LSST EPO Design Research Project JTM 2017 — Working Session Presentation

LSST Education & Public Outreach Research Findings, Personas & Concept Stories March 8th, 2017



Work Session Plan

Share research & introduce personas



Walkthrough initial concept stories



JTM 2017

- Review the research findings including the personas and concept sketches
- Explore the possible opportunities highlighted in the current journeys
- Introduce Invision Platform for • Commenting & Brainstorming

LSST-specific content

MOVERS - Sclar System Inv

Topics Near Earth Objects Astroids Trane Neptunian Objects Comets

> Orbital Farameters Size clistribution Colors Light Curves

Insights Planetary Formation & Evolut Astroids coming towards Ear



Personas

Synchronous & Asynchronous Worksessions via Invision

- and feedback
- new ideas

Review concept stories to identify content opportunities and additional ideas

entory	BLINKERS — Transient Sky
	Topics
	Gravitational Lonsing
	Search for Super Novae
	Physical Properties of Gamma ray Burst Sources
	Variable Star Populations
	Data
	Orbital Parameters
	Size distribution
	Colors
	Light Curvee
	Insights
21	Exploration of the Time Dimension - Time Machine
h	Discover Exoplaneta
	New Classes of Transients



EPO deliverable ideas

Review LSST concept stories & provide additional solutions, ideas

Iterate concept stories and add

Prioritize experiences for further design



Core Team

- Align on the UX strategy moving forward by prioritizing experiences to focus on in design phase
- Draft a project plan for the design work



EPO Methodology

- 1. within each user group
- 2. Perform needs assessment research to identify/validate user needs
- 3. Establish high-level requirements based on goals and low-level requirements based on user needs, then connect them
- Develop or enhance products to meet those requirements 4.
- 5. Continuously monitor and evaluate the products for effectiveness (awareness, engagement, and knowledge/skill)
- 6. Repeat cycle: update requirements and/or products as needed

Develop personas and user stories to represent a diverse set of users

Project Approach

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	We
Kick Off Workshop & Research Participant Identification	WORKSHOP									
Stakeholder Interviews	INTERVIEWS									
Plan & Prep for Field Research	PLAN	PLAN	PLAN							
Recruiting & Scheduling ~50 participants		RECRUIT	RECRUIT							
Digital Landscape Best Practices & Inspirations		LANDSCAPE	LANDSCAPE							
Generative & Evaluative Research Remote Chicago DC Area				REMOTE RESEARCH	CHICAGO RESEARCH	DC RESEARCH				
Making Sense of Data							SYNTHESIS & ANALYSIS	SYNTHESIS & ANALYSIS		
Conceptual Models Personas, Research Themes									CONCEPTUAL MODELS	
Concept Stories									PERSONAS & SCENARIO MAPS	
Present Finding & Design Strategy Workshop										WOF



Research Sessions with Participants & Stakeholders

Educators

General Public

LeeAnn	Educator - High School	Tykesha + Kirsten	General Public
Eman	Teacher	Marialuz + Luz	General Public
Tyler	Educator - Middle School	Anna	General Public
Shana	Educator - Middle School	Martazsh	General Public
Ed Prather	Teachers & Students	Frances	General Public
Frossie Economou	General + Teachers & Students	Lisa + Christian	General Public
Haydee Domic	Teachers & Students	Starr + Leila	General Public
Brice Menard	John Hopkins	Jose	General Public
Vicky Kalogera	Northwestern	Esther & Johnathan	General Public
Raffaella Margutti	Northwestern	Mallory Fuentes Salazar	Chile EPO Communications
Michelle Paulsen	Northwestern		
Aaron M. Geller	Northwestern		

Informal Science Centers

Citizen Science

Valeria Vera Galleguillos	Chile Informal Science	Chris Lintott	Citizen Science
Lucianne Walkowicz	ISE	Alice Sheppard	Moderator
Kevin Scott	Planetarium Vendor	Emily Levesque	Citizen Science PI
Kris McCall	Cernan Earth & Space Center	Phillip Marshal	Citizen Science
Johnathan Nelson	Cernan Earth & Space Center	Citizen Science PI	
Martin Ratcliffe	Planetarium Vendor	Laura Trouille	Adler Planetarium
Nathalie Rayter	Adler	Kelly Borden	Adler Planetarium
Mark SubbaRao	ISE		
Shiloe Fontes	ISE		
Jim O'Leary	ISE Content Creator	All A	reas
Patrick Mcpike	Adler	Suzanne Jacoby	ALL
Andrew Johnston	Adler	Amanda Bauer	ALL
Adler Teen Council	Adler	Chris Smith	Chile

Research Sessions with Participants & Stakeholders















































































Activities in the Field



















Findings: Technology Themes

Mobile & Tablet Apps

Virtual & Augmented Reality

Apps are Big

Apps are big....because people are not necessarily- we've gotten away from our laptops and our desk, computer downstairs. We use our phones and our iPad. Anything that's app driven. And then it's good for on the go, and it's easier. We take the laptop places but not really anymore. It's kind of old school.

...Because iPads are more portable. They are lighter. You can still do everything that you do on a laptop.

Students go to Apps First

Students nowadays will tend to go for their apps first. And then if it's something interesting they'll go to the computer for a little bit more.

VR is Most Compelling

The VR ones were the most compelling.

When you can control where you're going, it's much more interesting. I mean the websites are cool. But when you can just review information that others found out, it's not as interesting as when you can control where you're going and see what you want to see.

VR in the Classroom

This is what they would love. (laughs). Oh, yeah, this is nice. Now is this app out already?

... I would definitely use it but I would love if our school had, financially, would pay for it... You can do a cross curriculum with every subject with this.

There's so much you could do with this. That's giving me ideas. That's definitely a project based learning tool.

Science, math, ethics, social studies, social studies and english. How everybody can partake in it.

The writing skills, how can they do background information? Science, you can talk about the different planets with the research. Math, the distance and measurement. Social studies, just knowing how to get to north, south, east, so I would definitely use this as a project based activity.

And even, I would even have the parents and the community come in to see how it was used.

Sky Guide Helps Me See the Stars

The one that I use a lot is the Sky Guide. That's the one that plays music.

When you go outside, whatever direction you're in outside, I can always see Orion. Of course it's cloudy and crummy tonight. But if I go outside of my driveway, I always know for the most part Orion's up that way.

Social Media & Realtime Events

Facebook Route to Websites

Because I'm relying on Facebook. I can't remember what site. I'm sure it's NASA overwhelmingly and I was trying to remember...

I just saw an article that NASA is releasing all of its research for public viewing. It's an interesting time. People are making themselves heard in whatever way. So I'm sure I clicked on that and ended up on the NASA website.

Social Media & Live Streaming

I've been interested in it since I was a little kid and started out very basic, just looking at the moon and stars and whatever..in the last ten years, and then definitely the last year [my interest has] grown, I think with social media and stuff.

I see a lot more stuff, and a lot more stuff's available, and now they stream live, like NASA when they do their space walks.

That stuff was never ... I mean we used to try to like listen to it, on like a scanner or something, and you couldn't hear anything, but to see them, it's amazing to me.



Design Personas

What are Design Personas?

- Personas are fictitious people who represent the archetypal qualities of your audience.
- They are derived from field research and are unique from job roles or market segments in that they surface more human and behavioral differences in how the system will be used.
- They provide targets for design and are effective for deeper user empathy throughout an organization.

Personas help us:

- Move from system thinking to human experiences
- Inspire design
- Evaluate existing plans & designs
- Maintain focus on what is important to our audiences

Persona



Warts to do a good job

Role Llybrid Cew/Admin Collaboration: Edito

"I'm not sure if I might mess this up



Nativoles at a mid-lize company roles the sclepers more possible for setting. up and maintaining their new Hadoop cluster. They II be using their single cluster as a proof of concept, but in the meanwhile Neil is spending a lot of fime reading documentation and looking for enswers and examples

He wants to do things well, and do things right. This is a big project at the beginning of his career and he is excited about the possibilities and happy their be silolowing his passion for high later

To wade through the mynac of services and open source tools, hels trying lots of things and figuring out solid works for him and the team. The know that laying a good foundation for the cluster is way to focure success and ownta to de a good job setting it up

User Needs dicar documentation

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Persona

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Role 1 ybrid Dew/Admi Cluster Single

Collaboration: Ecto

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User Needs

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EPO Personas & Good Future Stories

EDUCATORS



Elena Astronomy elective

Data for Scholars

Easy to use and understand database that supports students in authentically conducting rigorous scientific inquiry.



GENERAL PUBLIC



Lecia future scientist

Serious Fun

Mobile-first interactive experiences, videos and articles to explore the universe beyond the scope of school.



Amelia astronomy enthusiast

CITIZEN SCIENCE



Candice RESEARCHER - PI

EPO Data for Science

Accessible LSST data to support science research objectives with citizen science activities



Tanya ms science title one

Immersive Learning

Direct, hands-on experiences that capture student attention and enable exploration and knowledge building.

INFORMAL SCIENCE CENTERS

Sandra small staff planetarium

Quality Collections

Real-time open access to LSST content library & updates, supporting both show creation and interactive presentations.

Astrosnacks

Updates & informative experiences that fit a passion for astronomy into a hectic schedule.

Margaret MODERATOR

Citizen Community

Ability to help people engaged in citizen science to connect with each other, grow their knowledge and do great science.



Camila science center – chile

Purposeful Multimedia

Content that intentionally supports the design of discovery-based, hands-on, interactive experiences.



_ionel large staff planetarium

Immediate Access

New LSST data, in raw and produced formats, seamlessly integrated into content creation & projection systems.



Educator Personas



Tanya MS SCIENCE — TITLE ONE Immersive Learning



Elena ASTRONOMY ELECTIVE Data for Scholars

RESEARCH PARTICIPANTS



Shana



Tyler







LeeAnn

Post Secondary -



Vicky Kalogera Northwestern



Raffaella Margutti Northwestern



Michelle Paulsen Northwestern



Aaron M. Geller Northwestern & Adler





Frequency of Engagement with Astronomy Content

Focus on Developing General Scientific Thinking

Focus on Developing Astronomy Specific Knowledge

Utilization of Astronomy Research Databases

Time Available to Pursue Interests in Astronomy

High

Overview

For the past 18 years, Elena has been teaching high school physics and elective courses in astronomy at a public regional science school —where students take an academically rigorous test to be admitted.

Her interest in astronomy began in college when she took a few astronomy electives while pursuing a degree in physics. She then completed a Master's in science education.

When she started at her current school there was a NASA project recruiting teachers to participate and she thought it sounded fun.

Over the years, Elena has become more deeply involved in astronomy EPO programs and has built relationships with universities, observatories, scientists, and NASA. She no longer seeks out opportunities for her classes to engage in research experiences because these opportunities are always coming both to her and her school.

In her work, Elena is actively preparing her students to pursue the sciences, become scientists and even astronomers. Her students are motivated by their studies and she works to ensure they have the best learning resources and experiences available to them.

A good day for Elena is when she is learning along with her students and continuing to discover the wonders of the universe.

Low

GOOD FUTURE: Data For Scholars

Activities

- Engage external resources such as astronomers, EPO programs, and grant funded activities to support student learning
- Helping students succeed throughout the research process and prepare them to legitimate scientific work.
- Directing students to resources and databases that will support their research projects.
- Collaborating with colleagues to cross cut - eg. combining math + science lessons
- Assessing student learning by rubric and other non-testing based methods
- Project and Opportunity pipeline is primed — Evaluate and select EPO and other classroom opportunities that will be best for me, my students and the school
- Engaging in professional development experiences where I am free to concentrate on science learning and new teaching and learning experiences

Current Resources

Star Walk - let kids download this
Zooniverse
Friends at the Astronomical Society in Chicago
NASA,
Goddard, Naval Research Lab
Universities & past astronomy students

Challenges & Delights

CHALLENGES

- For some students their phone is their only internet access at home
- Budget limitations and a need to impact as many students as possible
- Depending on the ordering of classes, it is sometime not possible to teach astrophysics if the students have not yet had the prerequisite math and physics classes
- Managing all to logistics and minutiae involved in bringing EPO programs into my school and classroom — everything form consent forms to background checks and permissions
- Standardized testing not a focus, but still can constrain choice activities

DELIGHTS

- Sharing my love of astronomy with my students.
- Learning alongside my students when we engage in EPO projects together
- Having the latitude and trust of my school to do the activities I think will best teach my students
- Excited by opportunities presented in Next Generation Science Standards for great teaching
- Preparing students to study science in college through authentic research experiences















Real Scientist Experiences

We try to keep it as close to experiences that they would do in a scientific exposure.

Some of them give their presentations at professional meetings, like the Lunar and Planetary Society. Or the Astronomical Society, has a section for children, for students...

The final paper, I usually use the Astrophysical papers, which is a professional format for that to be given in. So we do this multiple times so they get practice having to give a presentation all throughout the year.

Accessible Databases Also For Citizen Science

A major thing the LSST could do is to make the databases as good as Sloan's but more accessible with some guidelines as exactly how to navigate them, how to find the spectrum of the object, for example.

Use Databases in Research

My goal, and one of the goals that you might think for high schools — especially for the senior research, is to have them use the databases in their research.

That would be a main goal and objective for the classroom, and the other thing is to be able to share that data with any class that comes in at different levels, like elementary school and the high school.

Becoming Intrigued by Astronomy

Solar system- stellar evolution, galaxies, cosmology, we work with the equations and we look at the possibilities of different things. The juniors that were in their first semester tend to focus mostly on the solar system.

In their projects, but if they take the whole year they can opt to take one semester, or two semesters for astronomy. Usually by the time they get to second semester they're so intrigued with galaxies and cosmology they sometimes change their mind, which is OK. They don't have to really commit to a project until their senior year.

Topics For Databases

Galaxies, the visual, looking at them in a visual sense, versus an infrared sense and a radio, multi-spectral, so if we wanted to look at, let's say Andromeda, which we wouldn't, but look at it in a multi-spectral level.

Learning how to read. How to analyze.

Those galaxies in that particular type of a spectrum would be a big one.

We've done some trying to find the Hubble constant, trying to verify.

Hubble constant using quasars, distant quasars. So measuring is important there.And that's why we need the scale.

That kind of thing. Some of them have looked at galaxies in detail in the multispectral which helps, and that's where they need to do the image enhancement, so they can see little things and big things.

Learning to Use Databases

When my kids used High Rise- the Mars database...they had to learn what each of those terms were or when they're trying to go through a galaxy, a radio galaxy, and understand what each of those terms are. Some of them were self-explanatory. Others were not.

