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Eclipse from Micronesia

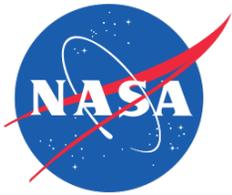
Webcast dissemination and impact

A summative evaluation report

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An evaluation study sponsored by the Exploratorium

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Abstract and citation

Abstract

The Exploratorium hands-on science museum in San Francisco collaborated with NASA and the National Science Foundation to produce a live webcast of a total solar eclipse from the Federated States of Micronesia on March 8/9, 2016. The live feed webcast was embeddable and available for broadcast use. A successful digital dissemination strategy of “many channels and a mobile app” provided high-quality STEM education content about solar science to over one million people. External evaluation finds the project combined technical production capacity, extreme competency in promotion through social and conventional media, and commitment to education and outreach programs. All proposed activities were implemented as intended.

Citation

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Main Findings

Summary

The Exploratorium clearly demonstrates capabilities to implement a new strategic approach using digital media to effectively engage learners in NASA and NSF STEM education priorities.

Total Solar Eclipse: Live from Micronesia is an informal science learning project at the Exploratorium in San Francisco jointly funded by the NASA Science Mission Directorate (SMD) and the National Science Foundation Advancing Informal STEM Learning (AISL) program.

With resounding success the Exploratorium team transmitted a live webcast of a total solar eclipse on March 8/9, 2016 from Woleai, a small and extremely remote island in the Federated States of Micronesia, a US affiliated Pacific Island nation.

The project used this unique solar phenomenon to provide high-quality STEM¹ education content about solar science to a large US and international audience using multiple platforms including: integrated video, social media, and public programs.

With confidence the Exploratorium demonstrated: (1) technical **capacity** to produce and transmit a live international webcast, (2) **competency** to promote the event through social media and coverage by prominent media, and (3) **commitment** to education and outreach programs sponsored by the Exploratorium, by providing live and embeddable content for programs at partner museums.

A detailed, rigorous, and comprehensive external evaluation shows clear and consistent evidence of success in **production, promotion, and programs** around the 2016 total solar eclipse in Micronesia.

The Exploratorium is positioned to become the go-to provider for the live webcast of eclipse content for the total solar eclipse occurring in the United States in August 2017.

The project should be considered a priority for continued national investment due to its commendable progress and extraordinary potential. The risk associated with future investment is modest whereas the potential reach and return is very high.

¹ STEM is an acronym for **S**cience **T**echnology **E**ngineering and **M**athematics.

Findings

Promised vs. Produced

This report presents an implementation evaluation to assess whether strategies were implemented as planned, and whether expected outputs were actually produced as proposed. Evaluators compared proposed goals to project activities and outcomes. In-depth interviews with Exploratorium staff, document and deliverables review, and external assessment by outside experts show that **all proposed activities were implemented as intended.**

Dissemination

PRODUCTION

- Multiple channels and mobile effectively used to reach over one million viewers
- Highly successful live webcast produced by mature teams who work well together
- Mobile app shows strong potential to promote STEM content and social interaction
- External reviewers rate webcast and website very high across all dimensions

Webcast Ratings	
Stream	★★★★★
Picture	★★★★★
Sound	★★★★★
Interest	★★★★☆

PROMOTION

- Exploratorium press office shows well-planned and comprehensive promotion
- Social media – intentional and organic – shows wide reach
- Eclipse video picked up by over 50 prominent broadcast or online media outlets

Website Ratings	
Quality	★★★★★
Usability	★★★★★
Learnability	★★★★★
Interest	★★★★★

Impact

EDUCATION

- NASA provided knowledgeable experts and scientists who were able to present correct information in a hands-on way that was interesting, relevant, and fun
- Live broadcast and produced videos presented basic and advanced STEM content

OUTREACH

- Spanish-language broadcast prioritized bilingual–bicultural Latino audiences
- Education outreach served nearly 1,000 K-12 students in Yap and Woleai

Recommendations

PRODUCTION

- Continue exemplary efforts to prepare, practice, and obsess over planning
- Agree early on broadcast resolution(s) for 2017
- Aggressively continue refining, testing, and promoting mobile app for 2017

PROMOTION

- Wide promotion by the Exploratorium press office is critical to distribution
- Expand contact with key people at media that featured the eclipse in 2016
- Promoting videos produced by the Exploratorium works – 92% of views were promoted videos
- Exploratorium name recognition is high. Sentiment is positive on Twitter. Actively encourage more references to NASA and NSF to further increase name recognition
- Aggressively partner with prominent broadcast or online media outlets
- Recruit high-value authors and journalists to promote Eclipse 2017
- Define important audiences who emerged in social media analytics – for example women ages 25 to 35

Impact

EDUCATION

- Make STEM content clear to all viewers simply and clarify unfamiliar terms
- Define new concepts for non-scientific audiences. Review vocabulary to create a concept inventory – a list of new terms associated with main ideas
- Scaffold new terms and test the script for content understanding by non-scientists

OUTREACH

- Prioritize even more bilingual–bicultural Latino audiences as “top of mind” audience
- Strengthen promotion and partnerships within the informal science learning community
- Build on viewer interest in local culture and geography

Dissemination

AT A GLANCE

- The Exploratorium achieved and exceeded its goal of reaching one million viewers
- 916,712 combined views March 8 alone
- 696,700 views on NASA TV / UStream
- 457,387 YouTube views
- 106,883 views of Exploratorium produced videos
- An innovative mobile app received over 41,000 screen views
- Promotion and organic social media are key to broad dissemination

EVALUATION QUESTION

The Exploratorium asked evaluators to help answer a simple but rich question: Is our digital strategy of many channels and mobile effective? The answer is yes.

In more formal parlance: What is the efficacy of the Exploratorium's strategy to broadly distribute STEM content through promoting and distributing a live webcast of a solar eclipse and produced videos over multiple online channels and apps for mobile devices?

SUMMARY

On February 22, 2016 Robyn Higdon and Dr. Paul Doherty of the Exploratorium boarded a plane in San Francisco bound for the Western Pacific island of Yap, capital of the Federated States of Micronesia.

