easy and consistent as possible. For this reason we eschew the native menus of OpenSpace and build custom control pages where we can arranged controls sequentially, but also take advantage of feedback from OpenSpace's websocket and javascript in the webpage to create a series of failsafes that check for object status to account and correct for human error and allow for flexibility in the presentation. Regardless of what order the presenter visits each location in, transitioning to a new location will always check that the correct assets for that location are enabled, while disabling ones not needed for that storyline, keeping memory use manageable and operation reliable.

While OpenSpace has a "local bookmarks" feature that allows for creation of targetable bookmarks on planets and other globes, it doesn't yet support fully flexible bookmarks to easily travel to spacecraft. Using a connected web control panel allowed us to capture the navigation state for scenes we liked the look of and then send that command to the camera in OpenSpace to create consistent looks at our destinations. We also were able to use these controls to make smooth fade-in-fade-out transitions where appropriate too.

In Morrison the planetarium presenter sits behind the audience at the control computer, but in Hohfeld they stand in front of the audience. To facilitate easy interaction they can access these control pages through either an iPad or a touchscreen on a podium. Flight control is then achieved with a gamepad controller, which of course can also be handed to engaged visitors, especially children, to get a taste for flying through space.

Conclusion

Landscapes of the Solar System proved a fun show from both the development and presentation perspective. It was a great chance to leverage the strengths of both OpenSpace as a software platform and Hohfeld Hall as a presentation space to make a unique, engaging program. Early audience tests showed excellent engagement and that audiences naturally bridged their own knowledge and experience from Earth to the similar environments throughout the Solar System.

OpenSpace is an open source software project and is freely downloadable and usable by anyone. This has also brought a new dimension to using it for presentation (that we also briefly experienced with Microsoft's WorldWideTelescope software), where we can encourage visitors to download and use the software at home to further their own exploration journeys with professional planetarium software at home. This also makes it ideal for collaboration between institutions as more planetariums adopt and utilize the software. We are happy to contribute to the community by freely sharing all material prepared for Landscapes with anyone interested.

PRELIMINARY RESULTS OF AUDIENCE OPINIONS ON DOME-BASED CAPTIONING OPTIONS

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The Big Astronomy Team strives to make our resources available to individuals with physical disabilities, by making our resources available to the blind and visually impaired (BVI) and deaf and hard of hearing (DHH) communities. We conducted research surrounding three captioning methods to ascertain how planetariums can implement each option and which method was preferred by the DHH community. We also researched the hands-on activities that were modified for the BVI community. With our results, planetariums can make informed decisions on which captioning method works with their planetarium and budget. In this paper, we are presenting our preliminary results from this research.

I. MOTIVATION

Captioning is something that planetariums as a whole are trying to make commonplace in their theaters. Planetarians want to ensure that their domes are accessible to everyone, which includes the deaf and hard of hearing (DHH) and blind and visually impaired (BVI) communities. Information on captioning has been presented at GLPA conferences in the past in 2016, 2017, and 2020 by Steve Burkland, Christelle Barclay, and Sarah Komperud et al. respectively. In the 2020 GLPA paper, Sarah Komperud et al. discussed the accessibility options offered in their planetarium with some amount of audience feedback. The preliminary results of the research discussed in this paper will give planetarians an idea of what audience members thought of three different captioning options tested in Morrison Planetarium with the DHH community.

II. METHODS

The Big Astronomy research team traveled to California Academy of Science's Morrison Planetarium to test their three options for captioning with the DHH community. Over the course of three days, Sept. 27-29, we tested a handheld device, Epson glasses, and captioning on screen. We spoke with focus groups after two shows each day. We also employed American Sign Language (ASL) interpreters each day. These planetarium shows consisted of just the showing of Big Astronomy: People, Places Discoveries, and no live star talk. During our focus groups, we were able to interview ten individuals from the DHH community as well as our two interpreters for those three days for a total of twelve individuals. We also spent a day testing hands-on activities and spoke with 7 individuals who are members of the BVI community about their experience with the show and activities.

III. ANALYSIS

During the interviews, we spoke to people from the DHH community about their experience with the captioning and with the show. We asked several questions related to their experience with each captioning option with included what they liked and did not like about the captioning option they used. We also asked if the captioning option still allowed them to enjoy the immersive experience of a planetarium show. These preliminary results will mostly talk about the pros and cons of each captioning option from the user perspective which can be seen in Table 1., as well as suggestions to improve upon each option.

Handheld Device		Epson Glasses		Captions on the Dome	
Pro	Con	Pro	Con	Pro	Con
Can change size and location	Not sure best place to hold device	Captions move when you look around; best for an immersive experience	High failure rate; 2/6 during testing did not work	Easily available to everyone even those who do not identify as DHH	Only available in one language
Ability for multiple languages; which includes ASL interpretation	Takes away from looking at the show; lose a bit of the immersive experience	Ability for multiple languages; which includes ASL interpretation	Don't work well for someone who wears glasses		White color made it hard to read
Ability to move device	arms/shoulders uncomfortable holding device		Black frame obstructs screen		Captions were small
			Image quality diminishes		Captions were close to bottom which loses the immersive nature of the show
			Makes people feel exposed and uncomfortable		

Overall, the individuals appreciated that captioning was an option even though each option has its pros and cons. They commented that the pace of the show was good for captioning. The pace allowed for captions to come up and then disappear to allow those that use them to be able to look around and then return to the captions when they came up to indicate someone was speaking. It was also noted that not all members of the DHH community are comprehensively literate in English as ASL is their first language. Therefore having more options for languages in captioning, and including ASL in those options would be preferred. For those who were completely deaf, they mentioned that without an ASL interpreter they would have missed the safety briefing and introduction before the show.

Captioning with Device

We spoke to one individual during this day of testing who was hard of hearing. They used the device mostly to pick up what they were missing but was unsure of the best place to hold the device while watching to still be able to get the full experience of watching the show and being about to look around. This individual liked the ability to change the size and location of the captions on the device. We also spoke to our ASL interpreter for the day, who also used the device. They brought up that the pacing of the show was good and when the captions left the screen it allowed them to look around and take in the images on the screen. They also commented on the ability to move the device was good but after a while caused some discomfort in their arm and shoulder and voiced a desire for a tool to hold the device for them. They also voiced that having to repeatedly look at a device in their hand, caused them to have to choose between watching the images on screen and wanting to understand what was being said.

Captioning with Epson glasses

We spoke to 6 during the day we tested with the Epson glasses. One hard-of-hearing individual was in the first focus group and five deaf individuals were in the second focus group. The Epson glasses worked in conjunction with the tablet so that the glasses mirrored the captions from the tablet. The first individual liked the glasses' ability to be able to allow the captioning to follow where they are looking. They also took off their glasses during the show and switched to the tablet for a little while but having to look down at the tablet they commented that it made them miss what was on the screen. They said that they would prefer the glasses to the tablet.

The second group was 5 individuals who were completely deaf and heavily relied on the captioning for understanding the show. During this showing, we had a high failure rate with the Epson glasses as 2 out of 5 pairs stopped working at some point. The glasses are also inconvenient for those who had glasses already, as it required them to adjust the Epson glasses repeatedly throughout the show. They also stated that they had to remove the glasses from time to time as the Epson glasses distorted their view of the show. Those whose glasses stopped working tried to use the tablet but as it was uncomfortable for them they just watched the show and it became a purely visual experience. They also commented that the Epson glasses design was unruly and obstructed their view of the show as it has a black frame, and the lenses themselves are thin. It was also brought up that the white text for the captioning was bright and they would have preferred a yellow or amber color to avoid the shock of white text in a dark space. They also commented that wearing the glasses made them feel exposed and singled out in a way, or "made [them] feel like a robot". Many in this group stated that, due to the uncomfortable nature of the glasses and tablet, they would prefer captioning on the dome.

Captioning on the dome

This captioning option had 4 individuals who participated in focus groups one individual also participated in the glasses focus group. This captioning option focused on captions on the screen. The individuals discussed details that would improve this captioning option. Individuals commented on having to decide whether to look at the captions at the bottom of the screen or to look around at the imagery. This caused them to miss out on one or the other. They also commented that the captions were white and small which at times made them hard to read and they would prefer captions of yellow or amber, and to have some sort of background, thick outline, or shadowing to make them easier to read. They also stated that the caption could be bigger and in multiple places maybe towards the bottom and the top, for ease of use when they are looking high in the dome. One downside of this option is this can only be captioned in one language at a time, and the other options have the ability to be personalized for an individual's preference.

IV. DISCUSSION AND FUTURE WORK

The biggest takeaway from the focus groups was that captioning is an important necessity to make planetarium shows accessible to the DHH community. They all expressed their appreciation that captioning was available even if there were some issues that can be improved upon. All individuals agreed that yellow or amber is the better color when it comes to captioning as well. From our research so far, five out of twelve individuals stated they would prefer captioning on the dome but any captioning is better than nothing. Captioning on the dome would also be the easiest for most domes to implement.