So I think definition of terms, a tutorial, what you need. Maybe even some sample questions like, "What are you looking for?" Are you looking for the brightness of the galaxy? Then you need to know this, and this tells you. Are you looking for how to enhance the image?

You need to know this, and these are the terms we're going to go through.

I think that's very important.

And kids as opposed to someone from my generation, if they're on a database or they're on a query they don't care. They're not afraid to put in a number and see what happens. They're very comfortable with computers and they're very comfortable with databases.

So don't be afraid, as long as it doesn't mess up the system to put in something that you think might be kind of mundane at first.







To prepare her students to select research topics for their senior projects, Elena sends her Astronomy class a collection of objects in the new LSST database (via Google Classroom). The students' first assignment is to figure out what they are looking at and why the collection might be considered important.





Zoe, a student in Elena's class, clicks the first link and launches the LSST Database. As she views the collection of objects, she starts to make sense of what she sees by rolling over definitions, adjusting data sliders to see changes, and watching a short tutorial.





Zoe records what she learns about each object in her science journal and shares her findings which her classmates, leading to a heated discussion. Soon all the students are making cases and arguing for why this set of objects could be considered important.





For her research project, Zoe decides to focus on plotting the orbits of a number of astroids in the Kuiper Belt and identify which ones will eventually collide. In the data portal, Zoe sees that an LSST scientist is working in this area and she reads a draft of a new research paper.





As she continues to work, Zoe discovers she can make comparisons of objects and their orbits directly in the database and begins to create a map of her findings in the tile viewer.







Working with the new LSST database and the mentorship of Elena, Zoe is able to predict new collisions in the Kuiper belt. She prepares an end of the year presentation to share with her class and submits her paper to the local branch of the Astronomical Society.



Tanya TEACHER | MIDDLE SCHOOL TITLE ONE



Frequency of Engagement with Astronomy Content

Focus on Developing General Scientific Thinking

Focus on Developing Astronomy Specific Knowledge

Utilization of Astronomy Research Databases

Time Available to Pursue Interests in Astronomy

Overview

Tanya teaches science at a Title C middle school outside of Baltimo She has spent the past three year her current school, and has taugh for a total of 12 years. She teaches three levels of science classes regular and gifted to 6th, 7th and 8th grade students.

Tanya's area of specialization is in teaching biology, but as a middle school science teacher, she also teaches her students topics in chemistry, physics, geology, engineering and a little astronomy.

Her choices in curriculum materials are highly influenced by state, county, district and school requirements and by Next Generation Science Standards and Core Curriculum

Tanya's students face many challenges in life before arriving in her classroom. She works hard to inspire and empower her students by understanding what is important to them and connecting her students' interests with the curriculum and the school community.

High

GOOD FUTURE: Immersive Learning

Activities

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ESL,

- Inventing and creating new ways to connect with, engage and motivate my students.
- Focus on addressing student "learning styles" — primarily focused on hands on direct learning,
- Finding materials without abstraction, complex vocabulary, long lessons
- Motivating students to engage in textbook-driven instruction and a set of content resources approved and provided by the school, district, state
- Ensuring students are successful on high stakes tests
- Using social media such as Pinterest to find classroom ideas and and twitter to connect with other teachers
 - Identifying activities that can act as a thread and connect to my students over time?
 - Considering if a new activity will work in my classroom? I would like to see it in use before using it.

Current Resources

- Pinterest
- Science Spot
- Textbooks with websites
- Discovery Techbook online labs
- Brain Pop
- NASA
- The Universe Today
- Twitter Teacher Hashtag

Challenges & Delights

CHALLENGES

- Scores drive funding. Student test score drive school funding, opportunities for resources and even if school will stay open.
- Math skills needed. Science teaching can require supplemental teaching of relevant math skills such as graphing, fractions and rounding.
- Not always experts. Do not necessarily have domain expertise in Astronomy or even science more generally
- Reduced choice. State, county, department heads, standards and testing requirements all drive curriculum choices
- Challenge to maintain student engagement. Teachers work hard to connect science learning to students everyday lived experience — e.g. focus on future employment, connecting to local environment, relevant audiences

DELIGHTS

- When I find activities that spark my students interests and I see them truly engage in science learning
- When students really engage and create amazing work that reflects their authentic selves











Reading with a Purpose

I'm much more likely to pick something that's a drag and drop or interactive over them sitting there reading an article because kids get bored really easily by doing that. If it's something where they're reading while doing something, they're much more engaged.

I have found if you them to learn something by reading...it's a weird way to phrase it, but force them into reading, saying like, "In order to be able to do this, you have to have the knowledge from that reading to be able to do it, they're much more likely to read it.

Pictures, Videos, Hands-On

The kids are interested in [astronomy] ... all they remember is the solar system, they want to know more, but you just got to know how to get their attention.

I think it's with the pictures and short videos and hands on things.

How Can I Catch Your Attention

How can I catch your attention, or what's going on today, because my goal is to focus on real world activities.

I always go to the internet first.

And Brain Pop, especially, because they're kids. They like cartoons. How can a cartoon capture them because they're drawn to cartoons.

And I'll ask them, "So, what do you know about stars? What do you want to know?" It's called a KWL chart. What do you know? What do you want to know, for right now? And then, some will say, "They're big, they're in the sky."

You do other activities to compare and contrast them, and then we do reading because right now informational text is very important on the test and for comprehension skills. And so we will go into that.

I would probably show a video.

For me, I'm a hands on person. So, I tend to try to do labs or demonstrations at least four times out of the week

VR in the Classroom

This is what they would love. (laughs). Oh, yeah, this is nice. Now is this app out already?

... I would definitely use it but I would love if our school had, financially, would pay for it... You can do a cross curriculum with every subject with this.

There's so much you could do with this. That's giving me ideas. That's definitely a project based learning tool.

Science, math, ethics, social studies, social studies and english. How everybody can partake in it.

The writing skills, how can they do background information? Science, you can talk about the different planets with the research. Math, the distance and measurement. Social studies, just knowing how to get to north, south, east, so I would definitely use this as a project based activity.

And even, I would even have the parents and the community come in to see how it was used.

Low Turn Out Science Fair

Does your school do science fairs and things like that?

We did my first year there...Honestly, when I did the first science fair, it had a low turn out, and that was the first time ever and it's just ... I hate to keep blaming the parents, laziness. But, we do not get a lot of parent participation. And it may be because income based, but I always charge the parents, use the dollar store or I can help you or we have things here, either or. I'm in of a poor ward and the priority is not education. So, the more we can do for them, is better. That's why we try to do so many hands on and field trips.

Ideal Student Interactions

Ideally, if they're interacting during an activity, they're learning from each other. Instead of asking me a question, they ask each other and work together to find answers. That's building on critical thinking skills, building on collaboration, and understanding that not everybody knows the answer. I don't have all the answers and that's okay.





anya TEACHER | MIDDLE SCHOOL TITLE ONE



GOOD FUTURE: Immersive Learning

Tanya is always looking for fun learning activities to engage her students. She recently came across the LSST VR space app while browsing Pinterest. With the app students navigate and map the Milky Way while learning middle school physics. Perfect!



lanya TEACHER | MIDDLE SCHOOL TITLE ONE



She is excited to see how well the activity fits with her class and students. The language is accessible, the student training videos are short, the activities are authentic and cool, and it maps to NGSS. She can also print the student activity handouts

GOOD FUTURE: Immersive Learning



anya TEACHER | MIDDLE SCHOOL TITLE ONE



Tanya signs up for the LSST Virtual Reality Experience and two weeks later a box arrives at her school with simple VR headsets for her classroom — all ready to go. She is as excited as her students to start exploring the Milky Way.

GOOD FUTURE: Immersive Learning



anya TEACHER | MIDDLE SCHOOL TITLE ONE



Tanya also receives a tablet as part of the LSST Virtual Reality Experience. With the tablet, she can see what the students are seeing in real-time. She lets her kids explore and then guides her class on a shared adventure that is truly out of this world

GOOD FUTURE: Immersive Learning



LSST Journey Starting Points

LSST Multi-Media Desktop Mobile Data to Dome Social Media

LSST Nightly Update Social Media Portal Mobile Data to Dome

LSST Hands-On VR Mobile Mobile + Classroom

Schools & Students

General Public

LSST Tile Viewer

Desktop Mobile



DATA FOR SCHOLARS

LSST Object Pages & Database

> Desktop Mobile

LSST



IMMERSIVE LEARNING

Zooniverse Projects

Desktop

Mobile

Mobile + Classroom

Informal Science Centers

Citizen Science



General Public Personas



Amelia ASTRONOMY ENTHUSIAST Astrosnacks

RESEARCH PARTICIPANTS



Lecia

Serious Fun

FUTURE SCIENTIST

Lisa & Christian (16)



Starr & Laila (13)

Chicago





an.

Anna

Frances

Demographics

- 4 families with teens traditionally underrepresented groups in STEM: women, African Americans, Hispanics, American Indians and Alaskan Natives
- 2 bilingual family with middle school or high school student who enjoys science
- 2 persons 20s-30s tech savvy, active on social media
- 2 persons 40-60s

Astronomy Engagement

(4 sessions) **High-engagement** -- for example: amateur astronomers (goes to star gazing parties, belongs to a community or club related to astronomy, shares interest in astronomy with others)

(4 sessions) **Some-engagement** -- for example: armchair astronomers (follows space news sites, watches science-related programming, follows science and astronomy content on social media, visits planetariums and science centers)

(2 sessions) **Open to engagement** -- fond associations with astronomy or science generally, often from past positive experience, perhaps some occasional engagement with major headlines

DC Area



Martazsh







Esther & John (13)

Marialuz & Luz

Jose

Tykesha + Kirsten

Lecia GENERAL PUBLIC | TEEN | FUTURE SCIENTIST



Frequency of Engagement with Astronomy Content

Focus on Developing General Scientific Thinking Focus on Developing Content Specific Knowledge Utilization of Astronomy Research Databases Time Available to Pursue Interests in Astronomy

Overview

When Lecia was in the third grade, she organized a trip to the planetarium for her whole class. That was five years ago, but Lecia continues to have a passionate interest in science and astronomy.

At school, Lecia sometimes feels that she is not learning enough in her classes. It seems to her that there is a lot of boring homework and just occasionally there is work that really captures her imagination and intellect.

She's been involved in an after school science club for girls for the past few years and has strong relationships with other girls who are also interested in science.

Lecia is proud of her interests and also knows that sometimes they separate her from her friends, who aren't always "smart enough" to know what she's talking about.

Her parents are invested in Lecia having broad experiences and taking advantage of many types of learning experiences. It is important to them that Lecia continues to be interested in science and math and they seek out opportunities for her within their means.

Low

High

GOOD FUTURE: Serious Fun

Activities

- Attend after school program for girls interested in science
- Research astronomy topics I find personally interesting
- Browse my NASA app and Instagram for interesting content
- Play videos games and experiences VR
- Watch astronomy tv shows with dad
- Finding ways to interest my friends in science and astronomy

Current Resources

- Star Globe Augmented Reality Star App
- YouTube Videos
- Instagram profile called Science
- Snapchat
- Mobile Smart Phone
- iPad Tablet
- Computer Usually only for homework
- Google
- Google Images
- NASA App | Website
- Reddit
- Kerbal Space

Challenges & Delights

CHALLENGES

- It's been years since I was at the planetarium. It was cool, but I don't remember much.
- Finding astronomy experiences that I can share with her friends that they will think are interesting or cool.
- Being able to pursue my interest in astronomy with content at the right level, not too simple and not too technical.
- Being bored with the astronomy content that I learn in school.
- Having my interests taken seriously

DELIGHTS

- Sharing my interest with my parents having a shared topic to be curious about together
- Imagining a future that might include me traveling to space
- Experiencing the world beyond earth and considering my place in the universe
- Seeing beautiful images and inspiring videos
- Seeing myself as part of the practice of science







My Topics versus School Topics

When I do it for class, it's mostly about things that we've learned. It's usually just about the Earth. It's only Earth related.

When I do it by myself, it's more of the universe, galaxies, black holes, super novas, things like that. But for class more like Earth related. It's about how the Earth fits into the universe. But when I do it for myself, it's more about just the universe itself and other planets and things like that.

Browsing in My Spare Time

Um, so I usually just like when I'm not doing anything, or don't have anything to do, I'll, um, like look at the apps, um, like in my free time and stuff. And just like browse through the headlines and see what's going on. And, um, uh, occasionally at night I'll like go outside and I'll look, um, at the stars and stuff ...

Good for Learning & Fun

How important is it to you that it's realistic, like it matches to the true understanding of science that we have versus fun.

I definitely think it's important that's accurate because if it's not, it won't give you the right information. And if it doesn't give you the right information, you're going to be wrong about your knowledge on that topic.

So, I definitely think it should contain a lot of information, but the correct information.

But then when you look at that, do you see more of a game?

I see a game, but I see a game for creativity and exploration. So, it's good in both ways, good for learning and good for fun.

Always Learning & Growing

Mom: If her homework gets boring then she gets into something else and it's always helpful to have that something else be something to learn and grow from though.

So, that's why I don't beat her up too bad because she is still learning and growing from it. It's just not on task.

VR - When You Can Control Where You're Going It's Much **More Interesting**

The VR ones were the most compelling.

When you can control where you're going, it's much more interesting. I mean the websites are cool. But when you can just review information that others found out, it's not as interesting as when you can control where you're going and see what you want to see.

Having Special Interests In **Stuff That's Really Hard to** Understand

I like the type of stuff that is like really hard to understand. Like black holes because they're invisible. And things that are misunderstood ... 'cause you know people will think that black holes just appear out of nowhere but usually they happen when stars explode and die.

Gravity pools a lot and then eventually it forms and they're not actually black which a lot of people think they are.

So I like black holes and galaxies ... basically like really big stuff that people don't understand fully. Because the galaxy's really, really, really, big, can fit like a million, billion planets in it and that's basically what I like to learn about, and planets that could potentially have life on them.





Lecia General Public | TEEN | FUTURE SCIENTIST



Today at school, Lecia did a super interesting class activity where she explored objects discovered by the LSST Telescope in virtual reality. She picked her favorite planets, stars and asteroids and saved them in her own collection.



Lecia General Public | TEEN | FUTURE SCIENTIST



When she gets home, Lecia is still very curious about the stars and planet systems she saw at school. Using her own phone, Lecia downloads the LSST Mobile App and uses her Google Classroom log in to take another look at the objects she saved.