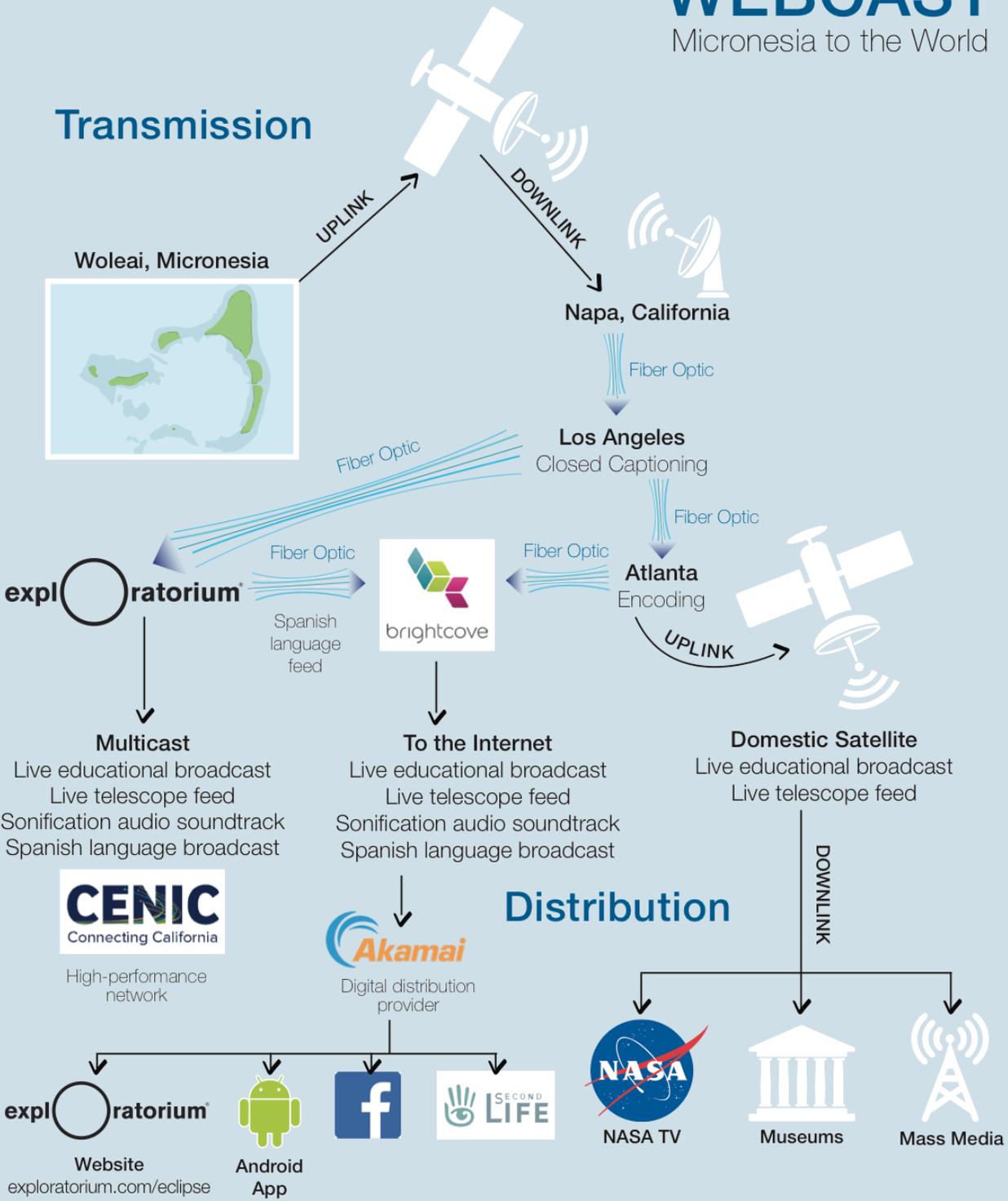
Several days later Interim Director Dr. Rob Semper and a production team of 20 technicians touched down in Yap, marking the start of an odyssey to transmit a total solar eclipse to over one million viewers in countries across the globe. On March 9 at 1:00 am UCT (March 8 at 5:00 pm in San Francisco), the team began the fifth successful broadcast of a total solar eclipse by the Exploratorium since 1998.

The Exploratorium eclipse webcast from Micronesia provided and provides a valuable STEM education resource and demonstrates impressive potential for broad dissemination of the webcast of the 2017 eclipse in the United States.

WEBCAST

Micronesia to the World

Transmission



Numbers Served

The project compiled metrics based on data from Google Analytics and social media metrics. Also other measures were provided by project partners, for example, Brightcove video publishers and Android app metrics. Evaluators did an independent review that verified metrics and measures provided by the project.

Although it is difficult to authoritatively calculate the number of people and geographical locations reached by the project, it is fair to say the eclipse webcasts and Exploratorium produced videos reached a total of over one million viewers in the United States and internationally.

Measures below provide evidence to support the efficacy of the Exploratorium’s digital strategy of “many channels and mobile.”

Views by Channel – March 8, 2016

Channel	Number	Measure
exploratorium.com/eclipse	55,647	Views
Live Feeds: programs, telescope, sonification	55,647	Live Views
Exploratorium Videos	21,492	On Demand Views
NASA TV	21,700	Peak Views
UStream.tv/NASA	675,000	Views
Android App	41,069	Screen Views
Total	870,555	

Social Media – Agency and Organic

Measure	Number	
Reach	2,970,123	
Likes	44,513	
Comments	965	
Shares	6,909	
Clicks	14,138	
Video Views	84,933	
Posts / Tweets	190	All Platforms
Vine Loops	13,148	BBC World
Agency and organic combined effect		

Video Views – March 31, 2016

Measure	Views	
YouTube	479,990	25 channels
Brightcove	112,482	30% 'Totality Highlights' Video
Produced Videos	106,883	92% of views from promoted videos
Total	699,355	

Android App – March 8, 2016

Measure	Number	
Users	3,309	60% new users
Sessions	4,981	44% Indonesia, 25% US
Screen View / Session	8.25	Indicates active use
Session Duration	6:17	Average
39,310 app downloads as of March 31, 2016		

Media Coverage



The New York Times

The Washington Post

Chicago Tribune



Palm Beach Post



Newsweek



the guardian



GeekWire

AccuWeather.com®

The Street

GIZMODO

MAXIM



YAHOO!
NEWS



inhabitat



OVER 50 PROMINENT US AND INTERNATIONAL MEDIA OUTLETS FEATURED THE ECLIPSE WEBCAST

KGO 7 Local Partner

A partnership with local San Francisco ABC affiliate KGO 7 proved effective and beneficial for the Exploratorium and for KGO 7. KGO 7 was very active in promoting the event in social media prior to and on the day of the eclipse.

The project leadership also reports that “for the first time in their history, they [KGO] preempted their national news to bring an hour-long special on the eclipse. They’ve never done that before, and we got great amazing feedback from them. We expected that they would do a story on us but the fact that they went just all in was surprising and very risky on their part and they reported great success.”

Promotion

The Exploratorium press office plays a critical role in increasing the reach of digital content.

The Exploratorium press office showed well-planned and comprehensive promotion through press releases, social media, agency-directed paid advertisement on Facebook and a Google ad words grant.

Social media – intentional and organic – showed wide reach. Posts by the Exploratorium were professional, concise, creative and conversational. Comments, shares, and likes showed broad engagement and interest in the topic.

The Exploratorium Facebook page promoted the Eclipse webcast and public event beginning in late February and increasing during the first week of March. The clever use of information and promotional posts combined with produced educational videos featuring scientist Dr. Paul Doherty. Two Facebook advertisements gained wide exposure. An external evaluator asked: “Who maintained the Facebook page? Because that page is well-maintained.”

On Twitter 68 tweets by the Exploratorium produced 1,110 retweets. Between March 1 and 8, 2016 over 11,000 cumulative tweets reach 78,132 followers.

Deep analytics of 70,000 eclipse-related tweets by IBM Watson² showed consistent interest in the topic by prominent media for example, @Wired, @CNN, @WSJ, @NYTimes.