These results so far are preliminary, a more in-depth analysis is forthcoming. We also have data from surveys that were distributed after each show to individuals who were not a part of the DHH focus groups. We also have data regarding focus groups and observations from the BVI community revolving around the show and the hands-on activities, that have yet to be analyzed. We will publish this information in the future and it will be available on our webpage www.bigastronomy.org/research.

This project is funded by a supplement to an NSF Advancing Informal STEM Learning program (#1811436). The team includes Associated Universities, Inc., Association of Universities for Research in Astronomy, Michigan State University, California Academy of Sciences, Astronomical Society of the Pacific, Peoria Riverfront Museum, and Ward Beecher Planetarium.

50 YEARS OF DISCOVERIES: CELEBRATING A HALF-CENTURY AT THE MSUM PLANETARIUM

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The MSUM Planetarium is officially fifty years old! The space has shifted drastically over the years, but its original purpose stands. This presentation will center on our 50th Anniversary and the many projects associated with our celebration. From video interviews with staff members from the very beginning to a "50 Years of Discoveries" show displaying the incredible advancements in astronomy since 1972 to fundraising efforts to purchase a laser system. Join us as we walk through our process, progress, challenges, successes and lessons learned. We remember and celebrate the past as we look to the future

Introduction

In 1972, the Minnesota State University-Moorhead Planetarium opened its doors for the first time. In the fifty years since, the space has been used to mystify, educate, and entertain thousands. To celebrate this incredible milestone, the planetarium staff has been hard at work developing programs and projects revolving around the fiftieth anniversary. The celebration began in July and will be about to finish up at the time of this paper's presentation.

As the Space Race and the Moon Landing brought an era of elevated interest, and subsequently government funding, to astronomy and space exploration, many planetariums were erected in the early 1970's. Therefore, the purpose of this paper is to share our ideas and experiences to hopefully assist other planetariums in their anniversary celebrations.

Planetarium

Our planetarium logo.

Anniversary Season

Partially because a long celebration was preferred over a single event and partially because the exact opening date of the planetarium is unknown, it was decided that an anniversary "season" would be planned instead of one isolated event. The first event to kick off the celebration was the James Webb Space Telescope First Images event. The planetarium was proud to be named an official NASA Community Event Host and to display Webb's first images to the public. The event was an incredible success and an overflow third show had to be added to allow all students and community members to attend.

As the academic year kicked off, the local DJ who often partners with the planetarium during our monthly sky tours came in to welcome back students with a blend of music and astronomy. He played to a full house, which was an encouragement to our

marketing team. One of the main goals of our fiftieth anniversary was to raise awareness of the planetarium in the local community and to encourage higher attendance to our future programs. Increased student and community engagement can also enable us to do more events and grow our ever expanding student staff.

A logo created for our promotional materials.

Interview Project

The project of creating a series of video interviews with past and current employees of the planetarium began at the beginning of this summer. A list of names of past employees all the way to the very beginning in 1972 was curated from the archives. Sara and I began work on tracking down people who have long since left the area, some of which embarking on very different career paths since their time at the planetarium. As interviews were conducted, more and more names were mentioned as stories were told. All said and done, eighteen video interviews were conducted over the span of several months. Then began the process of turning several hours of raw footage into five succinct episodes. To separate the interviews, a rough timeline was developed.

Prior to the opening of the planetarium in 1972, the only astronomy course Moorhead State offered was taught in the math department. As the planetarium moved into construction, astronomy and astrophysics courses were created and passed onto the physics department. In my interview with Bev Wesley, wife of physics professor Walter Wesley, she mentioned that the trio of Wesley, Jim Wertz, and possibly Jim Wray, went to New York to pick out the original planetarium projector. They decided on the Spitz 512 Starball, and got to work developing curriculum for the classes. Eventually, Jim Wertz stepped into the role of the university's first Planetarium Director. Student staff members were added to the team to run the observing sessions which were a key part of astronomy courses and still are to this day. This included Bob Schnitzer who was what we refer to today as an observing assistant. After Dr. Wertz left the university, Denis Mudderman took over as planetarium director in 1979. Dave Weinrich stepped into the role in 1983, and this transition was used as a marker to separate the Early Formation episode from the First Galaxies.

More student staff members who were technically employed earlier than 1983 are also in this category as they were not involved in the planetarium's formation, but are better represented as young galaxies. This list includes Mary Jane Dodge, Virginia Efta, and Robin Ladd. After an impressive thirty-one year career, Dave Weinrich retired in 2014, which more or less separates our First Galaxies from our Protostars.

The Protostar category contains mainly student staff, featuring Tyler Lane, Abigail Bormann, and Callie Tescher. The Rising Stars category was reserved for current employees of the planetarium excluding Dr. Sara Schultz who took over for Dave Weinrich after his retirement in 2014. She was the subject of the fifth video, Star Forming Region. Included in this video were student staff members Lily Myers, Chloe Heydt, MJ West, and Maddy Rechtzigel.

The duration goal of the compiled interview videos is to keep them to a digestible six to twelve minutes in length. The videos were used as pre-show viewing for the FullDome Film Festival as well as posted on our YouTube channel. In addition to video interviews, seven participants who were unable to record video interviews were given the option to provide written interviews which were used by the campus marketing department for an article on the planetarium's history and the upcoming celebration. This article was shared on the university's homepage and social media pages. This project offered a rewarding experience for all involved, as capturing a piece of history is always a worthy goal.

This QR code links to our YouTube channel and the interviews.

"50 Years of Discoveries" Show

Also in honor of the fiftieth anniversary, I had the idea to do a show based on the major advancements in astronomy and space exploration that have occurred since the planetarium opened. Two other student workers at the planetarium ended up taking on the project, MJ West and Izzy Moen.

As was mentioned earlier, the planetarium was built shortly after the 1969 landing of Apollo 11 on the surface of the moon. Although the Moon Landing was the unofficial end of the Space Race, it did usher in an amazing era of space exploration. Many of the events following that historic moment are mentioned in the show. Some of the subjects Abby and MJ cover include Apollo 17, the "Blue Marble" photo, Voyager 1&2, the Hubble Space Telescope, Mars rovers, and the Parker Solar Probe. The visuals are a combination of photos and Open Space projections.

Fundraising Efforts

One of the main goals of the fiftieth anniversary is to raise funds towards a new laser system. Our total goal is fifty thousand dollars which would enable us to purchase a new laser system among other upgrades. The new equipment, a Solid-State laser Projection Music Entertainment System, would allow the planetarium to revive our LaserFest annual event and supplement our recent purchase of AVI's Laser Camp. Laser Camp is designed to introduce the scientific fundamentals and properties of light, laser safety, the technology used for laser scanning and light shows, as well as artistic creativity being combined with laser light.

Money will be raised with a combination of selling merchandise and raffle tickets at various events and encouraging donations at our annual MSUM Giving Day. Community events like Moorhead Cruise night featured raffles for various prizes like t-shirts and a custom James Webb-inspired light piece created by one of our student staff members, Jacob Karsten. We will be selling planetarium T-shirts in many styles created by former student Abigail Bormann and current student graphic designer Kate Leom. Stickers designed by Kate Leom will be for sale as well.

Minnesota State University-Moorhead also hosts an annual Giving Day, where alumni, community members, faculty, students and their families can donate to certain clubs, organizations, and programs. Over the last few years, we have increased our promotion of Giving Day and have been able to raise enough money for upgrades. While fifty thousand is an ambitious goal for us, by stepping up our fundraising efforts, we are hoping to meet that goal to get our own laser system and start creating and presenting laser programs regularly.

Lessons Learned

With this extensive list of moving parts all contributing to our 50th Anniversary Celebration, some events and ventures were bound to be less successful than others. This process was completely new to all of us so there were definitely some growing pains. Starting early would be the first advice we would give. The actual anniversary date was uncertain, so things were put off and not addressed in the most timely manner. Knowing that the planetarium opened in 1972, we decided to choose our own celebration timeframe and select a handful of special "milestone" events to celebrate along the way. When trying to figure out what to do and how much, the advice Sara received was to think about what we can handle and don't overreach. It doesn't have to be grandiose, but whatever you do, make sure it is done well. Know your limits and stick to them. Being a small facility with only one permanent staff, we knew it would have to be limited. The semester gets busy as well, so not celebrating for an entire year seemed like a good idea.