Lecia GENERAL PUBLIC | TEEN | FUTURE SCIENTIST



Lecia discovers she can learn more about the objects she favorited in class. She checks out each of her favorite objects and then looks at asteroids with crazy orbits in the tile viewer.



LECIA GENERAL PUBLIC | TEEN | FUTURE SCIENTIST



In the tile viewer, Lecia also sees all the new objects LSST has observed that moved or blinked in the past 24 hours—it's amazing how much is discovered in just a day. She learns that scientists are asking for help to classify these new discoveries. With a single click Lecia is following classification steps and helping real scientists.



Lecia GENERAL PUBLIC | TEEN | FUTURE SCIENTIST



While classifying, Lecia decides to learn more about the light curves she is working with. She watches the linked video "What is a Blinking Light Curve and Why Should You Care?!?," Smiling, she looks up from the video and realizes it's time to do her homework. She sneaks in a final video"LSST Sees Exoplanets While We Sleep", and then closed her app, for now.



Amelia GENERAL PUBLIC | ASTRONOMY ENTHUSIAST



Frequency of Engagement with Astronomy Content

Focus on Developing General Scientific Thinking

Focus on Developing Content Specific Knowledge

Utilization of Astronomy Research Databases

Time Available to Pursue Interests in Astronomy

Overview

When Amelia was growing up, her father had a telescope and loved to spend time outside showing his children the stars and planets of the night sky.

Amelia's interest in astronomy re-emerged when her children started learning about the solar system in grade school. She realized it was a passion she shared with one of her children and over the years they have continued to enjoy the night sky, tv shows and videos about astronomy, new discoveries and more recently astronomy apps and simulations.

As Amelia's kids have become teenagers, it's important to her to connect with them around shared interests and keep active their interests in science and astronomy.

Often times they are learning together, sharing links and thoughts via texts, and exploring questions they are curious about.

Current Resources

Facebook App Instagram NASA App Astronomy Picture of the Day App Sky Guide App — Augmented Reality Star Viewer Fireball App — notifies upcoming comets and meteor showers Space News App

YouTube

High

Low

GOOD FUTURE: Astrosnacks!

Activities

- Watch live videos of space walks via Facebook
- Planning and taking small trips to explore my interests — such as driving out into the country to see a meteor shower
- Researching questions I am curious about, such as why and how Pluto was not deemed a planet.
- At this point, I am explore astronomy with my kids outside of the school spectrum.
- Browsing social media and finding something that peaks my interest. Continuing to explore and research from there
- Using Astronomy as an opportunity to broaden my kids' perspective on the world, help the kids have a sense of perspective and scale — both significant and insignificant in the bigger picture
- Looking for enjoyable activities to enrich my children's lives and broaden their opportunities

Challenges & Delights

CHALLENGES

- I am very busy. and I want to use my limited free time on activities that are valuable, entertaining and not too demanding.
- Finding experiences such as apps where there is always new content that keeps me interested
- Continuing to deepen my interests in astronomy without engaging in math and numbers

DELIGHTS

- Keeping up with my favorite astronomy topics — Saturn, astronauts, Aurora Borealis.
- Reading something and having a visual as well so I can imagine more and get the whole picture.
- Feeling relaxed when looking at the astronomy picture of the day
- Finding activities that my teenagers authentically enjoy doing with me
- Excited to learn that I could be a citizen scientist and help scientists with their work.



An Understandable Database **Object Page is Validating**

[From Galaxy Zoo] there is the ability to actually go to database where all of these pictures come from, the Sloan Digital Sky Survey....

Anna: That's so cool.

Often astronomers would be looking at this.

Anna: I'd like to see it too.

Yeah?

Anna: If I'm a like a citizen scientist. I should have rights to that, right?...It validates me.

I don't know what any of this means. (Laughter) So without knowing what that means. I want to be there I want to have access, but I also want to know what I'm doing.

I would very easily be like, okay that was fun next. But I would like to be able to click and maybe like a pop up or something.

Or maybe even like um, a version of this for the citizen scientist, not necessarily the actual astronomer...

I would want something that would encourage me to keep researching and to keep reading more not something that like shuts me down like, "You're so stupid."

Social Media & Live Streaming

I've been interested in it since I was a little kid and started out very basic, just looking at the moon and stars and whatever..in the last ten years, and then definitely the last year [my interest has] grown, I think with social media and stuff.

I see a lot more stuff, and a lot more stuff's available, and now they stream live, like NASA when they do their space walks.

That stuff was never ... I mean we used to try to like listen to it. on like a scanner or something, and you couldn't hear anything, but to see them, it's amazing to me.

I do this on my own time

I mean anytime you have hands on, you are going to get more people. Because that's how you learn. That's how we learn, is hands on visual and just ... It doesn't feel like work. Its fun. That's what I mean about the podcast. It had to be fun. You have to be interested in it in some way or form. Especially because you are doing this on your own time. This is not required to do. You doing this on your own time so you want it to be fun. Yeah. I like that. I like that. I like the whole concept of it. I could see us doing that for sure.

Challenge My Kids' Minds

When my children were born and you know you have to be thoughtful about what you want for them - Astronomy was part of a bigger commitment to exposure them to nature and for them to have an understanding of how small and big they are at the same time...

To challenge their minds because I think specifically with astronomy is the understanding that they're not the center of the Earth. There are so many different realities and I think in terms of building their character and their understanding of what their responsibilities as a human being, I think is a huge part to grasp that this is not just it - your neighbor is not, your house is not just it, your neighbor, your planet is not just it.

Engaging Experiences

I like new. I like exciting. I like something that is helping us grow... And I like games. That's another thing I like. Games. Interacting. Anything that interactive. It just makes me want to keep doing it or try to figure it out.

Organically Growing My Knowledge

I've probably come a long way in the last year and a half, as I say we're just pretty basic.

Go look outside, look at stuff and whatever. And now I know about black holes and dying stars and the different stages of stars, and that kind of stuff...

It's not one of those subjects where you can just sit down and read the book and go, oh. You have to process and process and process.

If you watch the, the "Cosmos" series, you can't just sit down and dah, dah, dah, watch it. You just have to process it as you go.






Amelia is always on the look out for space-related shows on TV or YouTube to watch with her daughter. While browsing Facebook, she sees a special about the new LSST Telescope. She texts her daughter the link and they plan to watch it after dinner.



When the special ends, a link appears for the LSST VR experience. They are excited to try it. Amelia's daughter downloads the VR app to her phone and gets their viewer. Taking turns, they tour LSST's new discoveries and save locations to share with each other.



Amelia loves landing on asteroids and riding their newly discovered orbits. As she zooms through space, planets and their names fly by. Amelia is pleased to realize she now has a physical sense of how far away planets are from each other. She saves her new favorite astroid into her collection.



A few days later, Amelia is notified of updates to the asteroid data for 433 Eros in the LSST app. She is delighted to know what is happening with her new favorite astroid, taking a moment to escape her current realm of busy work, kids and chores.

LSST Journey Starting Points

LSST Multi-Media Desktop Mobile Data to Dome Social Media





Mobile + Classroom

ASTROSNACKS

LSST Nightly Update Social Media Portal Mobile Data to Dome

Schools & Students

General Public

LSST Tile Viewer Desktop Mobile

SERIOUS FUN

LSST Zooniverse Projects

Desktop

Mobile

Mobile + Classroom

LSST Object Pages & Database

> Desktop Mobile

Informal Science Centers

Citizen Science



Informal Science Center Content Creator Personas





Sandra SMALL STAFF PLANETARIUM Quality Collections

Camila **CHILEAN SCIENCE CENTER** Purposeful Multimedia

Planetariums

RESEARCH PARTICIPANTS



Patrick Mcpike Adler



Andrew Johnston Adler



Adler Youth Council Adler



Nathalie Rayter Adler



Lionel LARGE STAFF PLANETARIUM Immediate Access



Kris McCall Cernan



Johnathan Nelson Cernan

Science Centers -



Valeria Vera Galleguillos Museo Interactivo Mirador



Sandra CONTENT CREATOR | SMALL-STAFF PLANETARIUM



Frequency of Engagement with Astronomy Content

Focus on Developing General Scientific Thinking

Focus on Developing Content Specific Knowledge

Utilization of Astronomy Research Databases

Time Available to Pursue Interests in Astronomy

Overview

Sandra is the director of a small planetarium built in the 1960s. Both Sandra and her co-worker Jim starte at the planetarium this past year, inheriting declining attendance and a new, but uncommon in America, digital projection system from the previous crew.

Sandra and Jim have a great deal of experience working in larger planetariums in informal science centers and are delighted to have the challenge of building a new program from the ground up.

They see the planetarium as a unique venue where people can experience the vastness of the universe and leave the dome changed and inspired.

High

Activities

	٠	Establishing new approaches to addressing
ed		current events and new discoveries in
		astronomy and being able to interpret them
		for visitors

- · Creating a collection of new and relevant clips and models that can be used to address the needs and interests of a wide variety of audiences including k-12 classes, the general public, and students of the college where the planetarium is situated
 - Becoming familiar with their planetarium software and starting to create new shows and programs of a quality they previously produced at larger science centers
 - Identify astronomers and astronomy resources to work with in the small-staff planetarium context
 - Conduct outreach to the community to promote shows and new programs and grow the planetarium's audience
 - Write grants and find resources to update the exhibit area outside the planetarium
 - Browsing content libraries from the ESO and NASA to find content they can use in the planetarium
 - Being in front of the audience describing things, talking about things, hearing and answering questions, flying through the universe and sharing relevant and amazing visuals

Challenges & Delights

CHALLENGES

- Building an audience for a small planetarium that has had declining attendance for 10 years.
- Inheriting a digital planetarium system that lacks the large community of content creators available on some systems such as Digistar and Sky-Skan
- Access to high quality, free and affordable content that they can use in their live interactive shows in the dome
- Unsure when and how their 3D sky simulation is updated and how it might include LSST updates in the future
- Creating a narrative context for media clips and models to help visitors connect personally with scientific discoveries

DELIGHTS

- After working in a large science center, having the challenge of building a planetarium program from the ground up
- Creating content and shows that connect with visitors, that create a fun environment where people are inspired and learning
- Being able share a love and passion for astronomy with visitors of all ages









Sancia content creator. |. SMALL-STAFF PLANETARIUM

Very Useful Full Dome Clips

Though there is a lot of free content out there from NASA, from ESO, from lots of places that essentially what they do is they'll put together just these fulldome, some of them are short, some of them are longer-

Anywhere from 15 seconds to five minute fulldome clips. Some of them are narrated, some of them are just the clips, and we have control over ... We can drop out soundtracks, we can put soundtracks on top of it.

But essentially what it lets us do is if someone asks me in the planetarium what is a black hole?

I can put a full pre-rendered clip on the dome that's kind of spiraling in towards the black hole, showing something cool. You can think of it them kind of like YouTube videos [formatted for the full domel.

Creating Impactful Visuals

The transformation from a 2D sky to a 3D sky, seeing that happen is another impactful moment.

We have been teaching and doing things in the planetarium long enough that we know how to these impactful places in a program.

And try to get these good visuals in front of people, but the more good visuals we have, the more we can ...

The more of those moments you've got in the show, the better your show is gonna be.

And the more kids are gonna learn and the happier they're gonna be, so it's a win-win all around.

Content Catalog & Metadata

So these nice big expansive free libraries, NASA is obviously big.

Just NASA in general has model libraries, they have image libraries, and everything NASA is public domain. So we can use anything from NASA essentially. ESO is another great source of those kinds of things. Those are big places we look for online.

What sort of expectations do you have as far as information that comes with the clip?

In some cases the more the merrier. You may not use or need all the details — but it helps to be able to educate yourself.

Knowing where the info comes from is important. And even if it isn't necessarily links to how is the data gathered?

Being able to talk ... And again things like you know, how big is the telescope? Where is it located? How is the data captured? What are they doing with the data? This is just one small sample — What group is responsible? What was the purpose of this? What was the goal? What was learned from this? All those things are, are useful to know.

So LSST provides us with a whole new catalog of small bodies in the solar system.

We go from one little rat ball to a giant rat ball of stuff and so ... But being able to have some background to go with it, and even if it's just links to things that would help us better.

Nonexistent Community Library

Super MediaGlobe II, does it come with a content library?

It came with a few very small things.

One of the challenges ... so there's the MediaGlobe Users Group, there's a Digistar Users Group, there's the Digital Academy, I think is what, sort of what Skyscan calls their sharing group.

And those communities, the people who have Skyscan and the people who have Digistar, they do a lot of ... They'll do a lot of sharing. I don't know how much sharing there is among Skyscan people.

But the thing is that somebody will create a really cool model demonstration of phases of the Moon and they can post that on a library website and other people can grab it, and so there's a lot of back and forth. And so rather than reinventing the wheel, you might go to the library, grab something, modify it to make you happy and you're good to go.

The MediaGlobe user community library is pretty much nonexistent.

Organize Content to Show Live

We both like to be in front of the audience to describe things, to talk about things, to see and answer questions, raised hands, things like that.

So pretty simple organization structure from this aspect. You've got movies, sound, images, objects, slideshows, things to work with here. And all of these libraries are things that we can add from computers.

Images & 3D Model Updates

We have real pictures of Pluto now, which is helpful.

For a long time, there was this fuzzy, gosh-awful, pixelated, it looked like a disco ball or a golf ball. For the longest time that was the best picture.

And then after a while, then there was sort of a colorized version of that, (laughs) but it was still large square blocks.

So now it's funny because you show this is what we thought Pluto looked like. This is the best image we had of Pluto, and then you see the real picture of Pluto. Wow!

Creating Content That Addresses School Standards

Right now we're focused on covering all the content areas that are core to the standards, to schools, to different grades that teachers can, that if it's a sixth grade social studies class they can look at the planetarium and say, "Oh, there's something here that would kind of reflect and match something that, that we talked about in the classroom."

In a couple of years, if we're talking a couple years down the road, I would like to have full coverage -

If any teacher called me on the phone, I could say, "Yeah, we can ... There's something we can talk about that matches what you guys want to talk about."

That's pretty huge and having teachers know that we can cover that as well so that they can be confident in being able to call in and and find something s pretty key.





Sandra CONTENT CREATOR. |. SMALL-STAFF PLANETARIUM



Sandra loves sharing what is happening right now in Astronomy with the many students that come to her planetarium. Her go-to resource is the LSST Daily Digest email—a daily recap of the most interesting findings, media clips and statistics from LSST.