Edu disaggregated marketing data and audiences by researching 100 posts, news headlines, or bylines reported by the Exploratorium press office. ‘Media Type’ represents the category or topical focus of media outlets that publicized the eclipse. The majority of media types were broadcast media or general news, although science geek writers and informal science providers made up one third.

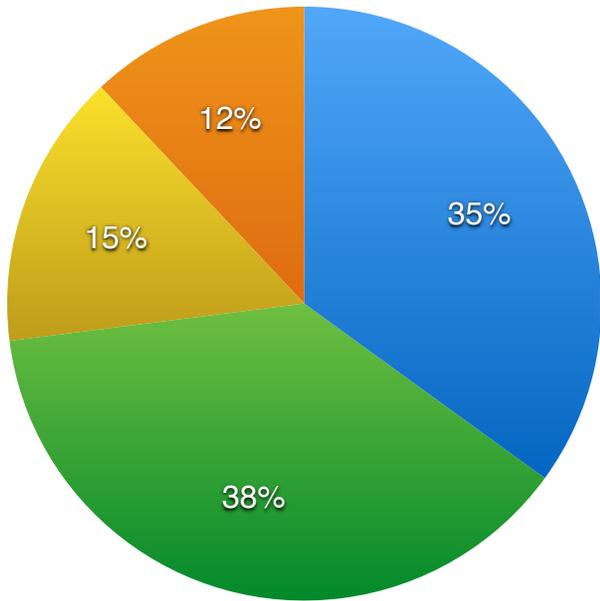
‘Audience Interest’ describes the intended audience of media outlets that covered the eclipse topic. Half were general audiences, 39% focused on tech. Business, lifestyle, and women were small but important audiences.

Almost two thirds of media providers were national, one quarter Bay Area, and the remainder international. Promotion was spilt between intentional (press releases) and organic.

² IBM Watson is an IBM supercomputer that combines artificial intelligence and sophisticated analytical software to answer questions. Watson uses natural language processing and machine learning to reveal insights from large amounts of unstructured data.

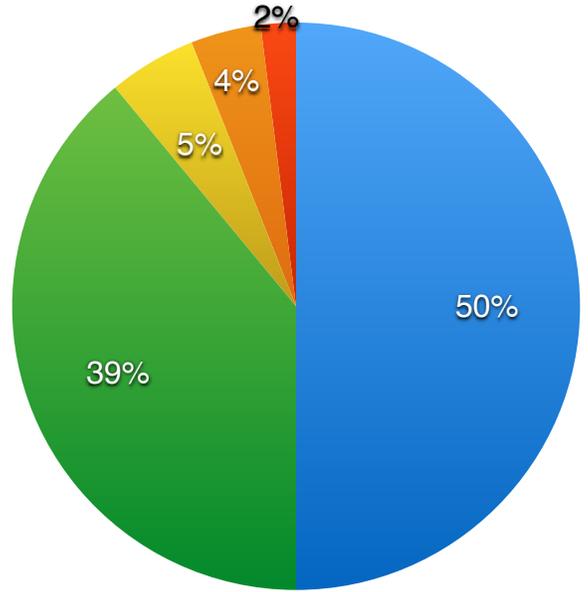
- General News
- Broadcast
- Informal Science
- Science Geek Writers

Media Type



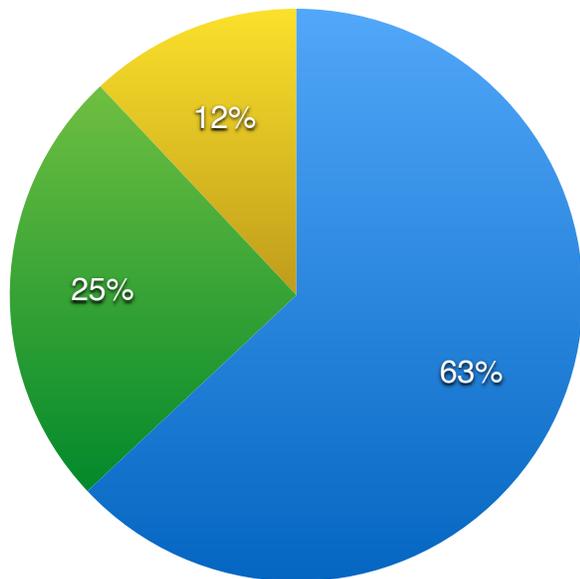
- General News
- Tech
- Business
- Lifestyle
- Womens

Audience Interest



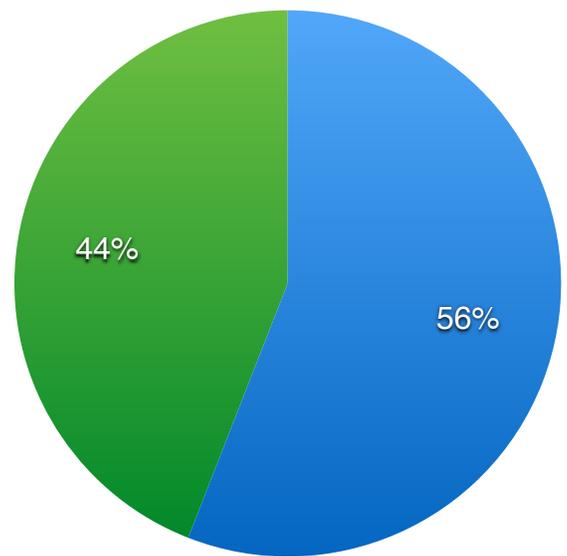
- National
- Bay Area
- International

Location



- Press Release
- Organic

Promotion: Press Release vs. Organic



Social Media – Deep Analytics

IBM Watson analyzes tweets

Edu used IBM Watson social media analytics service to do a formal concept analysis of unstructured text data from social media posts on Twitter. The objective was to understand the themes, trends, concepts, and location of posts on solar eclipse topics in the first 10 days of March 2016.

Social media analytics gathers and analyzes data from social media services to provide insight into the tone and sentiment of the conversation on a topic. The Watson service is structured way of deriving an understanding of the main categories, patterns, concepts or themes within a large data set.

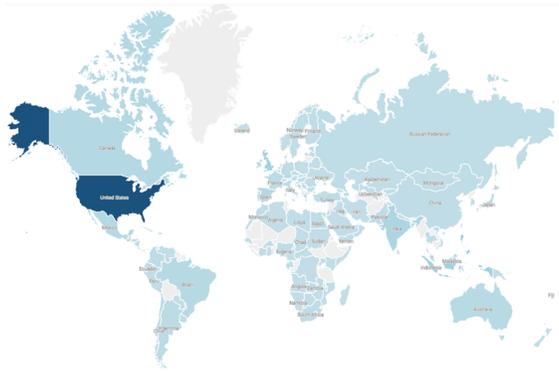
Eclipse topics most active on Twitter

Twitter had a large and more active conversation about eclipse topics than Facebook. IBM Watson³ analyzed eclipse related posts from across all of Twitter between March 1 and March 10, 2016. Watson analyzed 70,000 tweets that mentioned topics related to: solar eclipse, NASA, Exploratorium, #Eclipse2016, #Eclipse2017, totality, Micronesia, and Woleai. Review of a large sample of tweets by two human evaluators corroborated Watson's analysis.