Our university has an annual giving day where we do campus wide fundraising for scholarships, departments, programs, etc. This seemed like an

excellent opportunity to capitalize on the 50th Anniversary and work toward our goal of raising "$50k for 50 Years". We went with $50,000 because it tied in with the "50" theme and because it was a bit of a stretch but also fairly manageable. When planning something like this, it is good to center everything around the number you are celebrating. So, if it were a 25 year anniversary, we would either try to raise $25k or frame it in terms of $25K two times. We did this with our event scheduling as well, celebrating with an event 100 (or two 50s) days from our final anniversary event and again at the 50 day mark. Focusing everything around your number helps keep things tied together and keeps that number in people's minds. The giving day is towards the end of October on a Thursday, so we chose to have the final celebration event the weekend after. We chose not to do the final event the day of Giving Day because there is already so much going on that day and being during the week would make travel for anyone coming from a distance less convenient.

In terms of fundraising, there were several pieces of advice we found helpful. First, if you do not have a Foundation or designated fund-raiser for your facility, start by looking at annual reports from other institutions like yours. They are public and can typically be found via a search on their website. This list of donors/supporters might give you a good idea where to start. Additionally, check out your local business association, area foundation, chamber of commerce, etc. They can help point you in the right direction. One suggestion was to reach out to power companies in the area. This turned out to be excellent advice for me as the person I contacted is also an alum from MSUM and well connected in the community. He became my biggest advocate with other local companies.

If you are not comfortable with contacting companies yourself, or you have been advised not to, you can talk to friends or acquaintances who work for those companies and see if they will reach out for you! Also, do not be afraid to be honest and yourself. If you don't know how these things are done, tell them! Don't be afraid to be human, they will likely appreciate that and want to help you one way or another.

When trying to locate former students and staff, we used a number of resources including: Facebook, LinkedIn, whitepages.com, our campus archives, friends of friends of friends of friends, or relatives and former colleagues. It began to feel like taking on private investigation!

Conclusion

While anniversaries can sometimes seem arbitrary, remembering their purpose is essential. Anniversaries serve as acknowledgements that the subject of our celebration has endured. It has stood the test of time and has emerged– especially in the case of the MSUM Planetarium– stronger than ever. One theory as to why planetariums and space exploration are of such interest to us is the human need to discover. To go out, observe, and then go further. Humans have been using the stars as guides for thousands of years and the tendency to connect deities to the points of light in the night sky is ubiquitous across most cultures. Something about the vast yet predictable expanse of space draws us in and keeps us coming back to look up night after night. It was, in one form or another, that drive to learn and discover that made our planetarium and others like it possible. It will be that drive that allows us to share the skies with our neighbors well into the future. Here's to another fifty.

A poster made for the "50 Years of Discoveries" show

ASTEROIDS, METEORS, AND METEORITES, OH MI!

Shannon Schmoll
Abrams Planetarium
755 Science Rd
East Lansing MI
schmolls@msu.edu

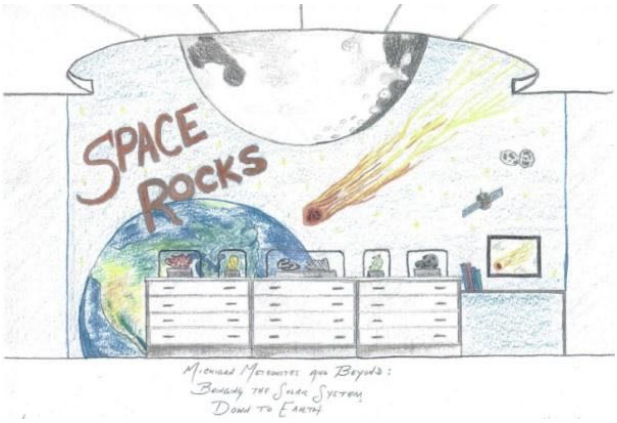
Craig A. Whitford

Is there anyone reading this paper who has not held a meteorite?

How many of you have meteorites on display in your planetarium?

How many of you use meteorites in your outreach programs?

In 2015 about a year after Dr. Shannon Schmoll joined the Abrams Planetarium as director, she was shown two Rubbermaid tubs that held meteorites of various types, descriptions and sizes wrapped in 20+ year-old newspaper.



Our first proposed sketch for the display

No meteorite can really be described as "ordinary" even though the ordinary chondrite is one of the three major types. For within these containers were remnants that fell on the Great Lakes state of Michigan. Named stones like Allegan, Grand Rapids, Iron River, Kalkaska, Reed City, Rose City and Seneca Township. Seven out of the nine named meteorites that make up Michigan's extraterrestrial history. Colleagues advised her to box them up and send them to the Smithsonian. Instead, we decided to return them to public display within the Abrams Planetarium. This collection of 70+ meteorites, many collected in the late 19th and early 20th century, had been off display since the mid-1990s. The last inventory was created by Von Del Chamberlain in 1973 and since that time much had changed within science and the meteorite community.

The time had come to share the only tangible evidence made of bits of stone and iron once again, rocks that had condensed and accumulated some 4.56 billion years ago from within the solar nebula.

Grant writing and funding

The mission and vision of the Institute of Museum and Library Services (IMLS) is to inspire libraries and museums to advance innovation, lifelong learning, and cultural and civic engagement. They provide leadership through research, policy development, and grant-making.

That last part "grant-making" provided us the avenue to place our extraterrestrial history back on public display and into the hands of our patrons. We didn't know whether we'd be successful in our endeavor, but it presented us with the opportunity to at least give it our best.

In October 2016 our grant proposal was sent off to IMLS. It would be nearly a year before we would know if our proposal would be successful. During this time, we continued to hone our design in anticipation of being selected. In the fall of 2017 word came that we had been successful in our endeavor to obtain funding. IMLS had received 558 applications requesting nearly $105 million dollars in funding. Only 132 projects were selected totaling just over $19 million. Abrams Planetariums portion came to just over $97,000 with $83,000 in matching funds from Michigan State University in the form of time for staff and advisors and $15,000 from the Dart Foundation for physical exhibit pieces. With $195,000 in funding, we were all set to begin. We formed our committee, hired a graphic artist and label writer, and plans were underway.

INSTITUTE of Museum and Library SERVICES

Official Award Notification for Grants and Cooperative Agreements

Page 1

Recipient Information	
Recipient Name : Michigan State University Org. Unit: Abrams Planetarium	
Recipient Address : 426 Auditorium Road Room 2 East Lansing, MI 48824-2600	**Recipient Unique Entity Identifier :** 193247145 **TIN No :** 386005984
Recipient Authorizing Official : Craig O'Neill	**Recipient Project Director :** Shannon Schmoll
Basic Award Information	
CFDA Name : Museums for America	**CFDA Number:** 45.301 **Federal Award Date :** August 10, 2017
Federal Award Identification Number (FAIN) : MA-10-17-0377-17	**Amount of Federal Funds Obligated by this Action :** 08/10/2017 $97,259.00 Original Award
Period of Performance Start Date : October 01, 2017 **Period of Performance End Date :** September 30, 2019	**Total Amount of Federal Funds Obligated :** $ 97,259.00 **Total Approved Cost Sharing or Matching :** $ 98,026.00 **Indirect Cost Rate :** 36.00
Federal Award Performance Goals : Grantee is to report on performance as presented in their final approved grant application.	
Reporting Schedule : Interim Financial Dec 30 2018 Interim Narrative Dec 30 2018 Final Financial Dec 29 2019 Final Narrative Dec 29 2019	

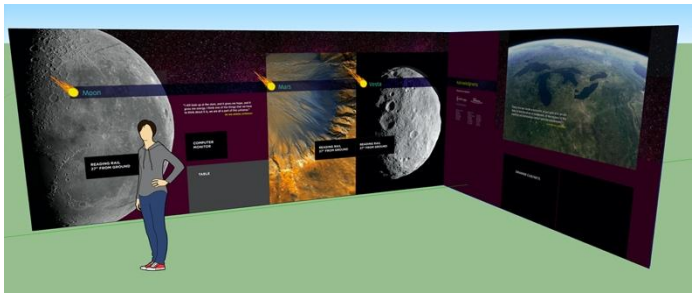
IMLS Award notification letter

A new exhibit and addition, walls, and lighting

In 2018 while our plans were underway to install the exhibit at the north end of our lobby word came of a possible expansion to the planetarium which would also happen on the same end. A revised plan was then made to place the new exhibit at the south end. Walls were stripped of their coverings and a wall insert built and installed in a portion of the wall that allowed very large items entry into the space from the outside. In the meantime, it was decided not to proceed with an addition.

Walls being prepared for a vinyl wrap and the insert wall being prepared to be installed within the double-door opening.

While work on the walls was progressing our graphic artist submitted a design to feature images of the Moon, Mars, and Vesta. Our vision was to allow patrons an opportunity to touch an actual meteorite specimen from each of the planetary bodies while at the same time being able to take a "selfie" against a backdrop image.



Artist's rendering of the wall design

Lighting was also a top priority. After viewing meteorite displays at several facilities, we wanted to be sure that all our displays were well lit for the viewers. Two runs of ceiling track lighting were installed, one along the wall images and reading rails and another over the specimen cabinet drawers.