GOOD FUTURE: Quality Collections



Sandra content creator. |. SMALL-STAFF PLANETARIUM



When Sandra sees a topic that is perfect for an upcoming show for 6th grade students, she jumps into the multimedia library on the LSST Mobile Portal to view new full-dome clips, helpful science questions ,and more detailed information.

GOOD FUTURE: Quality Collections

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Sandra content creator. |. SMALL-STAFF PLANETARIUM



GOOD FUTURE: Quality Collections

Returning to her computer, Sandra sees the clips she has selected are already downloaded to her planetarium's content library. She begins preparing for a fantastic Q&A discussion with students attending tomorrow's show, complete with LSST updates and compelling new clips.



Camila CONTENT CREATOR | CHILEAN SCIENCE CENTER



Frequency of Engagement with Astronomy Content

Focus on Developing General Scientific Thinking

Focus on Developing Content Specific Knowledge

Utilization of Astronomy Research Databases

Time Available to Pursue Interests in Astronomy

Low

Overview

Camila has worked for 20 years in the informal education. She started in cultural museums and then transitioned to a science center nice years ago.

She doesn't have a formal education in science, but over the years has acquired expertise in informal education practices and exhibit design. She is also active in teacher training and outreach beyond the science center.

As a content creator at the science center, Camila's work is guided by a specific methodology that incorporates three aspects of the visitor experience: fun, interactive, and self-exploratory

She works with a team to guide concepts for new exhibits through a creative design, prototype and test process that ensures the new experiences will be inspiring and engaging to visitors.

While Camila is engaging in best practices to science centers around the world, she is also specifically excited about the opportunities to contribute to expanding the learning opportunities for children in Chile and raising awareness with the public of the significant scientific contributions Chile makes to the world in the area of astronomy.

Activities

- Align with school curriculum as more than half of the 400,000 visitors each year are from schools
- Design exhibits that support people in inquiry, self-learning and personalized discovery
- Identifying key questions that activate visitors to become more curious, engage in exhibits and want to learn more
- Prioritization of exhibits is based public interests and what is the best for the Chile
- Engage EPO programs to discuss new content and how it might be used in the museum context.
- Identify and collaborate with scientists, educators, designers and fabricators to create new exhibits that delight, inspire and engage visitors
- Developing content scripts that help guide the exhibit design and link to educational curriculum
- Creating exhibits that are self-explanatory to visitors
- Reviewing practices at other science museums such as the Exploratorium to find inspiration and useful methodologies

Challenges & Delights

CHALLENGES

- Make exhibits as analog/tangible as possible—as opposed to digital. They always try to find a way to encourage physical interaction to engage the audience — this can be especially difficult with astronomy content
- Create immersive contexts for digital experiences when necessary
- Connect the exhibit experiences directly with people's life experiences so that new ideas can be both awe inspiring and relatable
- Creating context for images and other multimedia assets that inspire people to explore, question, and engage in the museum context
- Managing costs and finding funding for new exhibits

DELIGHTS

- Creating richer experiences for children than what they would find in the classroom
- Inform and instill a sense of national pride in the Chilean contribution to astronomy and scientific discovery
- Create exhibits that enable visitors to experiment and experience curiosity, wonder and ah-ha moments

















Questions Activate Visitors

By the museum being self-exploratory, it allows people to live experiences, and connect them with their prior learning. We have revealed on our proposals the value of the question. The question is right on there, on the module, and people can read them, and in that way, that question that approaches the scientific phenomenon of the module is the question that activates the visitor in some cognitive way, so that they can connect it with what they know about the phenomenon, or creates a sort of cognitive conflict.

That way, they'll try and find an answer. In that sense, we consider ourselves a complement because here, we put abilities at play, which normally scientific thinking, which normally wouldn't occur in a classroom.

Enabling **Self-Exploratory Experiences**

The content is very important because since the modules are self-exploratory, they require very good instructions, they require a text about the phenomenon so that people can have a more detailed experience on what they experienced.

And it requires these key questions to activate them, so that they can ask themselves more questions, or look for the explanation to the phenomenon.

Using Content in a Context that Provokes a Reaction

The experience itself is very interactive. So with the image subject, we would probably add it to a software, or something that provokes something, a reaction, an action that has to happen.

Physical & Virtual Reality Simulations

These are very scientific simulations from the mathematical point of view, and such... On the distance module, we worked on a theme of "What is distance?" which is very important. The module that approaches a type of trip to the moon on a bicycle, and there is a screen in which you find out in depth the amount of kilometers you are traveling.

But obviously, you don't arrive at the moon immediately. You won't arrive. It's calculated that it would more or less take ten years approximately, so the visitor is just going to collaborate to arrive there. And there are some images there that in some way give a more immersive vision on the theme.

There is another module that deals with virtual reality images on the sun. For example, the sun flames, the person can go through these flames, and travel around the sun. So along those lines. We are now – speaking of simulations – but we're trying to see if there is a more MIM way of doing it.

Crafting Interactive Experiences from Images

I see that you're able to download [the images]. But also, for example, they should have scientific information, but not specialized for an astronomer. It should be information that allows to have a more profound knowledge of what you're observing without getting to describe what you're observing.

More like the phenomenon of the image in the background, and leaving it up to the person as to what that emotionally provokes.

Why these types of forms take shape in the universe? Why this nebulous, for example, make up these colors. We know that this is an edited photo. Right?

Unlike others. I don't know, it occurs to me to make it more interactive, makes you think a little bit more about what you're observing.

Do I – theme is how experiential is that simulation to the visitor? How involved can they feel observing it alone?

So we look to generate that even though it's an audiovisual element, the visitor does something with that audiovisual element, and it implies a reaction. It implies a change in depth, where he will feel compromised with that experience he's living.





Camila content creator | CHILLEAN SCIENCE CENTER



Camila enjoys getting daily updates from LSST in her email. She visits the Updates page to see new media and engaging astronomy questions she can share with her exhibit planning team.

Good Future: PURPOSEFUL MULTIMEDIA



Camila content creator | CHILLEAN SCIENCE CENTER



The LSST Tile Viewer & Object Pages provides the exhibit planning team with contextual information and easily downloadable assets.

Good Future: PURPOSEFUL MULTIMEDIA



Camila content creator | CHILLEAN SCIENCE CENTER



Having good discussion points and easily accessible purposeful media helps Camila and the rest of the exhibit planning committee design better interactive experiences.

Good Future: PURPOSEFUL MULTIMEDIA



Lionel CONTENT CREATOR | LARGE-STAFF PLANETARIUM

High



Frequency of Engagement with Astronomy Content

Focus on Developing General Scientific Thinking Focus on Developing Content Specific Knowledge Utilization of Astronomy Research Databases Time Available to Pursue Interests in Astronomy

Overview

Lionel is a content creator at a planetarium with a staff of over 100 people. He primarily works on creating content for planetarium dome shows and crafting visualization for the planetariums learning lab environment.

His planetarium develops a great deal of original content that it shows in house and also shares with other planetariums via their planetarium software. His preference when crafting original content is to have as much access to raw unprocessed data as possible.

Lionel works closely with staff astronomers and curators to create full length pre-rendered shows. He also develops simulations and models that are used by presenters in live non-linear programs. With these type of programs he works with the presenter to identify models and transitions that help them share a compelling story.

Lionel really enjoys the challenge of crafting stories that are rich and deep in new areas of scientific discovery and are also compelling and transformative to visitors of all ages and backgrounds.

Low

Activities

- Collaborating with curators and scientists who know how to identify the significant information in data to enable Lionel to create compelling stories for visitors
- Constructing content experiences that are emotionally compelling to visitors.
 - Working with planetarium software, Uniview and World Wide Telescope to create scenes for projecting on the dome
 - Creating a series of dome cast shows based on famous astronomy lectures to share with other planetariums and Google VR
- Working with a wide variety of tools to create the look and experience he has in mind including tools for 3d modeling, editing, space simulation, effects compositing and sound editing

Challenges & Delights

CHALLENGES

- Getting access in unprocessed imagery and content so Lionel and his astronomy team can have creative and scientific control over the stories they want to create.
- It is hard to share the content they create with planetariums that don't have the same software.
- They cannot dome cast to planetariums that don't have the same software.
- Receiving content and data that doesn't include what is this data, what does it mean, who is using it and what is it for
- Having astronomers write python scripts to get the data in the format they need for visualizations

DELIGHTS

- Good collaborations where scientists and data scientists are able to bring the right data and artists and storytellers are able to figure out how to make something that people care about.
- Helping to support meaningful connections between staff research scientists and museum visitors through the use of visualizations.
- Inviting visitors into the process of exploration and demonstrating that what we know about the universe is an ongoing and living practice that has spanned centuries











Dome Casting + Google VR

Dome casting's great. We just did, we have this new series called The Covley Vexer series that we've been doing in Uniview where we have really top-notch scientist come in with, and they usually have PowerPoint talk that they do. And, we take that talk and we create a full dome experience for it. So high-end graphics, animations, and everything and then we dome cast that out to planetariums all across the country.

This last one we did though we not only dome cast to other planetariums but we dome cast to Google VR so people at home can use Google Cardboard to watch the same lecture that we're doing here. So it's breaking down the walls of the planetarium.

Our community is Chicago but with dome casting it's becoming worldwide. We could be known for our-our-our lecture series.

Scientists & Storytellers

You need scientist and data scientist to be able to import the data but you also need the artist and the storytellers to figure out how to-to make that something that people care about.

Need For Shared Dome Casting Format

What would be nice if there was a shared dome casting format where Digistar dome casting can happen to Skyscan software and Skyscan software can dome cast to Uniview software.

That's gonna take some negotiations. Because they don't want to right now. They don't want to share.

What Is This Data & What Is It's Story?

We combine that discovery with you know new knowledge and hopefully some drama.

We usually have a curator or somehow scientist who knows how to-to find the significant information out of the data.

And then we take that and tell our stories. because not all the data is significant to-to what you're trying to say.

So I think having some type of-of curation of it. What is all this data and what does it mean or who's using it? What are they using it for?

I think knowing that would help tell better stories.

Access to Raw Data in Raw Formats to Tell Our Stories

I think one of the challenges that we have with a lot of these telescopes spacecraft is the accessibility to the data. In a raw format, not a curated format.

My biggest complaint is with Mars Express and some of these other Mars missions that have taken beautiful imagery, but they only give you what they've already processed, and they don't give you really the tools, really good tools to go ahead and-and extract information that you need to create your own story.

It's great if they take the time to put 20 images together and give you Olympus Mons ...but not everybody wants to tell a story about Olympus Mons so you have to have some kind of access to the data so that if we want to tell our own story ...

We can get in there, get the information out that we need, and put it in different programs that we have because we do a lot here ourselves.

We import a lot of our own data in. That's not gonna work for everybody. We have visualization lab so we can do that.

I think on the other side of that it'd be great if there was a direct path to programs like worldwide telescope or uniview that can directly access the data and import it in to their programs.

And then you can visualize it real time in the planetarium, kind of cut out that processing middle step

We Want To Share Our Content

We share a lot of our content. We don't necessarily take a lot of other people's content because we're producing at a higher level so they're usually waiting for us to make something, they take it but it's great to see what everybody's doing.

But yeah but again it's software dependent, usually and it'd be nice to break that down.

I'd love to say that in five years from now the planetarium world will have format standardized and all that but five years, that's probably not optimistic. Yeah it's probably fair to say that I'm taking five years but I'm assuming that's a pretty good time horizon.

That's gonna take some negotiations. Because they don't want to right now. They don't want to share.





LONEL CONTENT CREATOR | LARGE-STAFF PLANETARIUM



Lionel is collaborating with Harun, an astronomer at his planetarium, on a monthly show highlighting new findings from LSST. They have both been checking Universe Nightly for the latest updates and today Harun sees that there are brand new EPO images of Exoplanets.

LONEL CONTENT CREATOR | LARGE-STAFF PLANETARIUM



Harun selects the images that will best demostrate the science of the new discoveries and adds them to the LSST project in the planetarium software for Lionel to review and incorporate into the show.

LONEL CONTENT CREATOR | LARGE-STAFF PLANETARIUM



Lionel receives Harun's message and begins exploring how best to sequence and augment the images to inspire, delight and inform viewers of the cutting edge discoveries captured by LSST.

LIONEL CONTENT CREATOR | LARGE-STAFF PLANETARIUM



A few days later, Harun hosts their first show, dome casting around the world and via Google Cardboard newly found wonders of the universe, never before seen by the public.

LSST Journey Starting Points





HIGH QUALITY COLLECTIONS

LSST Nightly Update Social Media Portal Mobile Data to Dome

LSST Multi-Media Desktop Mobile Data to Dome Social Media



MULTIMEDIA

LSST Hands-On VR Mobile Mobile + Classroom

Schools & Students

General Public



IMMEDIATE ACCESS

> LSST Tile Viewer Desktop Mobile

LSST Object Pages & Database

Desktop Mobile

LSST Zooniverse Projects

Desktop

Mobile

Mobile + Classroom

Informal Science Centers

Citizen Science



Citizen Science Personas



Candice **RESEARCHER - PROJECT PI**



Margaret CITIZEN SCIENCE MODERATOR

RESEARCH PARTICIPANTS

---- Professional Researchers ----



Meg Schwamb Researcher



Emily Levesque Researcher

- Moderators –



Alice Sheppard Moderator

— Promote Citizen Science —



Laura Trouille Planetarium — Adler



Kelly Borden Planetarium — Adler



Candice CITIZEN SCIENCE | Principle Investigator — Researcher



Frequency of Engagement with Astronomy Content

Focus on Developing General Scientific Thinking

Focus on Developing Content Specific Knowledge

Utilization of Astronomy Research Databases

Time Available to Pursue Interests in Astronomy

Overview

Over the years Candice has worked with citizen scientists to discover exoplanets, explore the surface of Mars and discover new galaxies.

Through her engagement in these projects and the articles published from the results of these collaborations, Candice's appreciation of citizen science has continued to grow.

She values the contributions that people engaging in citizen science bring to astronomy and her research. Many times she has experienced how people looking at large data sets can lead to unexpected and interesting findings that can't be duplicated through machine learning.

Over the years, Candice has learned how to best construct classification tasks that people can do successfully, analysis methods that optimize the scientific value of people's participation, and approaches to community building that help sustain engagement and excitement.