We asked Watson to analyze the concepts contained in topics covered in eclipse related tweets. Watson returned data sets with these insights highlighting these key trends:

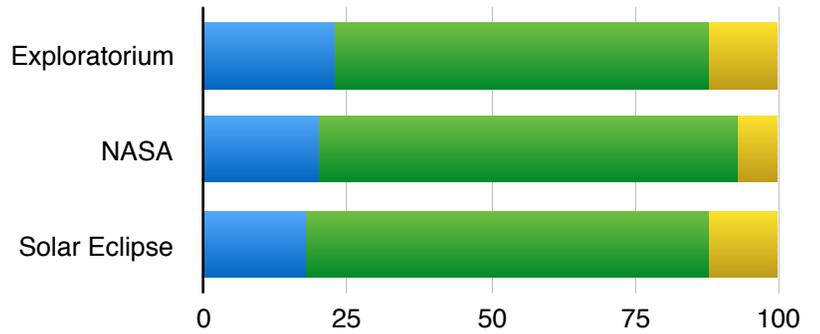
- Conversation size grew quickly based on retweets by prominent media
- Sentiment was positive and Exploratorium name recognition was high
- Geography – The majority of English language tweets came from the United States although the conversation was global – especially Indonesia and south Asia
- Source Demographics – gender when recorded was majority male but women made up a solid minority – especially those ages 25 to 35.
- Authors, followers and shares – @Wired, @CNN, @WSJ, @NYTimes were active in the conversation.

IBM Watson Analytics



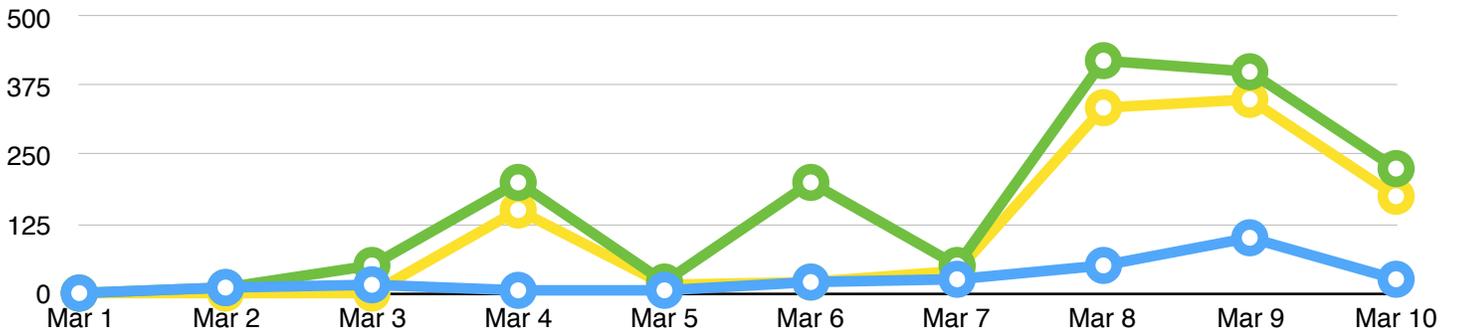
TWITTER CONVERSATION TOUCHED 87 COUNTRIES

Percentage of Mentions by Gender



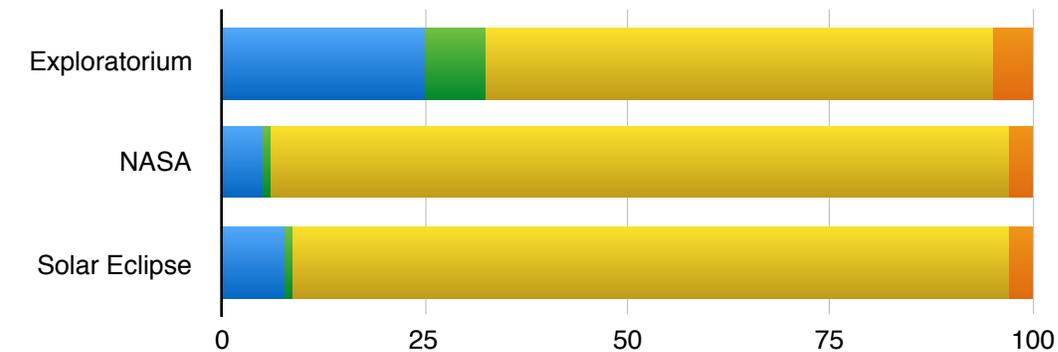
MORE MEN TWEETED THAN WOMEN

Share of Voice Trend (mentions per topic)



TWEETS INCREASED TO PEAK ACTIVITY THE DAY OF THE ECLIPSE

Sentiment Percentage by Topic



SENTIMENT WAS POSITIVE OR NEUTRAL. EXPLORATORIUM WAS THE MOST POSITIVE TOPIC.

Production

Resounding Success

The highly successful webcast from an extremely remote atoll in the Western Pacific once again demonstrates the Exploratorium’s ability to plan and execute a complex and multifaceted project. Interviews with the production team documented success and lessons learned from onsite production, transmission, and broadcasting of the stream. Staff shared best practices, challenges encountered and how they were addressed, and implications for 2017.



“It’s really something, to be able to transport this material to a place with no infrastructure at all, no connectivity to the outside world for Internet, no power, and actually do it. I’m really proud we did it.”

Producer Robyn Higdon on transmitting from Woleai

LOCATION

The broadcast site on Tullolop Island in the Woleai Atoll in Yap State, Micronesia is 6,000 miles from the Exploratorium in San Francisco. A 20-hour flight and 48 hours onboard a ship delivered the production crew to an eight-mile atoll with no power, internet, or stores.

Crew from the Solitude One live-aboard vessel transferred gear from the ship to a smaller skiff, and then unloaded it onto the beach. Local Woleaian high school students loaded all the gear from the beach onto a pickup truck and drove it out to the broadcast site on an abandoned World War Two era runway. Set up was efficient; all the gear was docked and onto the runway within four hours of landing at the beach. Two days of setup, testing, and rehearsal followed.

Looking ahead to multiple sites planned for the transmission of the 2017 solar eclipse from Oregon and Wyoming, Producer Robyn Higdon said, “It’s a complex thing in 2017 with two different sites and so we’re really looking forward to doing the two sites. Two sites are better than one, especially when you have just a couple minutes totality. But having two separate places doing this is going to be a really interesting dance of coordinating and doing the rehearsal.”

POWER

Producers brought backup generators to provide electricity. When they arrived at the atoll they discovered that local generators were unexpectedly not working, but the team had ample power courtesy of their backup equipment. The team also placed several 12 volt batteries in series to power a telescope when its power supply failed.

TRANSMISSION

The team's satellite people successfully managed the transmission path logistics. Having this team in the field proved useful. For example, the team needed to make an unexpected decision regarding whether to transmit the webcast satellite signal to Napa, California, or Singapore. The crew decided to have both routes ready to go and on standby. As the transmission date approached it appeared the Napa reception site might be going offline during the eclipse window, a potential obstacle that posed no problem since the satellite team had already set up the Singapore path.