Read, touch, feel

Mounted out from the wall-size images of the Moon, Mars and Vesta are three separate reading rails.

Reading Rails for the Moon, Mars, and Asteroid Vesta with 3D crater impression and openings for patrons to touch a meteorite specimen from each planetary body.

Information about meteorites that originated from each of the planetary bodies is provided along with acrylic disks with tapered finger holes allowing the visitor an opportunity to touch a meteorite specimen from each. Also included on each rail is a 3D acrylic cast of a crater formation providing a tactile element. The crater acrylics were made from casts of 3D printed examples, which were not strong enough to withstand the rigors of thousands of school age children touching them. Once the casts were made acrylic resin was poured into the molds. Once dry each was then hand painted to reflect the surface color and texture.

Our extraterrestrial heritage on full display

At the time we submitted our grant proposal to IMLS we had just seven of the nine known Michigan meteorites. Since the planetarium is in the heart of Michigan, our main display, the entry point to the exhibit, would feature all the known Michigan meteorites – at least all which we had in the collection. Within a short time, we added number eight. In early 2018 our great state would experience another meteorite fall – Hamburg. Through our efforts with a lucky finder, we were able to add the ninth of ten known. Then in the fall of 2018 came word that a new iron meteorite was discovered from Montcalm County located in the northwest portion of the lower peninsula – Edmore. Once again through our efforts to reach out we found a donor and MSU acquired the tenth of now eleven known Michigan meteorites. We were down to missing just one. Even prior to planning for a new exhibit we had tried to secure even a tiny fragment of the missing meteorite which had fallen in the state in 1994. Through intense negotiating and some give and take we had finally secured a specimen of the Coleman meteorite and our collection was finally complete – unless another happened to either fall or surface. We could now boast having the only complete collection of Michigan meteorites in the Universe!

Completed Main Display with Michigan Meteorites

meteorite wipe out the dinosaurs?" Each visually appealing drawer was carefully crafted with descriptive text, images and selected specimens for our viewers to observe and take home a better understanding of these unique rocks from outer space.

Two 8-Drawer Specimen Cabinets with acrylic topper providing additional display space for rotating exhibits

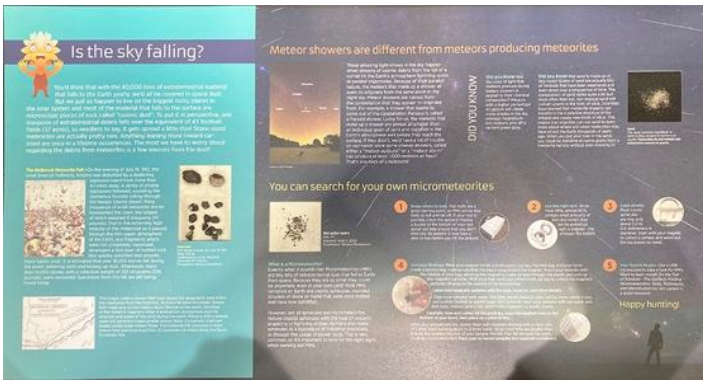
Throughout this entire time, we had worked to design, re-design and hone our plan. The main display would have to be well built to withstand the thousands of visitors most of them elementary school age students. Once the design was finalized the display was constructed and moved into place for finishing touches, paint, a vinyl graphic wrap, glass, computer and locking devices.

"How do we know meteorites are from space?"

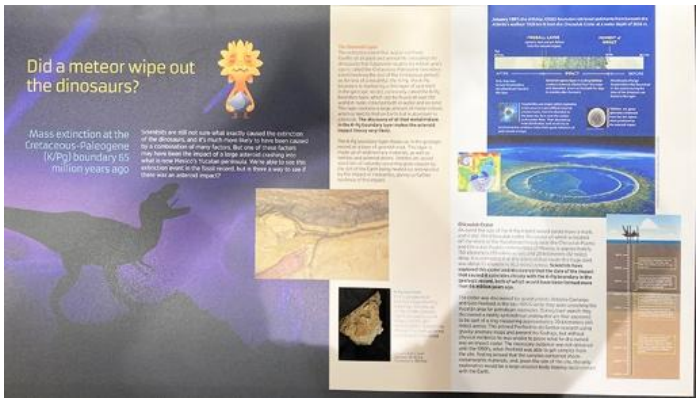
Answering the most asked questions

DART Container Corporation the maker of everything Styrofoam and beyond like most large corporations has a foundation set up to assist non-profits. DART has assisted the Abrams Planetarium on a few projects and our new meteorite exhibit would benefit from their involvement. Two archival four drawer specimen cabinets with acrylic toppers were purchased from Delta Designs Ltd from Topeka, Kansas with a $15,000 grant.

Each of the eight drawers would answer some of the most asked questions about meteorites. From "Where do Meteorites Come From?" to "How do we know meteorites are from space?", What Happens When Meteors Strike Earth?" and "Did a meteoroid or



"Is the sky falling?"



"Did a meteor wipe out the dinosaurs?"

A sampling of three out of eight drawers which each answer a commonly asked question about meteorites

Say Hello to FeNi

Early sketches of FeNi

As we envisioned and worked on this project it was clear that we wanted to be able to brand our new exhibit. One of the employees at MSU illustrated children's books in his leisure hours. He was invited in to hear our ideas for a character mascot that would represent our new exhibit. We presented him with ideas about how our mascot might appear as such as a well-defined oriented meteorite with flutes emanating from its nose to the back of its head, a well-rounded alien body with two feet. When we met a second time to see his proposal, we felt that he had truly captured our vision for the character. Then came time for a name and since a large percentage of meteorites contain iron and nickel – the name FeNi was born. FeNi our lovable oriented meteorite has become the mascot of Abrams Planetarium.

FeNi – Our character mascot for the display and the Abrams Planetarium

Launching in a grand way

For a project that began in 2016, IMLS grant awarded in 2017 and work underway in 2018 we were confident that we could complete the project by the end of 2020 – until the unthinkable occurred – COVID. Even though we continued to work in the planetarium during this time all our suppliers and staff went on furlough – including the Federal Government. This meant asking for a one-year extension which ended in the fall of 2021. With Covid nearly in the rearview mirror by fall it was time to celebrate and unveil the new exhibition. The grand opening was held as part of our members preview and the reopening of public shows, on a limited basis, on December 11, 2021. As a gift to our patrons a pair of custom crafted organic chocolate "meteorites" were ordered from a mid-Michigan chocolatier for the event called Oh MI, Organics. Due to inclement weather our turnout was less than expected allowing us to spend more time with those who attended. Feedback relating to the exhibit was very positive and answered all our expectations.

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Images from our Grand Opening – December 11, 2021

Why we do what we do

Even before considering placing the meteorites back on public display and writing the grant we used our meteorite collection in every public outreach event we held or attended. From school science nights, planetarium events, public presentations and more, meteorites are that tangible piece of astronomy and science that gives the public a unique experience to touch a physical object that originated from within our solar system. The expressions on the faces of children and especially their parents as they experienced the size, weight and characteristics of an actual meteorite that isn't locked up behind glass for viewing only.

Now that our exhibit is complete and answers many of the questions about who, what, why and where we went the extra step and created a master outreach meteorite kit as well as five smaller kits that educators can sign-out from the planetarium for a period to

share with their students or group. These kits have been a qualified hit with educators.

One of five "Exploring Meteorites"
Outreach kits for Educators to sign-out

Summary

At the beginning of this presentation, we asked how many of you have meteorites on display in your planetarium or use them in your public outreach? The answer to this question for the Abrams Planetarium is easy – we love to share our meteorite collection with the public. No matter how large or how many specimens you may have, or if you're considering adding a small collection of meteorites to your planetarium and outreach – your patrons will enjoy and cherish the experience of holding an object that spent time, perhaps billions of years, within the realm of our solar system. Meteorites are truly the time capsules for answering the many questions about planet formation and our unique existence among the stars and life.

If you don't have a collection of meteorites start one. Place them on display whether it's a small wall cabinet or a table in the corner. Use them in your programming, public outreach and beyond. Think about all the young and old lives you'll touch, most for the very first time, with something that came from out there – the great beyond where no member of humanity has travelled. Think of inspiring the next generation of explorers to reach higher and further than ever before simply because those tiny bits of iron and stone inspired them.

Our future in space!

With that said we'd like to leave you with the two quotes featured within the design of our wall graphics. The first by Dr. Mae Jemison, Astronaut, "I still look up at the stars, and it gives me hope, and it gives me energy. I think one of the things that we have to think about it is, we are all a part of this universe." The second is by G.J.M. McCall, Geologist, "Every time we handle a meteorite, or just gaze at it, we are likely to feel the shiver of excitement, of the mystery of reaching out and making contact with the unknown."