With the scale of data that LSST will be gathering in mind, Candice is already creating preliminary projects that will help her test methods and analysis approaches for when LSST goes live.

She is looking forward to all that will be discovered and learned from LSST and she also looks forward to continuing her work with the contributions of many thousands of citizen scientists and communities.



GOOD FUTURE: EPO Data for Science

Activities

- Determining if a project is well suited to citizen science and then crafting projects and tasks that can be accomplished by citizen science in a reasonable time period
- Selecting the most effective and efficient data to include in the citizen science process to optimize time spent by people in support of research findings
- Using the Zooniverse project builder to construct the website, information pages and tasks for the project
- Iterating new projects based on feedback from the Zooniverse community to ensure the task, science objectives and overall mission is understandable to citizen scientists
- Conducting follow up observations on secondary telescopes based on survey discoveries
- Keeping in contact with the project discussion moderator and ensuring communication bridges between the people engaged in citizen science and the project's professional researchers
- Answering research and science related questions on discussion boards

Challenges & Delights

CHALLENGES

- Significant concerns around EPO data limitations when conducting research supported by citizen science
- Ensuring

DELIGHTS

- Engaging in research discussions with moderators and citizen scientists
- Evangelizing citizen science to research teams when I see an opportunity for both together to authentically engage in moving science forward
- Being surprised by the number of people who are excited to be part of a project and do classification work
- Publishing papers in a timely cadence that helps all citizen scientist directly see the value of their contributions











Why Limit Citizen Science Data?

If you want to put 10% of the data for people to walk through and explore, great, but why if you're wanting to use citizen science for research, why are we putting that limit?

Now someone's going to have to check, and I have to estimate how many images I'm going to use overall.

Citizen Science Makes EPO Part of the Science Collaboration

Every other science collaboration is telling LSST data pipeline people what they need and they're starting to build the portal that people are going to test out that we're going to use, that the internal collaboration people use. It would be nice to see this same thing happen with I think citizen science...

EPO is also sort of part of the science collaboration because they're taking on the citizen science task.

Determining the Right Size Data for Analysis and Timely Paper Writing

Do I have something that's manageable. I want to write a science paper now. I don't want to write a science paper in four years.

Is my data set the way I want it? Could I do a smaller search now and write a paper and figure out all the bumps and stuff on something that's smaller that'll take me a year and then I can write that bigger paper in three years when we reduce all the data.

For me, it's always what are we going to get out now. None of us want to be waiting five years for a paper.

So making sure we've figured out that that data set's going to work. What's the minimal amount of stuff we can do now to write that interesting paper? I think the mantra is we don't want to waste people's time.

Coordinates for Zooniverse Data Access, Not Uploading & Downloading

What would be nice about LSST, from what I've heard is that I will be able to just say these are the things I want, click, and it will go grab it. I won't need to know how to do it.

You mentioned earlier, like a coordinate file or something like that?

Right. Exactly. This image observation, this position, this big.

That will be nice because this is a lot of work.

...it would be nice if there was a toolkit we could give and say here, you can [01:20:00] run this and upload it. I think that's very important to LSST that that's going to be the way to do it.

So there's not downloading and uploading.

Right. It's reuse of expertise, because then I got to learn the images format. How do I query to get a sub image, then I'm going to have to go reduce that and make that because I don't know if they're storing raw images or reduced images. Then I'm going to have the disc space for all that to then upload them. It's all upload time. I was pleased to hear that that's one of the reasons that they're going to do, the Zooniverse back end is going to get plugged somehow into LSST.



Candice CITIZEN SCIENCE | Principle Investigator — Researcher

Researcher with LSST data rights* has a citizen science project idea and uses SUIT to develop query for desired dataset and requests a sample set.

SUIT tells Researcher request is "pending" via UI, sends sample set request to EPO Center and monitors JSON file for result



** Zooniverse One-Time Effort:

Zooniverse team updates Project Builder Tool to dynamically check a TBD JSON file from the TBD LSST EPO Center which lists available citizen science datasets and whether they are sample sets or full. This data populates the TBD "Available Datasets" dropdown on the Zooniverse Project Builder Tool wizard's Subject Sets upload screen.

* TBD:

- Opportunities for researchers without data rights?
- ٠ from LSST EPO quota tally?
- . metadata?
- request

GOOD FUTURE: EPO Data for Science

EPO Center uses query provided by SUIT to pull a limit of 300 rows/images from the US DAC, scrubs science metadata?*, and updates the JSON file**

SUIT detects pull completion via JSON file (or times out after TBD wait*) and notifies Researcher via UI

When project is ready for beta testing, Researcher submits idea to a Zooniverse+LSST panel for review

Researcher launches the Zooniverse Project Builder Tool, selects the desired newly-listed sample set from the wizard's dropdown** and launches a sandbox project to begin internal testing

Researcher notifies beta testers to begin testing the project (making project adjustments as needed)

When project is ready to go live, Researcher notifies Panel

LSST member of panel schedules an EPO Center pull for the full requested dataset from US DAC using the SUIT query, scrubs science metadata?*, and updates the JSON file**

Once catalog data passes two-year proprietary period, remove

Instead of an LSST EPO quota, can we just scrub the scientific

Need mechanism for SUIT to notify EPO Center team of failed

Researcher notifies public volunteers to begin working on project

Panel notifies the Researcher and optionally advertises the project on Zooniverse.org





Margaret citizen science | moderator



Frequency of Engagement with Astronomy Content

Focus on Developing General Scientific Thinking

Focus on Developing Content Specific Knowledge

Utilization of Astronomy Research Databases

Time Available to Pursue Interests in Astronomy

Overview

Over the past few years, Margaret has been a citizen science moderator for a number of Zooniverse projects. She enjoys connecting people from all walks of life with the practice of making new discoveries and being an active part of science in action.

While she has always had an interest in science, it was initially by happenstance that she became a community moderator for astronomy projects.

Over the course of a few months on her first project, Margaret became an active participant on the discussion forum and found herself helping people who were new to the discussion find their way around.

She was officially enlisted by the research team and became instrumental in creating an environment for everyday people and scientists to connect via the discussion board to learn from each other and share probable findings and unusual objects.

As a moderator, Margaret helps to empower people to go deeper into the science, explore the object pages, and eventually even make their own research projects.

High



GOOD FUTURE: Citizen Community

Activities

- Ensuring a safe, appropriate and informative environment on discussion boards
- Helping researchers stay involved with the community by highlighting questions and important discussions
- Helping people make the break from school science where there is a right answer to real science where people are empowered to provide their best theory based on the evidence before them
- Welcoming new people on to discussion boards and inviting them to participate
- Helping people have scientific arguments without hurt feelings or misunderstandings
- Letting researchers know when citizen science tasks are too difficult or confusing to participants
 - Connecting participants with the science objectives of the project
 - Ensuring participants are acknowledged as legitimate collaborators when researchers publish findings
 - Making sure people get answers to their questions and feel confident continuing to contribute to citizen science

Challenges & Delights

CHALLENGES

- Reducing the intimidation factors of citizen science including unfamiliar terminology, not having a right answer, and people being afraid of math and science
- Adjusting to changing discussion board technologies that may optimize some aspects of the discussion interactions, such as discussing particular objects, while making other aspects such as organic interpersonal connection more difficult

DELIGHTS

- Creating a discussion environment where people can share their interests and become a community
- Making new friends who are interested in science and astronomy and who are wellbehaved, enthusiastic and positive
- Empowering people to engage in citizen science regardless of their level of expertise or background
- Alerting researchers to interesting things the community has found and connecting researchers with citizen discoveries more broadly
- Broadening people's understanding of the research and astronomy science associated with specific classification tasks

















Margaret citizen science |. MODERATOR

Citizens Plus Scientists Equals Human Endeavor

I love it. I'm really sick of the image of scientists as really cold and aloof people in positions we'll never get to. I feel that science is for everybody.

It was really terrific that there were three scientists who spent a lot of time hanging around on the discussion forums and chatting with us not just about the galaxies and about what they did, but also talking about cats or food with the rest of us because we really got to know each other as people and it became much more accessible. It became a human endeavor.

A Platform For People to **Answer Each Other's Questions**

Providing a platform for people to answer each other's questions and people to give each other ideas about what to do is really important because much as some people like to see science as some ideal, it's always going to be human-driven and people are always going to know if you speak to them personally than if you leave them a set of instructions.

Discussion Forums are Where Real Thinking Happens

The way the citizens science projects have been developing is not the same thing as the kind of lesson plans we're thinking about the classroom. Cause the citizens science projects involves a task that is very repetitive, uh, that can become addictive as I have learned myself.

But it's not clear to me that in the hundreds of thousands of citizens looking at images as they do this, that act alone does not develop necessarily their critical thinking. It's not that act but it's the add-ons that you get...

With discussion forums, having to research it as well. That's where the real thinking and the questioning and answering and debating comes through.

New Discoveries Come Out of the Discussion Tool

There's another component of this which is having so many eyes trolling through your data that you could find the rare gems.

It might be stuff you're not necessarily looking for. If you treat them as collaborators, and you go on a discussion tool, you will get the most out of this.

It's been almost every project I've worked on, something's come out of the discussion tool, if there's a chance for it.

Revolutionize People's Concept of Science Through Discussion

Someone would post such a galaxy on the forum saying, "What's this?" Person A would come along and say, "I think that's an elliptical." Person B would come along and say, "I think that's a spiral. Look at the core. There's a bit of dust in a spiral shape." Person C would come along and say, "Come on, it's neither of those. It's an old merger. There's been another galaxy collided with it."

Then this poor new person would say, "I don't want to watch people arguing. This is really upsetting and stressful. I want to know the right answer is. I don't want to mess things up."

That would be the moment when someone. often me, often not me, would tell them what would revolutionize science for them, that there's no such thing as a right answer here. There's nothing in the back of a textbook.

These galaxies are not classified in advanced and waiting for you to be tested. Actually, we are creating the database for ourselves and science is alive.

Discussion Form is Critical to Citizen Science & New Discoveries

I always try to stress to my team. If you use that, and you invest, you get out of it.

If you don't, that community leaves. If you don't set the tone in the first two to three weeks, they never come back.

When you launch, if you're not on the discussion tool, and they don't feel like you're there as a science team, those people stop commenting because why would you do it.

I stress that launch is the most important, but set the tone. If they see you answering questions, even if afterwards, you're like a week delayed, they see that you're there and the older people will talk to the newer people. They need to feel like they're part of it.

I would call the discussion forum also building for serendipity. Use that discussion forum.

If there's things that you might be really rare that might be in your data set, so some kind of repeating supernova or whatever, tell them about it because they'll find it.



LSST Journey Starting Points

LSST Multi-Media Desktop Mobile Data to Dome Social Media

LSST Nightly Update Social Media Portal Mobile Data to Dome

LSST Hands-On VR Mobile Mobile + Classroom

Schools & Students

General Public



LSST Object Pages & Database

Desktop

Mobile



CITIZEN COMMUNITY



EPO DATA FOR SCIENCE

Informal Science Centers

LSST

Zooniverse

Projects

Desktop

Mobile

Mobile + Classroom

Citizen Science



LSST Journey Starting Points





HIGH QUALITY COLLECTIONS



ASTROSNACKS

LSST Nightly Update Social Media Portal Mobile Data to Dome

LSST Multi-Media Desktop Mobile Data to Dome Social Media









LSST Hands-On VR Mobile Mobile + Classroom

Schools & Students

General Public



IMMEDIATE ACCESS



SERIOUS FUN



IMMERSIVE LEARNING

LSST Tile Viewer

> Desktop Mobile



DATA FOR SCHOLARS

LSST **Object Pages** & Database

Desktop

Mobile



CITIZEN COMMUNITY

Desktop Mobile

LSST

Zooniverse

Projects

Mobile + Classroom



EPO DATA FOR SCIENCE

Informal Science Centers

Citizen Science



Components of the LSST Good Future

	Vinats on your mind? Visst Telescope Today at 10:14pm Oneck out our new special on how LSST is helping scientists discover new worlds! http://youtu.be/ExoplanetSpecial http://youtu.be/ExoplanetSpecial Watch Now! Watch Now!	<complex-block></complex-block>	Order Landbird on 433 Erocs	217 Catarier Cassified 217 Catarier Cassified ton high 217 Catarier Cassified ton high All Galary Types	Normal Control of Control o	
	Nightly Update	Multi-Media Library	Immersive VR	Tile Viewer	Object Pages & Database	Connecte Zoonivers
Platforms	Social Media Portal Mobile App Data to Dome	Desktop Web Mobile App Data to Dome Social Media YouTube	Mobile App Mobile + Classroom	Desktop Mobile App	Desktop Web Mobile App	Desktop We Mobile App Mobile + Classr
EPO Group Rank	General Public Citizen Science Informal Science Centers Schools & Students	Informal Science Centers General Public Schools & Students Citizen Science	Schools General Public Informal Science Centers Citizen Science	Schools Citizen Science Informal Science Centers General Public	Schools Citizen Science General Public Informal Science Centers	Citizen Scien Schools General Publ Informal Science (
Primary Personas	Everyone	Sandra Camila	Tanya Amelia Lecia	Elena Margaret Amelia Lionel	Elena Margaret Amelia Lionel	Candice Margaret Amelia



Content Areas for Solar System Inventory & Transient Sky

MOVERS | ORBITS — Solar System Inventory

Topics

Near Earth Objects Astroids Trans-Neptunian Objects Comets

Data

Orbital Parameters Size distribution Colors Light Curves

Insights

Planetary Formation & Evolution Astroids coming towards Earth

Ivezic, Z., Tyson, J. A., Abel, B., Acosta, E., Allsman, R., AlSayyad, Y., ... & Ansari, R. (2008). LSST: from science drivers to reference design and anticipated data products. arXiv preprint arXiv:0805.2366. *Also Northwestern Session*

У	BLINKERS — Transient Sky
	Topics Gravitational Lensing Search for Super Novae Physical Properties of Gamma-ray Burst Sources Variable Star Populations
	Data Orbital Parameters Size distribution Colors Light Curves
	Insights Exploration of the Time Dimension - Time Machine Discover Exoplanets New Classes of Transients



Commenting on Good Future Concepts

We have assembled a set of good future concepts based on the EPO personas. Those concepts are included in this deck, but also available online for you to comment.

You can access and comment using InVision—a popular web-based prototyping and commenting platform.

To comment please go to the link below. You will be asked to provide your name and email and to enter the password provided below

URL Link: https://tinyurl.com/LSST-goodfuture Password: goodfuture



Comment on anything using the comment toggle on the bottom right of the page.