FEEDS

The digital signal stream leaving the eclipse site in Woleai, Micronesia contained three digital feeds: a one-hour live educational broadcast, a three-hour live feed of solar images from an array of four telescopes, and sonification – a live audio track converting real-time images from the telescopes into a sound composition created by Exploratorium staff member Wayne Grim. A live Spanish language broadcast was added at the Exploratorium.

VIDEO RESOLUTION

The broadcast specification called for 720p HD resolution. Satellite transmission equipment originally set up by contractors for 1080p resolution had to be unexpectedly modified in the field. Within two hours the crew successfully downgraded the outgoing signal resolution to 720p, allowing throughput to the museum and broadcast partners.

Signal resolution is an important variable. First the team had to ensure the bandwidth capacity of all sites receiving the raw feed could support the resolution of the incoming signal stream. Resolution affects image fidelity from cameras and telescopes. Video engineer Aaron Rosen created custom high-definition, high-dynamic range video cameras that showed a view of totality and the corona very close to that seen by a human eye.

However, the ideal resolution for broadcast and for streaming may be different. Scientists and specialists of the world want the very best highest resolution, but the home or mobile viewer may prefer a lower resolution stream for smooth viewing. To paraphrase producer Robyn Higdon, “We have a really wide range of people we’re trying to reach and appeal to and be usable for. There are discussions around streaming the 2017 eclipse webcast in 4k (very high-resolution) which people like for broadcast but can get expensive for streaming and cause reception problems for people with lower bandwidth.”

Lessons Learned

HAVE ONE PERSON CLEARLY IN CONTROL

Telescope Image Orientation – During a transmission testing window from Micronesia a staff member at the Exploratorium commented to the tech people in the field that “images of the sun weren’t oriented correctly.” Telescopes positioned the prominence at 12 o’clock rather than at 2 o’clock to match Solar Dynamics Observatory (SDO) a major NASA creator of imagery—who oriented their telescopes to put that prominence at 2 o’clock. To prevent hours and hours of technical scrambling in the field, the producer was able to intercede to address the most critical things first – making sure that the telescopes matched each other and, because telescopes flip images, ensuring images were uniform in terms of what was facing up and down, and then addressing orientation. The takeaway – being clear on who’s going to make those calls is important.



“I was shocked at how well everything worked and I think it’s because we had really great experts in the field and because we spent a lot of time in preproduction technical meetings and going over things again and again.”

Producer Robyn Higdon

MAP POTENTIAL FAIL POINTS

Obsess and Test – The producers reported that “we drove people crazy, going over things looking for points of failure. What happens if this happens? What happens if that happens? It really paid off.” Nicole Minor, who led the in house production team at the Exploratorium, recounts two “incredibly successful field tests” with minimal communication and short satellite phone conversations to address technical issues. Tests addressed: how did the telescope images look? The camera angles, the exposure, the background, sound quality? Project Director Rob Rothfarb managed the app and signal path transmission tests. Minor

said, “The day of... we were thrilled. The telescope images were beautiful and everything was just looking and sounding great.” The takeaway – pay attention to details.

REHEARSALS ARE IMPERATIVE

Practice, practice, practice – Senior Scientist and presenter Paul Doherty said, “we rehearsed and rehearsed and rehearsed and we really got it down and thank goodness we did, because on the day of the eclipse, there were clouds. We were able to just react and change dynamically. We switched to the NASA story, the story of the Magnetospheric Multiscale Mission (MMS) mission to the sun which was scheduled for after the big events.” Because the team had the timing and the order firmly in their minds, they could change order to a presentation to fill in the gaps when the actual phenomenon was blocked by clouds. The takeaway – multiple rehearsals really help.

RESOURCE FOR INFORMAL SCIENCE LEARNING COMMUNITY

Broad Outreach – The Exploratorium eclipse live broadcasts and produced videos provide content for knowledgeable people in museums to use as they see fit. Dr. Doherty calls it “raw material that they can use.”

Quality of Experience

Expert review of the webcast is positive

Eight evaluators across North America monitored and reported video streaming Quality of Experience (QoE) during the live webcast / broadcast on March 8, 2016. Reviewers rated the quality of the stream (throughput, playback stalls, buffering), picture and sound quality, and their interest level. They also recorded STEM concepts from the broadcast.

Results were uniformly positive across operating systems, browsers, mobile devices, and channels. The evaluators entered ratings on a 5-point scale every ten minutes. Technical ratings across testers averaged 4.5 out of 5 for stream, picture, and sound. Interest rated 3.5 out of 5. Please see the following page for details.

Webcast Ratings	
Stream	★★★★★
Picture	★★★★★
Sound	★★★★★
Interest	★★★☆☆

The NASA TV webcast was smooth and without incident. A broadcast into Second Life was uninterrupted and spawned active discussion among attendees. The transmission through the Android app over a 3G cellular network was high quality but consumed over 300 GB of data using default settings. The app over WiFi operated smoothly and was used without incident.



WEBCAST IN SECOND LIFE VIRTUAL WORLD

MAIN CONCEPTS WERE CLEAR

What are the big ideas?

Reviewers understood concepts that matched project learning goals. Their takeaways include “solar eclipse,” safety, telescopes, and STEM concepts: heliophysics, the magnetosphere, planetary scale, totality, future eclipse locations, and upcoming NASA missions. Examples follow.

- “The difference between a full and partial eclipse and why it happens.”
- “You need special glasses to protect your eyes when looking at an eclipse.”
- “Telescopes are viewing the solar eclipse which helps to understand how it is seen.”
- “Great explanation of magnetism, the photospheres, corona, and layers of sun.”
- “NASA has a fleet of satellites focusing on the sun and how it works. It will hide in the shadows. How cool is that?”

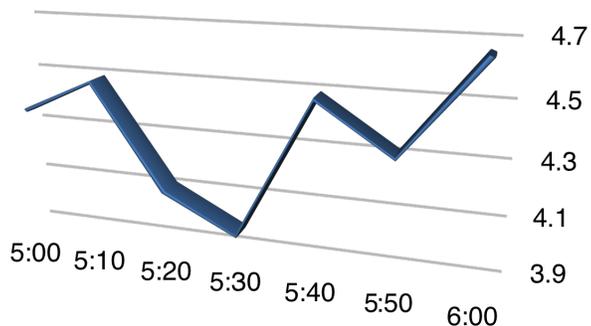
All reviewers found the local culture extremely interesting. For example, “Robyn discussed the sociology part of this science project, the cultural and social mores of

Micronesia and Woleai. This was cool.” Another said, “I liked when they spoke to the local people.”

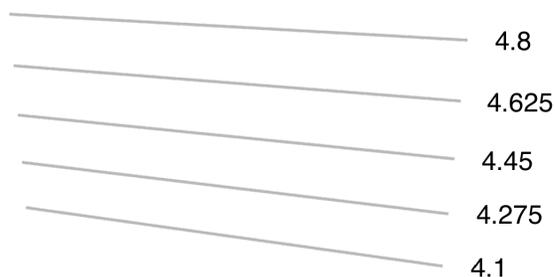
What do you not understand?