Watch For Falling Rocks!

NEREID: BRINGING TOGETHER EARTH AND SPACE RESEARCH, DATA, AND EDUCATION

Tiffany Stone Wolbrecht
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6209 St. Andrews Drive
Canfield, OH
tiffany.wolbrecht@gmail.com

The Network for Earth-space Research Education and Innovation with Data (NEREID) is an interdisciplinary community centered around earth and space science data as well as research and education. NEREID is intentionally designed to bridge domains, connect professionals working in research, education, policy, and industry, and facilitate convergence across these domains and professions. In achieving its goals, NEREID cultivates a collaborative space for curious minds to discuss shared challenges and brainstorm creative solutions. Learn more about NEREID and its upcoming activities as well as how to get involved.

About NEREID

The Network for Earth-space Research Education and Innovation with Data (NEREID) is an interdisciplinary community centered around earth and space science data as well as research and education. NEREID was founded in 2019 with an inaugural workshop sponsored by the National Science Foundation (NSF) and held at Green Bank Observatory in West Virginia. The workshop gathered an interdisciplinary group of 28 experts in earth sciences, space sciences, data and information sciences, and education, with outcomes and recommendations reported in a white paper (Uzzo, et al., 2019). NEREID has since evolved into a nascent community and "unobstructed think-tank" for sharing ideas and developing projects across disciplines, with over 25 institutional members and 75 individual members.

NEREID strives to be a go-to resource for scholarship, teaching, and proposal support, as well as a social network intentionally designed to bridge domains and facilitate convergence across earth and space sciences, in both research and education. NEREID activities are designed to promote convergence in the science process, education and knowledge exchange between diverse scientific and technical communities. NEREID is the ideal community for planetarians looking to meet others outside of their network, build new collaborations for projects or proposals, consider new perspectives on topics they teach, or simply looking to feed their curiosity.

Convergence On Tap

Amidst the COVID-19 pandemic that began shortly after the initial Green Bank workshop, NEREID maintained momentum in large part through this science café-style outreach event series. To date, four virtual and one in-person "Convergence On Tap!" social and community-building events have been held exploring topic areas that are ripe for intensive transdisciplinarity, with expert speakers and engaged audience discussion surrounding sets of creative scenarios that exemplify convergence

(Stahlman, 2021a; 2021b; 2022). See Table 1 for a list of previous On Tap! events, topics, speakers, and scenarios. The immediate success of the "On Tap!" series demonstrated that the NEREID community is largely built around the "practice" of sharing diverse perspectives and engaging in intellectual encounters that otherwise would not have occurred.

Table 1: Previous NEREID: Convergence On Tap! events

March 31, 2021: "Interdisciplinarity and convergence science: What do we mean? **Number registered: 93**		
Topic	**Panel of speakers**	**Scenario description**
#1. What is the essence of convergence science?	· **Dr. Inna Kouper, *Research Scientist***, *IU Luddy School of Informatics, Computing and Engineering* · **Dr. Ryan McGranaghan, *Scientist***, *ASTRA, LLC* · **Dr. Attila Varga, *Postdoctoral Fellow***, *IU Center for Complex Networks and Systems Research*	The impending approach of a "planet-killer" comet, and how solutions would be enabled by convergence. Groups were given slightly different scenarios – 9 years, 9 months or 9 days until impact – before brainstorming about how to save Earth and associated science communication challenges and reporting out to the group afterwards.
May 26, 2021: "Sea the Stars" **Number registered: 42**		
Topic	**Panel of speakers**	**Scenario description**
#2. Ocean research and indigenous knowledge	· **Dr. Michel André, *Biotechnology Engineer***, *National Institute of Applied Sciences, INSA* · **Dr. Travis Horton, *Associate Professor***, *University of Canterbury* · **Feather Metsch, A/V Storyteller,** *Little Traverse Bay Band of Odawa Indians*	Playing on the well-known "walks into a bar" joke genre, a combination of three pre-selected categories of individuals (for example, a space executive, policymaker, and ship captain) meet and discuss breaking news about a hypothetical discovery that humpback whales navigate using the stars. Participants brainstormed about the implications of such a discovery for humanity, society, and earth-space convergence.
September 23, 2021: "Secret Oceans: Below and Beyond" **Number registered: 42**		
Topic	**Panel of speakers**	**Scenario description**
#3. Deep underwater exploration on Earth & Saturn's moon Europa	· **Dr. Curt Niebur, *Program Scientist***, *NASA Planetary Science Division* · **Dr. Tim Shank, *Deep-sea Biologist***, *Woods Hole Oceanographic Institution*	Whole-group discussion was so engaging that no scenario was introduced to participants.

January 19, 2022: "Anarchy in the Sea and Sky?" **Number registered: 70**		
Topic	**Panel of speakers**	**Scenario description**
#4. Legality and ethics of international ocean and space exploitation	· **Michelle L.D. Hanlon, J.D., *Co-Director of Air and Space Law Program***, *University of Mississippi School of Law* · **Linda Sheehan, J.D., *Executive Director***, *Environment Now*	A hypothetical exploration mission. Groups were assigned to one of a) moon colonization; b) deep ocean mining; c) ocean colonization; d) asteroid mining; e) terraforming a planet or moon. Participants discussed the legal, ethical, and societal considerations of these missions.
June 14, 2022: "Voyage to New Worlds" **at the AAS 240 Summer Conference**		
Topic	**Panel of speakers**	**Scenario description**
#5. What and who are needed to preserve humanity	[No speakers]	A hypothetical survival mission. Participants discussed who might fill the manifest of a spacecraft with 100 people who were tasked with bringing humanity to a new world.

November Town Hall

Our Changing Planet Summit

Associated Universities Incorporated (AUI) will host a collaborative 2.5-day, hands-on Summit bringing together approximately 90 researchers, educators, policy makers, indigenous and philosophical knowledge holders and others to explore solutions to society's greatest challenges through authentic collaboration across disciplines. With the theme "Our Changing Planet," our goals for the Summit are:

- Promote deeper understanding of convergence science processes
- Empower new cross-disciplinary collaborations to advance earth-space-data convergence
- Increase capacity and membership for NEREID
- Connect with current and future NEREID members to better understand and provide effective platforms, services, and information resources.

The "Our Changing Planet" Summit will galvanize a body of work among academia, industry and research to identify, leverage, amplify and scale efforts to conduct new research, develop new tools, and engage learners and policymakers around climate change and other global challenges. This Summit reflects a collection of perspectives and approaches that come together to develop innovative solutions that address global changes. A cosmic perspective is critical when considering those global challenges. Planetarians are invited to participate in this event and will provide a valuable voice at the table. It will be fun so please join us. For more information, visit NEREID's website at earthspacenetwork.org

References

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MEETING STANDARDS IN THE DOME

Diana Yoder
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We all love astronomy, that's a given. But sometimes, it can feel like schools don't care about it. With the importance of state testing and local or national standards, it can be difficult to justify teaching astronomy to PK-12 students. However, there are a plethora of ways to use astronomy topics to teach these standards. This talk will help you to find those justifications and point you in the right direction to get the resources you need to share a love of astronomy with your students.

Introduction

Many planetarians consider themselves to be 'informal' educators as opposed to the formal educators of the classroom. Most of us usually don't have the opportunity to meet with the same students twice, let alone for a whole year. Along that note, many of us had never seen a learning standard before we started hosting school groups in our domes. We weren't taught what to do with these or how important they are to many schools. In this presentation, I hope to help you to understand the goals of these standards and to see the value in teaching towards them.

When trying to get school groups to our domes, we have to remember to market ourselves for our desired audience. We of course want to be a place of learning, imagination, and wonder. But we have to be more than that. We have to be valuable. We have to make it worth the time, effort, and money that students and teachers put into making a trip to their local planetarium. (Or bringing the portable to their school.) I think everyone here sees value in learning about space and astronomy. We are all passionate about what we do. Not everyone is going to immediately see that value, though. We have to prove it to them.

For PK-12 education, the easiest way to prove value, not express opinions or theories, but to prove their time and money won't be wasted, we need to address standards. This can appear to be a daunting task. Especially to those who have not taught in a formal classroom before. But there are many ways to go about linking what you have to offer, to the standards that many grades are required to study. Let's start by understanding your local standards.

Understanding Your Standards

For many educators, it's easiest to work with the Next Generation Science Standards, or NGSS. This is a set of standards created by teachers across the US. Many states have adopted these standards, or at least base their state's requirements off of the ideas stated in them. For many educators, teaching to a NGSS standard is better than not teaching to a standard at all.

In Ohio, where I live, NGSS is not the official science standards, instead, they have the Ohio Learning Standards and Model Curriculum for Science. If you peruse this document, you can find many similarities between it an NGSS. The grade level and some of the specifics are often changed, but the big ideas and goals are very similar. Many school also recognize an NGSS topic as valuable.