Personas & Good Future Stories

EDUCATORS



Elena Astronomy elective

Data for Scholars

Easy to use and understand database that supports students in authentically conducting rigorous scientific inquiry.



GENERAL PUBLIC



Lecia future scientist

Serious Fun

Mobile-first interactive experiences, videos and articles to explore the universe beyond the scope of school.



Amelia astronomy enthusiast

CITIZEN SCIENCE



Candice RESEARCHER - PI

EPO Data for Science

Accessible LSST data to support science research objectives with citizen science activities



Tanya ms science title one

Immersive Learning

Direct, hands-on experiences that capture student attention and enable exploration and knowledge building.

INFORMAL SCIENCE CENTERS



Sandra small staff planetarium

Quality Collections

Real-time open access to LSST content library & updates, supporting both show creation and interactive presentations.

Astrosnacks

Updates & informative experiences that fit a passion for astronomy into a hectic schedule.

Margaret MODERATOR

Citizen Community

Ability to help people engaged in citizen science to connect with each other, grow their knowledge and do great science.



Camila science center – chile

Purposeful Multimedia

Content that intentionally supports the design of discovery-based, hands-on, interactive experiences.



_ionel large staff planetarium

Immediate Access

New LSST data, in raw and produced formats, seamlessly integrated into content creation & projection systems.



APPENDIX
General Frameworks to Inform Design

Strand 1: Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.

Strand 2: Come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science.

Strand 3: Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.

National Research Council. (2009). Learning science in informal environments: People, places, and pursuits. National Academies Press.

- Strand 4: Reflect on science as a way of knowing; on processes, con- cepts, and institutions of science; and on their own process of learning about phenomena.
 - Strand 5: Participate in scientific activities and learning practices with others, using scientific language and tools.
 - Strand 6: Think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science.



Science Literacy

Foundational Literacies

- numeracy
- textual literacy
- visual literacy
- understanding of graphs and charts

Content Knowledge

- set of scientific terms
- concepts
- Facts
- old & new scientific developments
- Topics discussed in the news
- text book principles k-12

Dispositions & Habits of Mind

- inquisitiveness
- open mindedness
- Commitment to evidence
- value scientific approach in inquiry

Understanding of Scientific Practices

- science
- how to design and evaluate scientific inquiry in order to appraise scientific findings and understand if a question has been approached scientifically
- collecting data and analyzing
- interpreting scientific findings
- understanding of peer review, double blind trials, control variables, error reduction, etc.

Cultural Understanding of Science

- acknowledgment of the interrelationship of science and society and science and humanities
- recognition of science as a major human achievement

Snow, C. E., & Dibner, K. A. (2016). Science Literacy: Concepts, Contexts, and Consequences. National Academies Press.

understanding how scientists do

Identifying & Judging Appropriate Scientific Expertise

ability to make a judgement about expertise of scientists

Epistemic Knowledge

- how the procedures of science support the claims made by science
- assumptions and principles that underlie scientific work
- ability to explain why scientific results can be believed
- awareness that science is a human enterprise with strengths and limitations and appreciate the ethics that guide sciences in their work

Free-choice Environmental Learning

Learning is rarely an instantaneous event, but rather a time-consuming, cumulative process. — Falk

Learning Infrastructure: Interwoven network of educational, social and cultural resources

Science learning can be envisioned as strands of a rope intertwined to produce:

- + experiences
- + environments
- + social interactions that provide strong connections to pull people of all ages and backgrounds towards
- + great scientific understanding
- + fluency
- + expertise

prepare them for their future learning in unanticipated ways.

direct experience with phenomena.

Falk*, J. H. (2005). Free-choice environmental learning: framing the discussion. Environmental Education Research, 11(3), 265-280. National Research Council. (2009). Learning science in informal environments: People, places, and pursuits. National Academies Press.

- Informal science learning experiences often occur in situations that immediately serve people's interests and
- _earning experiences in informal setting also grab learners' attention, provoke emotional responses and support

Science Museums & Planetariums

Informal Science Centers Key Research Questions

Identity & Motivation

- + What are the objectives of the ISC?
- + What motivates content creators, currators and employees to engage in the work of the ISC?
- + How od people working at the ICS see themselves? What does it mean to be a connected creator or currator at this ICS?

Audiences

+ Who are the visitors to the ISC? How do creators and curators think about these audiences when developing and selecting content? Audiences that they are not reaching that they would like to?

Visitor Experience & Activities

+ Journey -- From a center perspective what is an ideal visitor experience from beginning to end? By type of visitor.

+ What are the types of activities, events, vehicles for connection used in the ISC? Goals, audiences, roles, qualities and characteristics for each? + Immersion and engagement - these are two goals for experiences that

centers talk about. What are the practical things LSST EPO can contribute to centers to support these experience goals?

+ What role do staff and planetarium operators play in the center attendee experience? How do staff and planetarium operators prepare to share new research and knowledge with center audiences? What are helpful/desirable/idea supports?

+ How can the ISC empower the public to participate in science? How does the ISC define science for the public?

+ What does the exchange of ideas look like in the ISC?

+ What are the characteristics of engagement in the ISC?

Content Creation & Experience Design

+ Journey -- from idea to implementation to evaluation and next ideas

as best for their audiences?

EPO Content in General and LSST EPO Content in Particular

special events, design challenges, connecting center with the broader informal science center? groups of people who come to the ISC? distance

- + What do centers need to be able to successfully bring LSST EPO experiences and content to their audiences?
- + How do content creators and curators think about the modularity of content? What is a useful content unit? What are the characteristics of the successful/desirable unit? How to units relate to each other and to units from other EPO programs? Is there a desire, practice of mixing and matching EPO units from different sources?
- + What role does cost play in the creation and acquisition of content? How might LSST EPO support centers in creating the content they see
- + What role does technological capacity play in the creation and acquisition of content? How might LSST EPO support centers in creating the content they see as best for their audiences?
- + Are there opportunities to connect EPO LSST content with exhibits outside of astronomy? Is this a valuable activity?
- + Where do content creators and curators look for inspiration?
- + Role of EPO content -- visuals help people engage in conversation, ask questions, make comparisons, talk about specific research questions and activities -- connect with other parts of the ISC.
- + What are the areas of the center's experience where LSST EPO content is relevant and useful -- eg. dome show, exhibits, design lab,
- community. + What are the areas that the center sees as having the
- highest opportunity for impact for LSST's content specifically?
- + Nature of the conversation with the public -- what are the kinds of content that can help anchor, fuel and scaffold conversations within the
- + EPO content that helps fuel conversation and engagement between
- + Role of EPO content -- visuals help people engage in conversation, ask questions, make comparisons, talk about specific research questions and activities -- connect with other parts of the ISC.
- + Astronomy -- What are the fundamental principles that can be demonstrated with LSST EPO content that supports informal science learning e.g.sense of scales, change over time, scale - time & space/

Change

+ How do content creators and curators think about change within the center? What sorts of shows and content anchor the center? What are areas that are ripe for change, open to trying new things? Do centers see themselves as conservative towards new thinking and experiences or early adopters? How generally is change and adoption of new technologies, content, mediums, channels address? How are current things sunsetted?

+ Freshness -- Content changes at the ISC - how often does content change, what does it mean if there is the ability to change or update content on a daily basis? Valuable? What do content creators & curators imagine -- impact?

+ What does it mean for ISCs that LSST content will be continuously updated and provide new discoveries?

Center Education & Outreach

+ Boundaries -- What are the intentional or unintentional boundaries between the Science Center & broader Community? Where does programming start and end? e.g. Adler - Here, There and Everywhere model looks at how content experiences are delivered onsite, in the community and online

+ What types of EPO content might a center want to share on it's own

website? Or link to? (See exploratorium videos and content for example) + What is the idea relationship between teachers and the center? What is the relationship between the center experience and the classroom experience? Are there opportunities for LSST EPO to participate in this relationship?

The Future

+ How does the ISC imagine the future visitor experience? What will change in the next 10 years? What will stay the same? Where should things be heading?"

Informal Science Centers Overview

Key Characteristics

- \cdot The ISC is there to inspire
- \cdot See the planetarium as an extension of the classroom.
- Prefer to have a direct connection to the audience during dome shows if staff/resources/software are available
- Aim to teach/reinforce the qualities of scientific thinking by connecting to peoples' everyday experiences and place in the universe.
- Looking to communicate how people use modern tools to make astronomical discoveries
- Longing for data standardization for planetarium software
- Often prefer modular assets over longer postproduced because they are easier to pull up in Q&A sessions.
- Generally don't see Domecast/VR as a threat, but an opportunity to engage with a larger audience.
- NASA and ESO were go-tos for quality assets





Valeria Vera Galleguillos Museo Interactivo Mirador

Research Participants



Patrick Mcpike Planetarium — Adler



Andrew Johnston Planetarium — Adler



Kris McCall Planetarium — Cernan



Johnathan Nelson Planetarium — Cernan



Jim O'Leary Maryland Science Center



Adler Youth Council Planetarium — Adler



ISC Detailed Overview

	Chilean Science Center (1)	Smaller ISCs (2)	Larger ISCs (2)
Goals	 See the museum as a physical extension of the theoretical education happening in the classroom. Focus on Chile's leading Astronomy infrastructure. Want people to understand the tools that contribute to Astronomical Discoveries Create good modular exhibits for self-exploratory learning. 	 Look to help supplement learning with local education systems (grade school, high school, and university) Help people better understand how world around them works (scientific process) Encourage dialogue about science. Increase number of visitors for more funding. 	 Inspire and encourage visitors to ask questions about science. Help build a deeper understanding of the scientific process and the required for scientific discovery. Engage with the local community with youth programs, satellite exhibits/experience, educational outreach with local schools Engage with a larger community with technologies like Domecal.
Resources	 Generally don't have in-house astronomers—find astronomers to be part of the exhibit committee Look to other larger science centers for any materials they can use in their own exhibits/shows Don't have many resources available to them so they end up sharing amongst other Chilean science centers 	 Generally don't have in-house astronomers—look for outside experts to help validate what they are presenting. Borrow heavily from NASA and ESO media Look to bigger planetariums for assets / examples Some small ISCs don't have the expertise to do live shows —they would like too. 	 Have larger teams (with in-house astronomers) and build own planetarium shows or interactive experiences Use the resources available in Planetarium Software, but ge build their own assets Do not like post-processed assets—do most post processing house Prefer modular assets to incorporate into their own narrative
Process	 Uses MIM process—variation of Exploratorium Work with a committee of experts to draft a content script which then is modified to a museum script Iterative prototyping and testing at 1:1 scale 	 Works with educators to understand what topics to cover. Works to build a library of assets across sciences to use in Dome Q&A Creates 30-60min of curated content for visitors 	 Work with in-house Astronomers and Curators to focus on in which to build a show Content creators balance theatrical experience with scientific accuracy by working with astronomers.
Visitors	 Most visitors are grade school kids and their teachers Most people don't have a great science understanding than most 10 year-olds Less than 5% of students in Chile will visit a planetarium Chile is not the most digitally connected society. 	 Most visitors are grade school kids and their teachers Try to extend the planetarium for science lectures from local scientists 	 Most visitors are grade school kids and their teachers Smaller group of repeat visitors; either volunteers or seas ticket holders People who walk in after visiting other nearby museums
EPO	 Help with exhibit consultation Help find local experts to consult with Image library with high-quality & beautiful imagery 	 EPO to provide assets in planetarium software. Those with planetarium software without community feel left out (would like data standardization) Help prioritizing the millions of nightly updates into compelling stories 	 • EPO to provide assets in planetarium software. • Tools to help analyze data for millions of nightly updates to compelling stories. Systems can't handle millions of updates





Adler Youth Council - Example Activity Sheets



TUCE When things are going well at The Adler, I'm... Doing applying what I'm inseractive activities listeningnead watching teaching and warning contexualizing at the same time experiences planning neiping others! having fun! about now to noving fun! explain things excitement best wonder! the vastness of cneativity! Knowledge explorative! How Mings effect me invigorated personany as well Feeling Thinking of others

Adler Youth Council - When things are going well at The Adler, I'm...

Doing

I'm Helping Others

- Having a great conversation
- Making a difference

I'm Actively Learning

- Learning new things
- Contextualizing experiences
- No "busy work"

I'm Helping Prepare

- Learning new innovative ways to help out my friends, family, and the rest of my community
- Contributing to real life projects
- Creative Criticism

I'm Enjoying The Space

- Enjoying the comfortable and open environment
- Having fun!

I'm Physical Interacting

- \cdot Hands On activities
- Coding or some type of STEM project
- Applying what I'm watching

Feeling

I feel welcomed

- Really loved and Welcomed
- Comfortable
- \cdot Hopeful

I feel Inspired

- Creative
- Curious
- Wonder!

I feel this fun

- ・Having Fun!
- Happy
- · Joy









I feel challenged & encouraged

- Intelligently Stimulated
- \cdot Explorative
- \cdot Invigorated

I feel engaged

- Social
- Helpful
- \cdot Free

Thinking

How do I improve?

- \cdot How do we improve this
- Solving problems & challenges
- Asking questions that I don't know the answer to

How does this relate to me?

- How does this fit in my life?
- How things effect me personally as well as others?

This is amazing!

- The vastness of knowledge
- Wow!
- When can I do this again?!

How do I apply this knowledge?

- How does this fit in my life?
- How to apply what I already know to what is happening?

How do I explain this to others?

- How to best explain what this is?
- $\cdot\,$ Who can I tell about this?

A







Adler Youth Council - Idea Generation



Interactive Exhibits

- Spin a wheel, as the wheel is spinning the sky is changing
- it means
- Exhibit on the history of past pictures taken of space (Timeline?)
- A baby LSST
- asteriod, learn facts about asteroids telescope works-the science behind, have the audience create smaller models
- Evolution of the sky exhibit • Kids track the movement and path of one Interactive activities explaining how the of the telescope
- View-finder type experience in the SVL, just opportunity to interact with these visualizations. Up for visitors, projected on walls, maybe talks

Static Exhibits

- A mini model of the telescope with a description about it near it
- Showing visualization of what is occurring
- Few different levels of explanation based on intellectual levels
- A video of the sky changing being projected on the wall during visiting hours

Planetarium Show

- A show like astronomy current events in the more 3D, interactive, flexible format
- Sky Show!