“Meaningful questions” help illustrate concepts that are not completely clear to the learner. Reviewers commented: “Some of the vocabulary is unfamiliar when describing layers of the sun. What is an aurora? Tetrahedral formation?” and “Unfamiliar phrases [such as] magnetic fill lines and reconnection event were used repeatedly leading up to the eclipse.” “What is a diamond ring?”

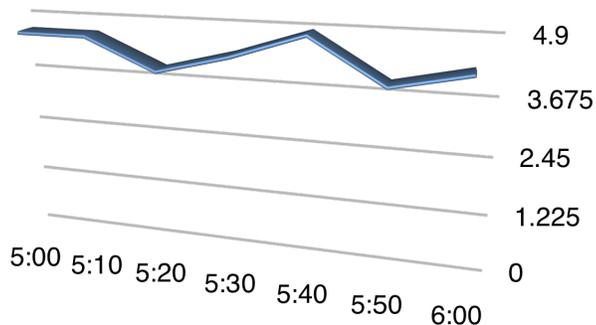
Stream Quality



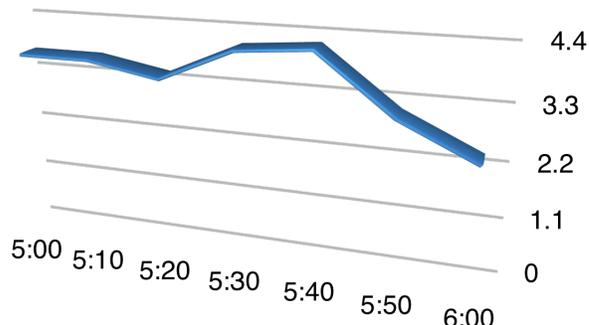
Sound Quality



Picture Quality



How Interesting



**REVIEWERS’ AVERAGE RATING DURING THE BROADCAST
(5 POINT SCALE. ALL TIMES PACIFIC.)**

Methods – Evaluators rated the quality of the stream, picture, and sound, and their interest in the content on a 5-point Likert scale every ten minutes. Ratings were averaged across time and testers. Eight evaluators ages 17 to 64 watched the webcast on desktop computers (using Windows, Mac, in Firefox, Chrome, Safari, and Internet Explorer), mobile devices, and the Android app.

Website User Testing

Quality, usability, learnability, interest rate high

Findings – Testers consistently gave the site high ratings. Professionalism (quality), navigation (usability), clarity of ideas (learnability), and interest in videos all scored 4.5 or greater on a 5-point scale. Testers’ comments offer insight to supplement findings.

Website Ratings	
Quality	★★★★★
Usability	★★★★☆
Learnability	★★★★☆
Interest	★★★★★

QUALITY



How professional is the site?

People’s initial impression of the site was universally positive. They said the site was “extremely professional” and “has good information and solid facts.” They immediately understood its purpose as “scientific and professional for the average person who wants to learn more about eclipses” or “an educational site to watch an eclipse online as it is happening.”



“It’s about science and space. Somewhere between professional and fun.”

“The quality of the videos was great. It made learning fun. I liked the music a lot.”

“This site is something NASA might want to fund. (Scroll down) Oh look – it is sponsored by NASA! Very cool.”

USABILITY



How usable is the site?

Users found the site inviting, intuitive, and easy to navigate. Several users complemented the design’s “fantastic use of black with white font and the use of other colors.” Videos of testers using the website showed consistently smooth navigation and ease finding and watching videos. All testers located the Spanish language video.

“This is an Exploratorium website - that adds weight and legitimacy to the site.”

Usability tester comments

“As soon as I started scrolling and clicking on videos everything was clear.”



“The text and headings were very easy to read and the site was very easy to navigate.”

Methods – User testing rated quality, usability, and learnability of the Eclipse website. Twelve users ages 20 to 62 tested the site, eight on desktop computers and four on mobile devices. Median testing time was 14 minutes.

LEARNABILITY



What are the big ideas you can learn about on this site?

Testers unanimously identified key themes that aligned with the project’s stated learning outcomes. Review and coding of testers’ commentary as they used the site along with post testing surveys showed clear engagement and interest in concepts about the sun, heliophysics, and related STEM content.

All testers (x12) identified “solar eclipse” as a key big idea and clearly articulated concepts presented in the videos. Two thirds (8 of 12) explained “eyeball safety” techniques in detail. Half (6 of 12) cited the next eclipse date as a main idea. Several more cited STEM concepts including the magnetosphere, planetary scale, totality, and eclipse locations. Most mentioned high-powered telescopes used to view the eclipse.

“I learned stuff I didn't know and remembered stuff I knew from school.”



“No matter what level of understanding you have of solar eclipses, this can teach everything you need to know.”

“Learning becomes more interesting when you're involved and that's what this type of video allows.”

“The site is so fantastic. The visuals are really good, the navigation tabs very visible, and the high quality videos create a really good learning environment.”

INTEREST



How interesting are the videos?

Users were extremely interested in video topics. Positive comments included: “The videos are great” and “I thought the videos were excellent.” Also “I love that there are so many videos to choose from.” and “The videos cover all sorts of topics.”

“It engages you in science and space videos so you learn in a fun and entertaining way.”



“I really appreciate seeing a science education website that isn't only for kids.”

“I want to congratulate them. It is a very informative website. Keep up the good work.”

ADVICE

What advice would you give the people who created this site?

Reviewers suggested advertising through online ads and partnerships to increase awareness of the website.. “The website is great but, needs to be advertised better. I had no idea the site existed.” Another said “Get the word out there. People will come if they know it exists.” Others suggested “When eclipses are coming up put ads online.” or “Maybe try advertising on the Weather Channel.”

Impact

AT A GLANCE

- 900 visitors attended a live eclipse webcast at the Exploratorium
- Results of internal evaluation of the live eclipse webcast were extremely positive
- Four experiments successfully tested new distribution channels for the webcast
- The Android app showed exceptional potential for using mobile devices to connect and interact with a wide audience
- The well-received Spanish language broadcast placed Latino audiences top of mind as opposed to secondary or an add-on to a program
- Outreach in Woleai stressed the importance of serving the local community and thinking about the unique needs and culture of local residents as an audience

SUMMARY

Impact evaluation assesses the changes that can be attributed to a particular project or intervention. Several initiatives combined to show early signs of impact. Formal measures of impact are not available.

Four webcast experiments represent successful new distribution channels developed or refined by the project during the 2016 Micronesia webcast.

A public program at the Exploratorium provided outreach to serve the public. An eclipse webcast viewing party at the Exploratorium included free admission to the museum for 900 visitors.

Broader Impacts include a Spanish language broadcast and extensive outreach activities in Yap and on Woleai.

Several other museums used the eclipse webcast as a framework for museum events.

Each of these initiatives represents a positive proof of concept for models of dissemination or education related to the eclipse webcast.

Exploratorium Public Program

Findings from Exploratorium Evaluators

AT A GLANCE

Internal evaluators from the Exploratorium conducted a well-designed and thorough evaluation of visitors' experience and conceptual understanding related to the webcast.