To find your states standards, its always a good idea to start with your state's education department. They should have links available to complete documentation of all the standards required in your schools. (This is available for Free!)

I can't speak for all 50 states in one 10 minute talk, but here is a quick breakdown of what it's like to read an NGSS standard and an OH standard. For this example, we are going to take a look at standards that involve teaching the solar system.

In OH, students learn about the solar system in the 5th grade. It's considered Earth and Space Science (ESS) content and the first content they teach. So the corresponding standard is called 5.ESS.1

The short version of a standard's description is called a Condensed Content Statement listed here: "The solar system includes the sun and all celestial bodies that orbit the sun. Each planet in the solar system has unique characteristics." For many planetarians, this is more than enough to go off of in order to teach an hour long class. However, if you need more information on the standard, the full description includes the Content Statement and Content Elaboration. You can read the full standard in the figures below.

Grade 5

INTRODUCTION TO CONTENT STATEMENTS

GRADE BAND THEME: INTERCONNECTIONS WITHIN SYSTEMS

This theme focuses on helping students explore the components of various systems and then investigate dynamic and sustainable relationships within systems using scientific inquiry.

STRANDS

Strand Connections: Cycles on Earth, such as those occurring in ecosystems, in the solar system, and in the movement of light and sound result in describable patterns. Speed is a measurement of movement. Change in speed is related to force and mass. The transfer of energy drives changes in systems, including ecosystems and physical systems.

EARTH AND SPACE SCIENCE (ESS)	PHYSICAL SCIENCE (PS)	LIFE SCIENCE (LS)
Topic: Cycles and Patterns in the Solar System This topic focuses on the characteristics, cycles and patterns in the solar system and within the universe.	**Topic: Light, Sound and Motion** This topic focuses on the forces that affect motion. This includes the relationship between the change in speed of an object, the amount of force applied and the mass of the object. Light and sound are explored as forms of energy that move in predictable ways, depending on the matter through which they move.	**Topic: Interactions within Ecosystems** This topic focuses on foundational knowledge of the structures and functions of ecosystems.
CONDENSED CONTENT STATEMENTS		
5.ESS.1 The solar system includes the sun and all celestial bodies that orbit the sun. Each planet in the solar system has unique characteristics. **5.ESS.2** The sun is one of many stars that exist in the universe. **5.ESS.3** Most of the cycles and patterns of motion between the Earth and sun are predictable.	**5.PS.1** The amount of change in movement of an object is based on the mass of the object and the amount of force exerted. **5.PS.2** Light and sound are forms of energy that behave in predictable ways.	**5.LS.1** Organisms perform a variety of roles in an ecosystem. **5.LS.2** All of the processes that take place within organisms require energy.

Figure 1: OH Grade 5 Content Statements

EARTH AND SPACE SCIENCE (ESS)

Topic: Cycles and Patterns in the Solar System
This topic focuses on the characteristics, cycles and patterns in the solar system and within the universe.

CONTENT STATEMENT	CONTENT ELABORATION
5.ESS.1: The solar system includes the sun and all celestial bodies that orbit the sun. Each planet in the solar system has unique characteristics. The distance from the sun, size, composition and movement of each planet are unique. Planets revolve around the sun in elliptical orbits. Some of the planets have moons and/or debris that orbit them. Comets, asteroids and meteoroids orbit the sun.	**Prior Concepts Related to Solar System** **PreK-2:** The moon, sun and stars can be observed at different times of the day or night. The observable shape of the moon changes throughout the month. The sun's position appears to change in a single day and from day to day. The sun is the principal source of energy. Earth's atmosphere is discussed. **Grades 3-4:** All objects are made of matter. Light is a form of energy. Earth's surface is discussed and gravitational forces are introduced. **Grade 5 Concepts** Planets in the solar system orbit the sun. Some of the planets have one or more orbiting moons. Earth is a planet that has a moon. The moon orbits Earth. Gravitational forces between the sun and its planets cause the planets to orbit the sun. Gravitational forces between a planet and its moon(s) cause the moon(s) to orbit the planet. If no forces were present, planets and moons would continue their motion toward outer space without changes in speed or direction. However, gravitational forces between the sun and each planet continuously changes the planet's direction so it remains in orbit. In the same way, gravitational forces between each moon and its planet continuously changes the moon's direction so it remains in orbit. Asteroids are rocky bodies that orbit the sun in nearly circular orbits but are too small to be classified as planets. Comets are a mixture of ices (e.g., water, methane, carbon monoxide, carbon dioxide, ammonia) and dust, and have highly elliptical orbits. A meteor appears when a particle or chunk of metallic or stony matter called a meteoroid enters Earth's atmosphere from outer space. Meteors that pass through the atmosphere and impact Earth's surface are called meteorites. General information regarding planetary positions, orbital patterns, planetary composition and recent discoveries and projects (e.g., missions to Mars) are included in this content. Tools and technology are an essential part of understanding the workings within the solar system. **Future Application of Concepts** **Grades 6-8:** The interior and exterior composition of Earth, Earth's unique atmosphere, light waves, electromagnetic waves, interactions among Earth, moon and sun and gravitational forces are explored in more depth. **High School:** Galaxies, stars and the universe are studied in the physical sciences.

Figure 2: OH Grade 5 Standard 5.ESS.1

One thing I absolutely love about the Ohio Learning Standards, is the Content Elaboration in the form of a list of Prior Concepts and Future Applications. These notes can easily help you justify why a 3rd or 6th grader should also check out your program on the solar system. If you include any of the related concepts, you can at least make a note of these for your teachers to consider. Or, these notes can direct you to the exact standards in other grades you want to build your program towards.

For example, in Grades 3-4, they learn about Earth's surface and are introduced to gravitational forces. If your lesson on the solar system includes distinguishing features of Earth's surface and the fact that gravity keeps the solar system in check, you can reference this as a reason for Grades 3 or 4 to attend this lesson. Now, I need to be clear here. If your lesson briefly discuss gravity and Earth's surface, please do not state that your lesson meets ESS standards for grades 3 and 4. In order to say that, you would have to dive much deeper into those topics. However, you can say that this lesson addresses concepts learned in ESS standards for grades 3 and 4.

Switching to NGSS, they don't recommend learning the details of the solar system until middle school (6th or 7th grade). This really isn't a problem for me in OH. Any show I create for 11 or 12 year olds, will also be appropriate for 10 year olds. In general, at least for OH, the grade differences aren't significant between NGSS and the state recommendations.

The content is also considered Earth and Space Science, so that keeps things relatively simple. The standards MS.ESS1-1 to 1-3 discuss "Space Systems", but we are going to look specifically at MS.ESS1-3 for info on the solar system. The short description of the standards reads: "Analyze and interpret data to determine scale properties of objects in the solar system." These descriptions read as objectives for your students to be able to accomplish after your lesson. As you can see, this statement is very short and open ended. You really need to check out the entire standard and the Evidence Statements in order to fully understand what the goal of the standard is. You can read this information in the figures below.

Students who demonstrate understanding can:

MS-ESS1-3. **Analyze and interpret data to determine scale properties of objects in the solar system.** [Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.] [*Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings.	**ESS1.B: Earth and the Solar System** • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.	**Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. *Connections to Engineering,Technology, and Applications of Science* **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems.

Connections to other DCIs in this grade-band:
MS.ESS2.A

Articulation of DCIs across grade-bands:
5.ESS1.B | **HS.ESS1.B** | **HS.ESS2.A**

Common Core State Standards Connections:

ELA/Literacy -
RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS1-3)
RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS1-3)

Mathematics -
MP.2 Reason abstractly and quantitatively. (MS-ESS1-3)
6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-ESS1-3)
7.RP.A.2 Recognize and represent proportional relationships between quantities. (MS-ESS1-3)

Figure 3: NGSS Standard MS.ESS1-3

Observable features of the student performance by the end of the course:		
1	Organizing data	
	a	Students organize given data on solar system objects (e.g., surface features, object layers, orbital radii) from various Earth- and space-based instruments to allow for analysis and interpretation (e.g., transforming tabular data into pictures, diagrams, graphs, or physical models that illustrate changes in scale).
	b	Students describe* that different representations illustrate different characteristics of objects in the solar system, including differences in scale.
2	Identifying relationships	
	a	Students use quantitative analyses to describe* similarities and differences among solar system objects by describing* patterns of features of those objects at different scales, including:
		i. Distance from the sun.
		ii. Diameter.
		iii. Surface features (e.g., sizes of volcanoes).
		iv. Structure.
		v. Composition (e.g., ice versus rock versus gas).
	b	Students identify advances in solar system science made possible by improved engineering (e.g., knowledge of the evolution of the solar system from lunar exploration and space probes) and new developments in engineering made possible by advances in science (e.g., space-based telescopes from advances in optics and aerospace engineering).
3	Interpreting data	
	a	Students use the patterns they find in multiple types of data at varying scales to draw conclusions about the identifying characteristics of different categories of solar system objects (e.g., planets, meteors, asteroids, comets) based on their features, composition, and locations within the solar system (e.g., most asteroids are rocky bodies between Mars and Jupiter, while most comets reside in orbits farther from the sun and are composed mostly of ice).
	b	Students use patterns in data as evidence to describe* that two objects may be similar when viewed at one scale (e.g., types of surface features) but may appear to be quite different when viewed at a different scale (e.g., diameter or number of natural satellites).
	c	Students use the organization of data to facilitate drawing conclusions about the patterns of scale properties at more than one scale, such as those that are too large or too small to directly observe.