Interactive wall. Updating data and what

Web/Mobile

- Perhaps an app that has the updated info and other relavant information
- App/website reminder-y program thing that backyard astronomers can use to spot cool stuff / know when cool stuff happens
- Spot the difference games using LSST pictures
- · Something they can take Home? A booth that captures the footage so visitors feel a part of the experience
- 360° Photo/Video
- Info on what is seen / Info on footage to give visitors something to learn
- INTERACTIVE!
- A demonstration / hands on way visitors get to see how the camera gets the footage
- VR possible thingy
- App that could partner with Adler to show like sky position and movement of objects in realtime

Games

- Maybe a game? Help the camera reach its goal of taking pics by the end of the day
- GAMES!
- • What do you spot on the screen?
- Memory games (do you remember what order the pics were taken?)
- Puzzle of the sky with images from the LSST

Telescope

- Videos that show the telescope functions
- creative ways of teaching students about how it works and what it is meant to do and the goal in building it

Social Media / Communications

- Post the change in the sky on our social media pages
- Get a snapchat filter that looks like the sky everytime it changes with the logo at the bottom
- Calendar
- Subject chooses day
- List of changes in the sky shown
- Showing how it changes in scale
- Send out a daily "newletter" for the universe to Adler members
- Newcast!

Community Events

- Hack day! About the project itself
- Periodic talks in the SVL (Space Visualization Lab) through the journey of celestial objects
- Test run for spectators
- Kids mobile making
- A work shop where kids learn about the telescope then try to make their own

Sky Viewer

- Interactive view of the sky made up of several pictures
- Google maps of the sky (interactive) Pics of the sky in different countries
- (kids) Mapping the Sky



Adler Youth Council - Selected Concepts

Spacetography

What it is...

An exhibit that displays the evolution of space photography over time.

Why people will think it's awesome...

- Minimal Reading
- A form of art
- Visually Pleasing

How it works...

- Introduce photos changing/streaming
- Old > Not so old (in-between) > Present

What people feel after they've used it...

- Educated
- Experience/been part of space
- Intrigued

CELESTIAL MEDUBROADCAST

What it is...

An interactive live-action "Universe News" show in the Granger Theater (dome). There's a live actor who explains the newest visualizations from the LSST which are projected on the dome.

Why people will think it's awesome...

Kind of like you are inside the visualization. It's always changing and new, and peope can see it again and again. The live actor can interact with the audience to make it personal.

How it works...

The live actor means that there doesn't have to be a whole new show every week. They can just the visualization and the actors talk.

What people feel after they've used it...

- Like they learned something new, up-todate on space news.
- Wonder because of being in the simulation. • A personal connection with the actor.



What it is...

GPS App. It informs you whenever there is an astronomical event occuring near you. "HUGE"

Why people will think it's awesome...

- Informative
- Real life application

How it works...

The app tracks your location and has information from the telescope.

What people feel after they've used it...

- Accomplished
- Informed
- Successful
- Feel like you're an astronomer!



Citizen Science

Citizen Science Key Research Questions

MODERATORS

Identity & Motivation

+ What does it mean to people to be be a moderator of Zoo talk?

+ Moderator Journey -- How do people become moderators? What is the trajectory from awareness to moderator? What are the significant moments in this journey? Where do people fall off and why?

+ Citizen Scientist -- Journey of a citizen scientist. What is the story of people who engage in citizen science on Zooniverse?

+ What expectations do citizen scientist/classifiers have for their contributions within a broader research project? What does the happy ending of engaging in a citizen scientist project look like for citizen scientists/ classifiers?

Content & Engagement

+ How does the research question and data influence community engagement? Do different types of people engage on different types of projects?

+ Does changing the nature of the citizen scientist tasks change who is or might become a citizen scientist? + What level of personalization and connection do citizen desire? What are tangible representations of this personalization and connection? How might LSST support Zooniverse, researchers and moderators in building this personalization and connections.

Relationships and Connections

+ What connection are moderators looking to have with professional researchers and citizen scientists? + Where do moderators see opportunities in improve or enhance relationships between professional researchers, citizen scientists/classifiers, research projects and astronomy data? Are there areas here where LSST can contribute value?

+ What do moderators and citizen scientists see as the relationship between themselves and professional researchers?

Empowering Citizen Science

+ How important is it to citizen scientists to have the opportunity to access data and create their own projects?

- + Do citizen scientists want to generate their own research questions?
- + Are there types of questions that citizen sciences would like to be empowered to address?
- + What might empowerment look like -- access to data, community input, scientists input, specialized tools?

The Future

+ How might citizen scientists want to engage in contributing to science in the future?

+ What do moderators and researchers think about citizen science as a method to train machine learning algorythms to analyze LSST data? How realistic is this? What might it look like?

+ What role might citizen science play in the classroom? And more specifically Zooniverse and Zoo talk? How might student engagement in Zoo talk impact the current communities? How has it in the past?

PROFESSIONAL RESEARCHERS

Identity & Motivation

+ What does it mean for professional researchers when they utilize citizen scientist to support their research objectives?

+ What influences professional researchers choice to engage citizen scientists?

The Future

Community Engagement

engage on different types of projects?

- + How do professional researchers imagine citizen scientists supporting their work and scientific discovery more generally in the future? + What role might citizen science play in the classroom? And more specifically Zooniverse and Zoo talk?
- How might student engagement in Zoo talk impact the current communities? How has it in the past? + What do moderators and researchers think about citizen science as a method to train machine learning algorythms to analyze LSST data? How realistic is this? What might it look like?

Developing Citizen Science Projects

+ Journey -- Professional Researcher -- Journey from thinking of project to publishing findings + What expectations do professional researchers have for the role of citizen science within their broader research project? What does it look like when citizen science work is complete?

+ What role do private projects and sandboxes play in the development of citizen scientist projects? What sorts of data do professional researchers need to prototype and model new projects prior to launch?

LSST Data

+ LSST EPO has access to 10% of all LSST data to share with the public, including citizen scientists. What are professional researchers expectations for how this data is shared with the citizen science population to accomplish research goals?

+ How to researchers plan to manage the fact that they have access to all data while their projects may have access to limited data through the EPO program?

+ What are the best ways for LSST EPO to manage it's data access in order to enable citizen scientist work that supports authentic research objectives and activities?

+ Successful Zooniverse projects most often have clearly stated objectives. What are some of the clearly stated objectives researchers envision for citizen scientist projects using LSST data?

+ How do researchers think about using data sets that are continuing to grow over time? Is this realistic or is the data set essentially for a fixed and completed time period?



Citizen Science Overview

Key Characteristics

- Citizen Scientists do the activities because of the science. They are most engaged when they feel like they are contributing and acknowledged for that contribution.
- Projects are most successful when there is active discussion on the forums. Researchers feel that being responsive to your community offers a greater possibility of serendipitous discovery.
- Researchers are looking for better tools for viewing, filtering, and image processing astronomy data. Current tools are difficult to use for highly engaged citizen scientists looking to make a case for what they are seeing.
- Project building tools have helped PIs focus less on development and more on the user experience of the task.
- Are concerned about how 10% EPO data is allocated.





Alice Sheppard Former Moderator

Research Participants



Laura Trouille Planetarium – Adler



Kelly Borden Planetarium — Adler



Meg Schwamb Researcher



Emily Levesque Researcher



Citizen Science - Detailed Overview

	Citizen Science Moderators (1)	Citizen Science Reserachers (2)
Motivations	 Citizen Scientists come to the activities because the science is interesting. Come engaged to help further the research project in their own way. Often people who reject "school science" and enjoy helping scientist do "real science 	 Important to think of a project in terms of what can be published as-soon-as possible. "Don't make people wait 5 years for a p Making the task as defined and accessible as possible. Iteratively testing tasks with the beta community to make sure you're getting the best data back.
Community	 Citizen Scientist come from a wide range of ages, interest, and areas of expertise. The community works together to better understand the tools needed to build a case. Participants often seem themselves as "outsiders" and feel the discussion forums are "nice places to be on the internet 	 There needs to be a place to ask questions while the telescope and data infrastructure are figured out. Slack? Seeing the images that are getting a lot of attention is important Researcher's responsibility is to bring people along with the project. Launch is the most important part—people must feel like they are contributing and being listened to. Those who effectively use the discussion board will get the most out of their project
Data	 Need to facilitate conversations around how data is used. While many Citizen Scientists don't have programming skills, they are still interested in how the data can be used for astronomical discovery 	 A small subset of scientists will need daily updates (e.g. comets and supernovae) and the ability to parse the data quickly for followup. Increased timely data availability will cause a rush to other telescopes
Machine Learning	 Unsure if the machines are good at finding the weird objects. People would need to develop strong intuition if only receiving difficult objects. Don't cut people out of the process 	 There will be so much data that machine learning will have to happen—we can't look at this data a traditional way—imagine Z will have a part in figuring that out. Don't feel people will be upset about helping machine learning if researchers are up front about the science
Tools	 The SDSS database is not accessible—it took a whole group to understand how to use it. 	 Project builder has been a big improvement to the process—allows a researcher to focus on the user experience of the task. Need more discussions on how data integration will work with the project builder API integration will make image processing much easier—nobody has that type of disk space
LSST	 It would be nice to make the tools easier to navigate and find the right databases. Be open to changes and don't invest too much on a single thing—good to test with people. Guided Videos for more complex astronomical phenomena would be helpful e.g. transient objects 	 Unclear of what 10% of the data means. Don't want to compete with other citizen science projects. Feel that citizen science proshould be treated like any other research project. Be sure to talk to people who have actually done Citizen Science projects Will need better tools to help query the data.



Building Increased Interest in Citizen Science

Found project through social media / friends

- See friends sharing project
- See it on page of someone you follow

Found project by exploring topic of interest

This looks interesting

Found project through school, ISC, or scientist

- That was a fun activity
- That sounds like an interesting wan to help scientists

Note:

This process is from a PI and Moderator Perspective and not from interviews from actual citizen scientists

Classify images

- Am I doing this correctly?
- I think I've figured this out.

Read about the research

- How am I helping?
- What will this project provide to the science community?

Go to discussion board

- I want to talk about an image I think is interesting
- I wonder what people are talking about?

Leave and don't come back

- I don't get this task
- What is the purpose of this?
- Nobody responded to my question!
- · I'm not interested in the discussion.

Read content on the discussion board

- Is the conversation interesting?
- Is this a place for me?
- Do I know enough to contribute?

Feel welcomed and find a way to contribute to the conversation

- I've found a nice place on the internet
- I've found a way to contribute
- Wow, I actually get to talk/help the scientists

Read but don't contribute

- I like hearing what people have to say, but I'm not the sharing type.
- I'm more interested in learning how to do the task better.

Learn through the discussion with the community about tools/methods for classifying images

- How do the scientists look at this?
- Maybe we can answer this question ourselves by building a case with the right tools?
- How have people identified similar things in the past?





General Public

General Public Key Research Questions

Identity

+ Why do people engage in astronomy related content?

+ How do people see themselves when they engage in astronomy related content?

+ What identities to people see as available to them when they engage in astronomy relation content? What identities do they want, if any?

Areas of Interest

+ What astronomy experiences attract the general public? - Events, talks, tv programs, social media content,

+ What makes these different experiences attractive? What types of experiences do peo chose not to gravitate to and why?""

+ What types of participation are people interest in engaging in with regards to LSST EPO consuming science and discovery, participating in science and discovery, creating science and discovery?

+ What role do particular scientists play in people's interest in science and astronomy? W role are people interested in scientists playing? TED talks, videos, museum talks, etc. Science celebrity?

Desired Experiences

+ What are people hoping to accomplish or realize through their engagement with scient astronomy, and EPO content?

+ What are people's interests regarding the self-exploration of data and visualizations of data versus guided exploration? What are people's expectations and preferences?
+ What are people's thoughts around a fixed collection of knowledge versus a body of knowledge that is changing, updating on a daily basis? What might be different about he they would like to experience each?

Technology & Platforms

+ Where do people currently and in the future want to explore interesting astronomy data Website, app, xBox, PS4, other?

+ Where do people go today for updates in astronomy/science? Do people seek out updates or are updates sent to them? Do people want LSST EPO notifications/updates? What types would be desirable?

ated	 Discovery & Engagement Journey + What are people's journey from awareness through engagement? What activities characterize each step? + Where do people chose to deepen or step away from EPO experiences? What deter these moments? + What experiences do people feel especially passionate about? + What experiences do people view as annoying, repelling, or identify as something th choose to ignore?
ple	Projects
°O nce	+ What do people see as the relationship between different astronomy related projects people attend to more than one project at a time? How do people keep track of their interests across projects if they do?
What	Personalization + What does a personalized LSST EPO look like to people? Is it desirable? + Is there a desire to make a personal collection of visualizations? Where would people to view these collections? Computer, mobile, TV, etc. Do people want to share these collections? In what way?
ice,	
:	Sharing + Sharing content - what science EPO content do people chose to share with their frie social circles? What makes something shareable and share-worthy?
OW	The Future + How does the General Public envision engaging in LSST and EPO content in the futu + What do people imagine to be their particular desirable future?"
a?	





Recruiting Criteria

Washington, DC Area & Chicago

- American Indians and Alaskan Natives
- 2 bilingual family with middle school or high school student who enjoys science
- 2 persons 20s-30s tech savvy, active on social media
- 2 persons 40-60s

We are looking for participating households in each city with at least one person in the household who is engaged with Astronomy:

- community or club related to astronomy, shares interest in astronomy with others)
- centers)
- experience, perhaps some occasional engagement with major headlines

• 4 families with teens – traditionally underrepresented groups in STEM: women, African Americans, Hispanics,

• (4 sessions) High-engagement -- for example: amateur astronomers (goes to star gazing parties, belongs to a

• (4 sessions) Some-engagement -- for example: armchair astronomers (follows space news sites, watches sciencerelated programming, follows science and astronomy content on social media, visits planetariums and science

(2 session) Open to engagement -- fond associations with astronomy or science generally, often from past positive

General Public Overview

Research Insights — General

Identities

- Having an interest in Astronomy means you are thinking a bit outside the box and interested in a world beyond yourself and everyday experiences. It's a bit unique.
- Looking for content rich experiences to share with and engage people in their lives — children, significant other and friends, nieces/nephews
- Many see Astronomy as filled with metaphors for the human experience "An understanding of we've all had that dark matter pointed in our lives. We've all had asteroids hit our lives."

Technologies

- People expect that there will be apps for Astronomy experiences.
- Almost everyone has an augmented reality sky-viewer
- app
- People spend most of their discretionary time on their phones and tablets. Computers are for school activities and deeper research.