The Exploratorium reports:

- 900 people attended the institution the night of the live webcast event
- Evaluators spoke with 60 visitors, did 35 in-depth interviews and made 16 concept maps

Visitors reported:

- The live webcast was interesting and important. Over 70% want to return to the Exploratorium in 2017.
- 41% had no frustration or confusion. Some visitors expressed small frustrations with large-event issues (seating, screen location) or minor confusion on specific content

SET UP

The Exploratorium held a viewing party inviting guests to “watch a total solar eclipse during our live broadcast from Micronesia.” The eclipse was live broadcast in three locations in the Exploratorium. Staff estimated “200 or 300 people in the Webcast Studio” and 200 at each set of screens in the Observatory and in the East Gallery. Staff estimated “75 to 100” people attended the Spanish language presentation. The entire broadcast replayed after the live broadcast ended.

The public program featured scientists and educators in Micronesia and at the museum using high-definition real-time images and video from Micronesia to explore heliophysics – the science of the sun. NASA scientists introduced NASA’s new MMS mission, a multi-satellite project to measure the magnetosphere that connects the Earth and the sun.

INTERNAL EVALUATION

Dr. Toni Dancu, a Senior Researcher in the Exploratorium's Visitor Research and Evaluation Department, led internal evaluation. Evaluators stationed throughout the museum spoke with 60 people to learn about visitors’ experience regarding the eclipse

webcast. Evaluators completed 35 full interviews (98% adults, 55% female and 45% male). Sixteen people did concept maps, diagrams that depict visitors' understanding or knowledge of relationships between the sun and the concept of an eclipse' – two key ideas presented in the program.

FINDINGS

Evaluation results were strongly positive. Visitors said they were interested and that viewing the live broadcast was important. Most felt the webcast was not confusing or frustrating. Over half expressed interest in traveling to see the 2017 eclipse, while more than 70% expressed interest in returning to see the 2017 eclipse live webcast at the Exploratorium.

Interest – Most visitors found the eclipse webcast interesting. 89% rated their interest at 4 on a 1 to 5 scale, where five represented “very interesting.”

Live and Important – A high number of visitors felt that the live aspect of the webcast was very important. Nearly all (34/35; 97%) said it was clear that the eclipse webcast was live. 86% felt that it was important or very important that they were viewing it live.

Frustrating or Confusing – 41% (18/35) of visitors interviewed felt there was nothing frustrating or confusing about the eclipse webcast. Frustration issues dealt with hosting a large event and are easily addressed. These included, for example, finding the screens in the museum, difficulty getting seating, audio level too low or screen size too small for a large audience. Confusion issues were more specific to individual visitors. Issues included wishing presenters used more basic language to explain or provided more context on the web stream. At least one visitor would have “liked someone who you could ask questions.”

Future Interest: Traveling within the US – 52% of interviewees were interested or very interested in traveling within the US to see the eclipse in 2017.

Future Interest: Returning to the Exploratorium – Nearly 3/4 of visitors (71%) were interested or very interested in returning to the Exploratorium to see the eclipse in 2017.

Concept Map – Concept maps used a clear coding structure to record visitors' ideas related to *sun* and *eclipse* and to document new knowledge gained through the eclipse webcast event. Codes categorized visitors conceptual models of the sun and eclipse. These included: basic eclipse knowledge, understanding of path of totality, the sun's dynamic and active nature, magnetism and the magnetosphere, the human experience of the eclipse, and interest in the 2017 eclipse. Final results of the analysis are pending.

Webcast Experiments

Android App



“I’m proud that we were able to have a mobile app that allowed people to watch a live telescopic image of an eclipse.”

Rob Rothfarb, Lead App Designer

The Exploratorium embraced a unique opportunity of using a high-profile webcast of a live astronomical event to connect with a wider audience through a mobile app.

Rob Rothfarb, the creative and technical force behind the app, explains. “Watching a live eclipse while you’re on the go is an amazing thing to offer. But, creating a mobile experience that also allowed people social interaction about the event was key. So we embedded a live view of Twitter for different hashtags or keywords that we were following.”

The app allowed people to tweet their own thoughts or their own images from within the app. It was a multicultural conversation that’s global and fascinating. For instance, in Indonesia, one of the primary populated land areas where this eclipse was viewable, people communicated that it was cloudy but they were excited to see the live broadcast.

Rothfarb points out, “We recognize that getting people to come to a website is increasingly challenging. So adding social elements to internet communication, especially for science communication, is a really vital thing to engage in.”

Plans are to add geolocative features to the app itself. For the 2017 eclipse, everyone in the United States will be able to see some aspect of the eclipse. Because the phone knows where it is and what time is the app can communicate through the phone how much of the eclipse can be seen from ‘where the user is at any time.

Second Life and FaceBook

VIRTUAL PUBLIC PROGRAMS

Almost 80 people gathered in Second Life 3D virtual world to watch the live program and live telescope stream of the eclipse. Rob Rothfarb explained that the Exploratorium “extended the concept of creating a public program in our museum around a live

streaming event of an astronomical phenomena and replicated that in the virtual world online for people all over the world to participate in.”

There were two different locations. One was the Exploratorium’s island, where the museum had interactive exhibits about the expedition to Woleai and others about how eclipses work explained in a visually interactive way. 57 people attended. A second location – Science Circle based in the Netherlands – hosted 20 people. To produce the event required extensive testing of the stream, setting up exhibits, and preparing the space online to welcome people and provide context for what was going on. In addition the Exploratorium streamed the live education program into Facebook.

CENIC and Internet 2

The webcast transmitted the four live programs via multicast through through CENIC – a high-performance research and education network (REN) connecting 20 million users at universities, colleges, schools, and libraries in California.

CENIC also connects to “Internet2”– an organization that operates the United State’s largest, fastest, coast-to-coast research and education network. CENIC also provides major connectivity to Pacific Ways, an initiative which connects the west coast of the United States to Asia and high-speed networks in Australia, Singapore, Japan, China, and Korea.

As high-performance private networks, RENs are very efficient and have a very high quality of service and speed. The key advantage of distributing through the CENIC network is the possibility of transmitting telescopic images at high resolution – 4K or even 8K – to universities, schools and libraries, reaching an important segment of the Exploratorium audience. RENs allow a much higher-quality signal than the broadcast standard 720p HD resolution. It would be difficult to afford or to distribute an ultra high-resolution stream through the public internet.

The Exploratorium is looking for ways to leverage their connection to the gigabit CENIC network and use it to share with the REN community in California and in the U.S. Rob Rothfarb commented “We just wanted to explore it as a distribution method and to see could whether we technically do it. This event was us beginning to learn about how to do that.”

Sonification

A third feed streamed a telescope-only feed that included a live audio sound track, a data sonification using “visual image” video signals from the telescopes to create a live composition. Created by Wayne Grim – an audio curator, member of the production team, and composer – the experiment used six different sources of data, all streaming in from an array of five different telescopes, each using different lens filters. Colors and the rotation of the sun and moon trigger different sounds. For example when the eclipse is at totality string samples swell in and out marking the pinnacle of the event.