Figure 4: NGSS Evidence Statements for MS.ESS1-3

If you take a look at section 2: Identifying Relationships, you can see that there is a lot of overlap between the NGSS and OH standards on the solar system. This makes it simple to reference both standards in your lesson descriptions. Now, please don't think that you have to make every lesson match both your state standards and the NGSS. I included these examples to give you an idea of how to make standards work for you in your state, regardless of state standards or if you've adopted NGSS.

For most states, teaching to NGSS is a really great selling point for your programs. But, some teachers might appreciate the link to the state standards they are more familiar with. If you are just starting out, I recommend learning one or the other. The NGSS standards are usually very well documented, and you might be able to find more resources online for these standards. However, you might have team members near your dome that are more familiar with your state standards. Try to gauge the resources you have easily available and make your decision from there.

Some standards are going to easily relate to your planetarium like the solar system example. Others, might be a bit more of a stretch. Not every grade is going to have a direct link to astronomy, so if you want to see those students, you need to get a little creative. Physics is a really good topic to stretch to your planetarium as topics like gravity, light, or energy could be taught to students using celestial bodies.

A good example is NGSS 1-PS4-2. This is a first grade physical science standard on light. The objective is: "Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated." Quite the mouthful to say that you need light to see things. This could lead to a wonderful discussion about things you can or cannot see at night and how the Sun helps us to see in the day. View the full standard below to better understand the Evidence Statements.

NEXT GENERATION SCIENCE STANDARDS For States, By States

*"Unless otherwise specified, "descriptions" referenced in the evidence statements could include but are not limited to written, oral, pictorial, and kinesthetic descriptions.

1-PS4-2 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

1-PS4-2. **Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated.** [Clarification Statement: Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.	**PS4.B: Electromagnetic Radiation** • Objects can be seen if light is available to illuminate them or if they give off their own light.	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Observable features of the student performance by the end of the grade:		
1	Articulating the explanation of phenomena	
	a	Students articulate a statement that relates the given phenomenon to a scientific idea, including that when an object in the dark is lit (e.g., turning on a light in the dark space or from light the object itself gives off), it can be seen.
	b	Students use evidence and reasoning to construct an evidence-based account of the phenomenon.
2	Evidence	
	a	Students make observations (firsthand or from media) to serve as the basis for evidence, including:
		i. The appearance (e.g., visible, not visible, somewhat visible but difficult to see) of objects in a space with no light.
		ii. The appearance (e.g., visible, not visible, somewhat visible but difficult to see) of objects in a space with light.
		iii. The appearance (e.g., visible, not visible, somewhat visible but difficult to see) of objects (e.g., light bulbs, glow sticks) that give off light in a space with no other light.
	b	Students describe* how their observations provide evidence to support their explanation.
3	Reasoning	
	a	Students logically connect the evidence to support the evidence-based account of the phenomenon. Students describe* lines of reasoning that include:
		i. The presence of light in a space causes objects to be able to be seen in that space.
		ii. Objects cannot be seen if there is no light to illuminate them, but the same object in the same space can be seen if a light source is introduced.
		iii. The ability of an object to give off its own light causes the object to be seen in a space where there is no other light.

Figure 5: NGSS Standard and Evidence Statements for 1-P24-2

Reading Between the Lines

Another way to bring standards to your dome is to read between the lines. Not every standards is going to be strictly astronomy related (like the light example). In NGSS, there is also something called the Science and Engineering Practices. This is a framework for the standards that includes incorporating science and engineering practices into all of the topics the students learn about.

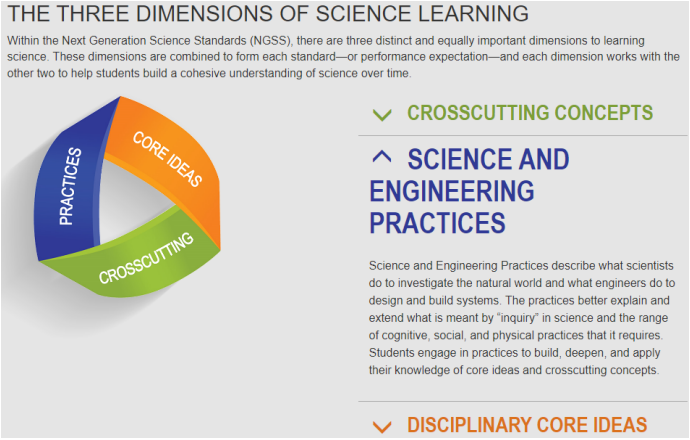

Figure 6: NGSS Science and Engineering Practices

The below practices are considered essential for all students to learn through their K-12 education.

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

You can find more specifics for each grade on the NGSS site and look at the Engineering Design standards for the appropriate grade. If you can incorporate these practices into your lessons, this is another great way to bring standards into your dome.

However, these are generally more challenging because they require active involvement from the students. You cannot simply lecture them on how to carry out an investigation. You need to guide them through an investigation to teach them the process. Maybe your dome could conduct and investigation on whether a planet is habitable or not. Have the students come up with problems and solutions and guide them through the process. This would allow you to reference the Engineering Design standard for that grade level.

Don't Recreate the Wheel (Resources)

I know this has been a lot for a short presentation. But don't despair! Educators have been making the standards work for planetariums for years. The GLPA education team has actually recently put together a document helping to identify which NGSS standards are fit for the dome and even provides some example lessons.

The Astronomy Literacy and Education Standards Handbook highlights standards at every grade level that could easily be applied to astronomy topics. The figure below shows the front page of the handbook and each of the tabs will bring you to a new section of the handbook. Each page has links that will open up more resources for you. At each grade level, you can click on the standard and it will open a document showing the full standard requirements with the evidence statements. The next page will provide example lessons or ideas. Some of these lessons are designed to take place outside the dome, but still give you an idea of which topics are best to focus on for each standard.

Please, use this document! It is here for you to take advantage of and completely free to use. We recommend downloading a copy of the slide deck, and then you can make any changes you find necessary. You could add notes to compare the NGSS standards to your home state. One of the long term goals of the education team is to create a place to store and track the state specific changes people make. This will require keeping separate copies of the slide deck for each state.

However, in the meantime, if you have any additions for the NGSS version, please pass these recommendations to the Education Chair. The current chair, Peggy, would be happy to make updates to the slide deck and to add your resources.

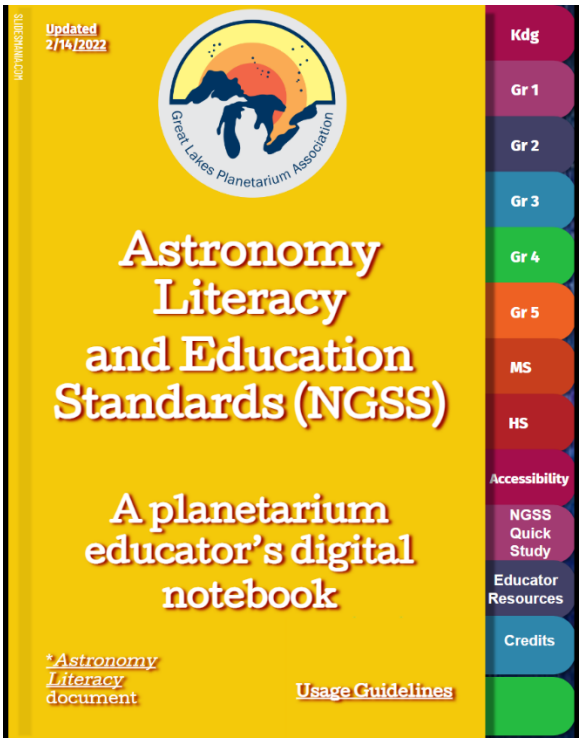

Figure 7: Front Page of the Educator's Handbook by GLPA

Another great resource for learning more about educating in the dome is the GLPA Educators Professional Learning Chat (PLC). These meetings are held via zoom on the second Tuesday of every month at 4pm EST. The Educators PLC is a way for planetarians to have dialogue regarding the practice of teaching in a planetarium. The intent is to have conversation, not a featured presenter or program. The hour may include topics like content-standard alignment in programs, presentation skills for school groups, session management with students, scheduling, current events in science relevant to planetaria, or follow up to a conference workshop or session. The goal is robust conversation all year round (monthly), not just at GLPA Conferences. If you'd like to attend, keep an eye out on facebook's Dome Dialogues or the google group Dome-L for the monthly invite.