Chicago



Martazsh





Research Participants

Lisa & Christian (16)

Starr & Laila (13)



Anna



Frances





DC Area

Marialuz & Luz



Jose



Tykesha + Kirsten



General Public Overview

Research Insights — Adults with Children

- See Astronomy as an opportunity to broaden their kids' perspective on the world, help their kids have a sense of perspective and scale — both significant and insignificant in the bigger picture
- They are very busy. and using their limited free time activities need to be valuable, entertaining and not too demanding.
- Looking for enjoyable activities to enrich their children's lives and broaden their opportunities

Research Insights — Kids

- Looking for deeper engagement into astronomy topics of their interest than they are getting at school.
- In some cases directly involved in programs to support under-represented people in STEM
- Have positive experiences with immersive video games and/or VR

Chicago



Martazsh





Research Participants

Lisa & Christian (16)

Starr & Laila (13)



Anna



Frances



Esther & John (13)



DC Area

Marialuz & Luz



Jose



Tykesha + Kirsten





Websites

NASA



Astronomy Picture of the Day

nost linch day a different image or photograph of our fastinating universe is featured, along with a brief explanation written by a professional astr 2017 February



Typically people do not start at the NASA page.

They follow links from social media or news headlines to specific NASA pages.

Some people do have and use the NASA app.

NASA is seen as a highly trusted resource.

Some people are familiar with APOD, but either follow APOD on Facebook, Instagram or have the app.

Astronomy Picture of the Day

ALMA Kids



Shared with people who also speak Spanish at home, specifically to talk about sites in multiple languages. No interest in this particularly from our participants.



Citizen Science Experiences

Galaxy Zoo

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		suve Is the galaxy simply smooth server	nand noundes), wiff moster of a disk?	

Some participants were very excited about Galaxy Zoo and wish someone had told them about it.

The idea of being the expert on a classification task and helping scientists was compelling.

Other participants felt less confident in their ability to provide good input.

SDSS Object Pages



The transition from Galaxy Zoo into the SDSS Object Pages was jarring for everyone.

People are interested in learning more without being confronted by unknown vocabulary and indecipherable numbers and graphs.

Web-based Sky Viewers

100,000 Stars



People enjoyed the ability to move through space and experience the vastness of our galaxy. People also wished it contained other things besides stars.



World Wide Telescope



People were open to exploring WWT but generally were note able to make sense of WWT's interface.

People did not respond with delight, but sometimes with interest.

Augmented & Virtual Reality

StarWalk 2



People loved seeing StarWalk2. They were excited to be able to see the stars even when it was either daytime or too bright in the city to actually see the stars.

Many participants also have augmented reality star viewer apps.

We tested this experience in Chicago. Both adults and kids enjoyed the experience and often times we had to ask for the device back. They inquired about price and how to get it.



It was seen as personally relevant, empowering and meaningful.

StarChart VR



We tested this experience in the DC area. This VR experience included a pointer which added interaction complexity and also additional control and information.

The learning curve was a bit longer on this experience, but people continued to be excited and interested to navigate the solar system and galaxy on their own volition.



General Public Research Cards - Activities



Activity Groupings

I do this now	I would like to do this in the next year	I would like to do this sometime in the future.
Awareness, Interest, Inspiration	Motivation, Interaction	Participation, Engagement, Commitment
Pictures	Personal Research	Observatory
YouTube Videos	Sky viewer	Database
News Headlines	Interactives - computer	Teach in Community
Apps	Space Simulations -computer	Podcast
Websites	Celebrity Social Media	Astronomy Club
TV programs	Magazines	Discussion board
Planetarium	Astronomy Talk in person or long video	Citizen Science
	Talk with Friends	Spectrum of Engagement
	Star Party	Intensity of En
	Follow on Social Media	
		Awareness Interest Inspiration Motivation Interaction Participation Engagement Number of People Engaged



General Public Research Cards - Topics



Activity Groupings

Familiar & Interesting	Familiar & Less Interesting	Less Familiar	Difficult to Understand
Within our realm	Known but less compelling	Known but not compelling	More abstract & eerie
Origins of the Universe Solar System Exoplanets Mars	Constellations Telescopes & Observatories	Super Nova Nebula Expanding Universe	Dark Energy Transients Dark Matter
Galaxies			Not So Interesting
Milky Way			Unless one comes to hit us
			Asteroids



Educators

Educators Key Research Questions

Identity & Motivation

+ Why astronomy? Why do teachers chose in include astronomy content in their classroom - especially in non-astronomy specific classes?

+ What knowledge, understanding, confidence, etc. must teachers have in order to adopt LSST content? How is knowledge,

understanding, confidence distributed between teachers, students and EPO?

Teaching & Learning -- Current Classroom

+ Content and tools teachers currently use in their classroom for science and astronomy education

+ Content experiences and tools that teachers have invested time and energy into that have not been successful for them - that they would not do again and why

+ Evaluation of learning -- what must students learn, be able to do in order for EPO to be successful in the classroom?

+ LSST EPO Personalization to specific classrooms, specific learners -- what is the granularly of personalization/customization that is useful?

+ Role of cross-disciplinary content in the classroom - STEM to STEAM?

Students

+ What does engagement look like for students? How do teachers foster student engagement in physics, math, astronomy? + How do teachers determine what curriculum/content is going to work in their classroom? How do they determine what their students are capable of conceptually, pedagogically, practically? What is the relationship between student capability and EPO content delivery? + What are the students doing? What activities, actions, thoughts, feelings are we looking to support in the students? e.g. What does doing research and doing queries on the LSST data look like? + What student identity formation around science do teachers want to support in the classroom? For example how important is it that students see themselves as scientists, participants in science, consumers of science information?

Content Resources

+ How does content act as a context for learning fundamental scientific principles? + What types of learning is astronomy content good for at this grade level?

+ What concepts must astronomy content illustrate to be successful in middle and high school classrooms? In college classrooms? + Characteristics of representations to scaffold learning

- - + tables
 - + graphs
- + what else?

+ How do teachers think about the match between EPO experiences from a pedagogical perspective -- priorities? For example, I will use this because it is a good example of inquiry based science, versus it enables the learning of these concepts, versus it is good enough and works well in my classroom environment with my students? + How important is it to teachers that students authentically participate in scientific research versus in environments optimized to realized pedagogical goals? Scaffolds for learning versus scaffolds for research participation? {citizen science question} + Does having specific people - astronomy researchers - as part of EPO content have an impact on student engagement? When is it useful to have specific person or persons versus a more content centric approach?

Expertise & Professional Development

+ What role do teachers see teacher professional development playing in their use of EPO content and materials? What PD experiences do they most value? Least value? What are the characteristics of successful/unsuccessful PD experiences in person? Online? Other? + How do teachers manage need for expertise in a topic or tool? What expectations do they have for what expertise the EPO content provides versus what expertise they provide?

Classroom Environment

+ What must online resources do or be like to be successful in the classroom environment?

+ What are the characteristics of EPO experiences that function well in the classroom environment? What are the most important characteristics?

+ What does it look like to have LSST has a partner in the classroom?

+ What are the specific qualities and characteristics of the school and classroom environment (if any) that may contrain how EPO engages teachers and students versus other audiences? + Is there value in connecting students/and or teachers with other classrooms also engaged in EPO activities? What sorts of connections are desirable, effective, supportive?

+ What is the best way to structure EPO content to be successful in the classroom? In many classrooms? What expectations do teachers have for EPO content? What specific things do teachers want -- e.g. complete curriculum of some duration, short videos, visualizations and tools, etc. What has been most successful for them in the past? examples beyond astronomy -- ""hour of code""?

Future Classroom & Learning Environments

+ The classroom on the future -- 5 years from now what do you see yourself doing? what do you see yourself not doing or not using that you use today?

+ Big data, data science, computer science -- how are educators thinking about these emerging areas that are relevant to LSST? To a new aspects of astrophysics?

+ The future of LSST & science EPO in the classroom -- remote access, tools, data, tasks, sequences, framework?

+ What role might citizen science play in the classroom? And more specifically Zooniverse and Zoo talk? How might student engagement in Zoo talk impact the current communities? How has it in the past?"



Education Overview

Research Insights — All Classroom Teachers

- Busy. Teachers are very busy. They do not have time to pick and use the wrong new experience.
- Student Motivation is Key. Looking for experiences that motivate their students — about the students, social, authentic audiences and interactions
- Easy, Engaging, Lessons. Looking for lesson ideas that make sense from their perspective, are easy to use and allow for some flexibility to adapt to their particular students, class and objectives
- Hands-on VR. VR exploration of space is seen as a possible hands-on activity — very interesting to explore in the classroom context

LeeAnn







Teaching Elective Astronomy Courses in High School



Nora - TBD



Teaching Middle School Science

Shana





University Educators involved in Education & Public Outreach and Broader Impacts

Vicky Kalogera Northwestern

Raffaella Margutti Northwestern

Michelle Paulsen Northwestern



Aaron M. Geller Northwestern & Adler **Brice Ménard** John Hopkins





Teen Program

Nathalie - Adler

EPO Director

Marllory Fuentes Salazar University of Concepción



Education Overview

Research Insights — Teaching Elective Astronomy

- Love Astronomy. Teachers who teach Astronomy electives love Astronomy.
- Informal and formal resource networks. Ability to engage external resources such as astronomers, EPO programs, grant funded activities.
- **Expertise.** Have expertise in Astronomy and teaching Astronomy to students
- Some constraints. Standardized testing not a focus, but still can constrain choice activities
- Like NGSS. Excited by opportunities presented in NGSS for great teaching
- Collaborate. Collaborate with colleagues to cross cut eg. math + science
- **Student Learning.** Assessment = evaluating student learning
- Project and Opportunity pipeline is primed don't have to look for EPO and other classroom opportunities, these opportunities come to the school or the teacher and the teacher focuses on picking
- Teaching scientists-to-be. Preparing students to study science in college through authentic research experiences

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Education Overview

Research Insights — Title One + Charter Middle Schools LeeAnn

- Scores drive funding. Student test score drive school funding, opportunities for resources and even if school will stay open.
- Math Skills Needed. Science teaching can require supplemental teaching of relevant math skills such as graphing, fractions and rounding.
- Not always experts. Do not necessarily have domain expertise in Astronomy or even science more generally
- **Reduced Choice.** State, county, department heads, standards and testing requirements all drive curriculum choices
- Challenge to maintain student engagement. Teachers work hard to connect science learning to students everyday lived experience — e.g. focus on future employment, connecting to
- Focus on addressing student "learning styles" primarily focused on hands on direct learning,
- Avoidance of abstraction, complex vocabulary, long lessons
- Text books and set resources. Textbook-driven instruction and primary focus on the set of content resources approved and provided by the school, district, state
- **Assessment = testing**
- Social Tools. Using social media such as Pinterest to find classroom ideas and and twitter to connect with other teachers





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Adding New Experiences to a Classroom

New Experience

Who are my kids? What are they interested in?

Survey - Learning Styles Collaboration - Group or self learning

Go Online & Check It Out.

Do I like this? Themes? **Objectives**?

What are the tools? Not too scripted Flexible?

If It Fits Students and the Program Get School Buy-In

Time, year, does it work for my work load personally?

How much time outside classroom for me & students?

Budget? Funding?

Fit what we are doing more broadly in the school community?

Does it work better as an after-school club?

Standards Application

How does it align with NGSS including content?

Are there opportunities for cross-cut learning?

How long is the experience?

Weeks? Month?

Can I fit it in my plan? Is it flexible enough if my time is different?

Assessment

How will I grade my students?

Work habit?

Formative assignment/ homework?

Summative – test. project presentation?

Testing knowledge?

Approvals

Share with department for content approval

Principal for student logistics & safety related concerns

Principal for any requests regarding professional development - time off, credits, etc.

Logistics

Request space and/or equipment if necessary

Consent forms

Background checks for any volunteers

Getting materials

Finding additional resources when necessary

Success

Good student outcomes.

Press release

Funding/affordable invited to do it again

Student reflections on experience

Impact on significant number of students


Education Overview

Research Insights — Northwestern Group

- Computational thinking EPO. Currently working on an initiative to bring astronomy data sets to science clubs, after-school science clubs and involve high school students into learning about data science programming, and getting some research experience through access to research level data sets. The idea is to develop things on websites, make data sets available across the country, and involve as many schools and teachers as we can.
- **Teacher EPO materials** useful and relevant materials and training collaboratively created with teachers to bring in LSST data and embed it in activities in their classrooms in some way that
- Teachers must lead collaborations. 'To form a healthy partnership, long term partnership with the teacher and have them agree to bring in this graduate student to the program, we have tell them that they're not going to change their curriculum. You've got what your district, your school, the state, national standards and that spelling out, we're not gonna try and change that. We're gonna try and find ways to fit the student's research into what you're already planning to do.'
- Be Aware of the Curriculum. Must be aware of what is part of the curriculum and support this — for example conducting a full research project may not be part of the curriculum.
- **Explore Data!** Team sees intrinsic value in people exploring data
- Evidence based decision making. Key EPO Objective. 'Enable people to take evidence, true evidence and utilize it to make a decision. It's a process that we all just thought happened very naturally but it doesn't."
- Question chain. Looking to support 'the chain of I get an answer and the answer gives me another question and I keep going this way."

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Education Overview

Research Insights — Northwestern Group

- **EPO Struggles.** It has been a struggle to run the Reach for the Stars program, where a graduate fellow is placed in a classroom, in struggling classrooms. Very important to plan to keep students' innate interest. Fellows prefer AP science teachers to teachers in struggling classrooms.
- Building Teacher Confidence. Classroom teachers need confidence to introduce new software, simulations, etc. to their classes. The graduate fellows were helpful with this.
- Scale Challenges. Ongoing struggle with the ability to scale education programs for broader impact.
- Material Challenges. Our lesson materials for teachers today are hard to find and text heavy. We are working on this — moving to better find-ability, teaching videos, and ability to share references more easily.
- Successful Simulations. The most engaging simulations for learning are ones where the student can pick up and play with it and explore on their own and interact to experiment and try to make a discovery or figure it out. Enabling students to have a-ha moments.
- Domain Knowledge vs. General Science Literacy. When students become directly involved with a research domain knowledge becomes as important as general science literacy - learning the process of science
- **Re Citizen Science** Classifying tasks on their own do not necessarily develop critical thinking, active discussion forums that support debate are also necessary Thoughts about how tasks might vary and sequenced differently in the future with LSST data

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