Spanish Language Broadcast

Outreach to underserved Latino audiences

Dr. Isabel Hawkins hosted a live 30-minute Spanish language broadcast of the eclipse from the Exploratorium with co-presenter, Kira Vilanova, anchor of El Despertar, (When We Wake Up) a morning show on KDTV, a Univision affiliate in San Francisco.

An astronomer by training, Dr. Hawkins holds a PhD from UCLA and worked for 20 years as a researcher at UC Berkeley Space Sciences Lab. An early adopter, Dr. Hawkins began outreach using web programming related to heliophysics in 2009 and later became an educator in astronomy at the Exploratorium. Ms. Vilanova is an Emmy award-winning anchor whom Dr. Hawkins described as “incredibly articulate, very engaging, and has a hand on the pulse of the Latino audiences in the Bay Area.”

The Spanish language broadcast format was an unscripted conversation based on “20 cool facts about an eclipse.” Audience reaction from the live audience of 50 was extremely positive. Evaluators watched the broadcast and did an extended interview with Dr. Hawkins noting these outcomes:

- Non-scripted conversation allowed flexibility to continue engaging the audience with discussion of STEM content when clouds unexpectedly blacked out the eclipse image.
- Poignant points during the eclipse supported content, for example the diamond ring and the appearance of the corona. Dr. Hawkins noted the “amazing prominence was

ABOUT BICULTURAL OUTREACH

Dr. Hawkins shared insights and best practices to effectively integrate bilingual / bicultural outreach:

- This broadcast grew from a larger and existing Latino audience engagement initiative.
- Latino audiences are top of mind as opposed to secondary or an add-on a program for them.
- Many Latino families and audiences love and trust media personalities.
- When you teach science, bring in the cultural component very broadly. When Latinos think of science, we may also think of dance and music.

enormous.” “It let us give viewers a sense of scale of the size of the sun compared to the size of the earth.”

- Beyond facts and data – informal conversation and the telescope feed went beyond facts and data. They appeared to help the audience gain a “sense of amazement and allowed an opportunity to create their own understanding and visual connection.”
- Dr. Hawkins cited the importance of recognizing the learning value of “emotional moment.” Watching a dramatic event like an eclipse gives a memorable basis for future learning.
- Evaluators compliment the inquiry-based format of the Spanish language broadcast.

Education Outreach on Pacific Islands

Producer Robyn Higdon and Dr. Paul Doherty, a Senior Scientist at the Exploratorium, led eclipse education programs in schools on Yap Island and also on Woleai – a small atoll of approximately 1,000 people and the site of the eclipse webcast. Yap State is located in the Federated States of Micronesia – an US affiliated Pacific Island nation located in the Western Pacific. The education outreach increased participation in STEM learning for over 700 students from underrepresented groups in Micronesia. It represents an NSF broader impact.

OUTREACH IN YAP

After arriving on Yap, being received by the Lieutenant Governor who voiced support for their efforts, and visiting the Head of Education for Yap State, Higdon and Doherty arranged to spend an entire day at a school doing eight presentations for grades one through eight. Yap has five official languages and several dialects with English as lingua franca. Hands-on interactive presentations used props to teach the important lessons about the eclipse. Grades six to eight learned in English, while grades one to five, with less English language proficiency, relied on demonstrations, hands-on activities, and interpretation by teachers.

OUTREACH ON WOLEAI

On Woleai atoll two men – Allentino Ruiquifmal (principal of the high school) and Stanley Retogral (previous Head of Education of Yap State) – arranged a two-hour presentation

HONORING LOCAL CULTURE

Upon arrival the team met with the five traditional chiefs of Woleai who welcomed them and offered their help.

- One of the traditional chiefs on Woleai is blind. Troy Klein of NASA had a special book made with images of raised plastic that showed the sun and moon and shadows and earth. As the chief examined the book with his hands, his “smile was incredible. The other chiefs smiled even more.”
- Robyn Higdon said “It is important to think about the local culture, especially the language and language ability and how you are going to translate hands-on lessons.”

to 200 elementary school students and a second two-hour presentation to 200 high school students.

NASA educators Troy Klein and Eric Christensen joined the presentations on Woleai. NASA provided a model of the four MMS satellites as a mobile that the kids could move and fly around the classroom. They also provided models that used magnets, glycerin, and iron filings to make a three-dimensional magnetic field. Dr. Doherty said it was “a brilliant way to present the information that just fascinated the kids.” Doherty continued, “What’s important is that NASA provided knowledgeable experts, knowledgeable scientists, who were able to present correct information in a hands-on way that was interesting, relevant, and fun.”



“The local Woleaians were really excited about doing night sky viewing. We had hundreds of kids come out the first two nights and view the stars with our telescopes. It was great to reach the kids in that way.”

Partners

Five Mini Case Studies

SINGAPORE

The morning of March 9, 2016, a partial solar eclipse was visible in Singapore, with nearly 90% of the sun obscured by the moon at the point of maximum eclipse. Science Centre Singapore hosted free public viewing of the eclipse using Venusscopes and viewing glasses while streaming a live broadcast of the total solar eclipse from Micronesia provided by the Exploratorium.

Ei-leen Tan, Deputy Director, Physical Sciences at Science Centre Singapore, led the effort to organize the event for Singaporeans. Viewing the webcast projected on a large screen in the main lobby, visitors seem interested and engaged in conversations about the corona and the reasons for the eclipse. People who missed the event have to wait until 2019 for the next solar eclipse visible in Singapore.



SAN DIEGO

On March 8, the Facebook page for the Ruben H. Fleet Science Center In San Diego March 8 invited viewers to witness the live broadcast of “today’s total solar eclipse live from Micronesia” in the Fleet’s Heikoff Giant Dome Theater. 30 people liked the post.

NEW MEXICO

In New Mexico on March 8, the Los Alamos Nature Center / Pajarito Environmental Education Center projected the live telescope feed from Woleai and the webcast in Los Alamos Nature Center 30-foot-wide dome of its planetarium to visitors. The program also used high-definition images and video from NASA SDO and STEREO satellite missions to explore the science of the sun. The Los Alamos Nature Center Planetarium serves as an astronomy and space-science education resource for Northern New Mexico.

OREGON AND SOUTH CAROLINA

Anticipating an eclipse in 2017 that stretches from Oregon to South Carolina, two institutions, University of Oregon's Erb Memorial Union and South Carolina State Museum, independently held “bookend events.”

South Carolina State Museum in Columbia held an eclipse event that projected the webcast onto the digital dome planetarium. A video clip from inside the planetarium at the moment of totality posted on Facebook received 576 views and 20 likes.

The Erb Memorial Union held a similar outreach program to present the eclipse webcast to the public.



Reuben H. Fleet Science Center

March 8 · 🌐

Don't miss out on today's total solar eclipse live from Micronesia! The fully eclipsed sun will be visible from only a few Pacific islands, but you can witness the live broadcast in the Fleet's Heikoff Giant Dome Theater! For tickets and details go to <http://rhfleet.org/event/total-solar-eclipse-live-micronesia>