Conclusion

Hopefully, this presentation helped you to understand more about what teachers and schools look for in their programming and how you might be able to bring those requirements into your dome. Remember, teachers are often looking for any excuse to bring their students on a wonderful field trip like heading to the planetarium. A program description that includes which standards will be included will make this much easier for them. School administrations are also much more likely to approve an excursion that has obvious value through state required standards.

Please take a look at the new Educator's handbook on the GLPA website, and if you have any comments or suggestions, pass those onto our Education Chair.

Thank you for your time, and happy teaching!

THE GLPA EDUCATION AND STANDARDS E-HANDBOOK

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The GLPA Education Committee has created a Google slide deck that operates as a resource for any planetarian or vendor. It is a synthesis of the 2015 *Astronomy Literacy: Essential Concepts for a K-12 Curriculum* document and the NGSS Standards. Included are activities, visit tips and NGSS connections for each grade level. The document will be added to and updated periodically and is available on the GLPA website to download. Users can modify their downloaded copy to fit their needs. This paper session will walk through the document and point out its uses and benefits.

Introduction or background:

In 2015 after several years of work multiple regional Planetarium Associations released a document titled, "Astronomy Literacy: Essential Concepts for a K-12 Curriculum". The Next Generation Science Standards (NGSS) had been recently released and multiple states were in the process of adopting or modifying them in some way to adopt them as the foundation for their science curriculum. This thorough, research-based document is an asset to our practice that answers why schools should teach astronomy and what the essential understandings are at each grade level K-12.

The NGSS and the Literacy document have striking similarities, as they should. We are the experts in our classrooms-domes for this branch of science. We were able to connect each of the essential understandings with an NGSS standard. However, the essential understandings had some topics in grades that didn't align with NGSS. And the Literacy Document was heavy in topics, but missing some of the science and engineering practices (SEP) and crosscutting concepts (CCC), the other 2 legs of the NGSS that are equally important as the topics.

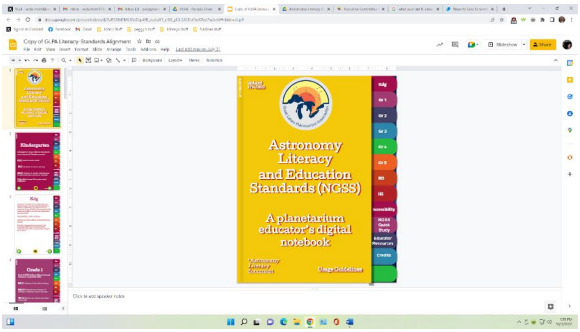
What we made:

From 2015-1019 we added specific lessons and resources shared by members. It was getting to be a large document, maybe a little cumbersome. And it was being updated often, with no end to that in sight. As the newly appointed Education Chair in 2019 with an education subcommittee, I started a project to find a way to marry the NGSS and the *Astronomy Literacy* document specific to planetaria in a simple, yet useful format. The idea of a digital resource, an E-handbook was born.

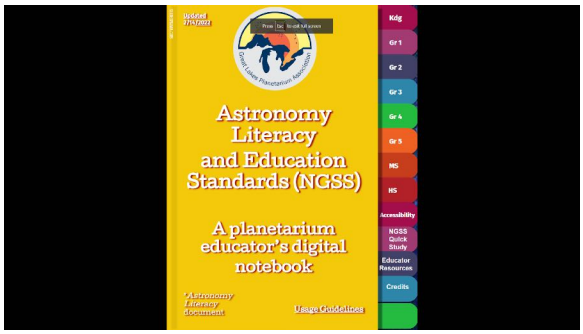
The final product is the Education and Standards E-Handbook. It is available to any planetarian from the GLPA website under the *resources* tab. It can be previewed and your own copy downloaded to use as desired.

It is not meant to be a static document that is printed and put in a binder.It is perfectly acceptable to print a page or documents if

needed for your work, but it is digital resource.



Front page of deck in edit mode



Front page of deck in present mode

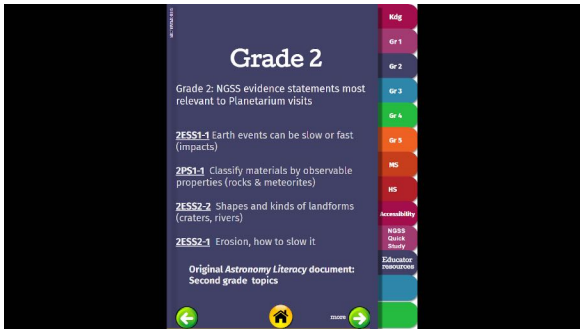
It is a living document. Changes made on the master deck become instantly available. The GLPA master deck will always have the latest update noted in top left. Likewise, a facility that downloads and shares their deck can make real time changes as needed. One can add, delete or modify the document as needed after downloading their own copy. The only exceptions are the last 2 slides, pages 25 and 26. The credits shall not be modified and the template used came from *SlidesMania*, so please leave those credits intact. This slide deck template is an information vehicle that is free to use and not intended to be sold or offered for sale.

Usage:

A user guide is available.

The notebook is a Google slide deck. Each grade level tab on the right contains relevant curricular information. Below the grade levels there are more tabs with general information relevant to all grades. The accessibility tab has a link to an entire slide deck of tips for increasing accessibility and inclusion for all visitors.

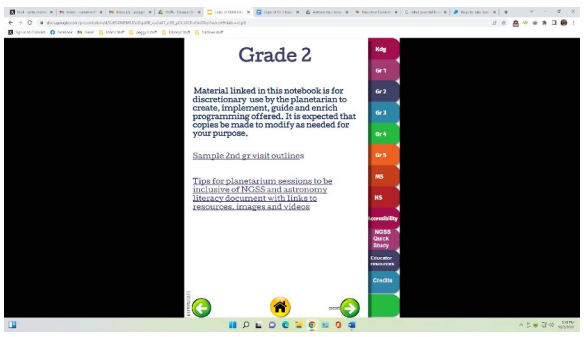
There is a plethora of information on each grade level tab. Each grade level has two separate pages accessed by the green "more" arrows at the bottom of each page.The format is the same for each grade.



Landing page for grade 2

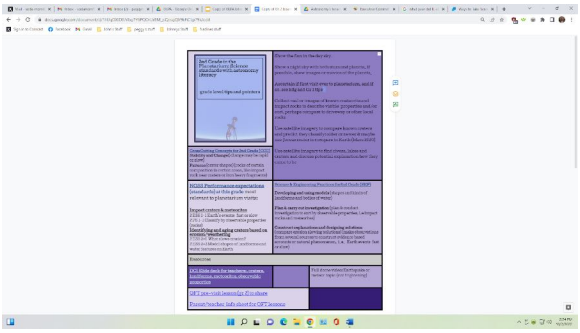
The color coded landing page has a link to the NGSS evidence statements for that specific grade most relevant to Planetarium programs. These are very useful documents to ascertain what that grade is supposed to learn and the limits, specifically what is not expected to be learned at that grade.

The second page of each grade has links to the guts…the nitty gritty details about and examples of lessons from colleagues.



Gr 2 second page

The *sample outlines* include my scope and sequence for that grade plus other planetarian's outlines. The *tips board* is a Doc with multiple links to lesson ideas and examples. This is the marriage part of the intent for this document. We can all look up and understand the standards pretty easily and we know what kids need to learn and understand, but what does it really look like on our planetarium classrooms with specific school sessions? What are some ideas for programs that will appeal to teachers and administrators expected to follow specific standards that are also essential understandings for astronomical literacy? How can we show the public what opportunities our facility offers for educational programs? How can I support my stance to administration for the programs I present? How can a vendor figure out who to market a new or proposed show? How can a producer find out exactly what grade level expectations exist for a specific topic? The handbook can help with all the above questions.



Gr 2 tips and resources board

Your downloaded E-Handbook can be modified. You can customize it by deleting parts not relevant to your programs. You can add anything that is relevant for your intended use at your specific facility. You can create multiple versions for different audiences.

Conclusion:

The GLPA Education and Standards E-Handbook is a useful tool for a planetarian or vendor to plan or create programs, but also a potential tool to share out information to visitors and potential visitors. The NGSS based performance expectation for each grade level are unpacked for quick access with links to integrating them at that grade are at your fingertips.

Acknowledgments:

Education and Standards E-handbook subcommittee members:

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Shannon Schmoll
Patty Seaton
Lisa Swaney
Sarah Weaver
Rachel Williamson


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