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Eclipse 2017 Livestream

An evaluation report for NASA

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Abstract

The Exploratorium hands-on science museum in San Francisco—with principal funding from NASA—produced a livestream of the Total Solar Eclipse 2017 from Madras, Oregon and Casper, Wyoming on August 21, 2017.

Successful dissemination of the livestream through many media channels and a mobile app provided high-quality coverage of the eclipse to an estimated 63 million people, NASA reported. Sixty major media providers, both online and conventional, widely rebroadcasted telescope feeds from the Exploratorium livestream.

Social media played an important role in promoting the eclipse and broadcasting the livestream to a wide audience. NASA reported 1.5 billion social media “eclipse posts” on the day of the eclipse. An estimated 182,000 people watched the stream on Facebook Live. Social media analytics reveal a robust conversation, positive sentiment, and active discussion of eclipse and STEM topics.

Edu, Inc., an external evaluation firm, conducted a study to help NASA understand the reach and impact of the Exploratorium’s livestream and one-hour live programs in English and Spanish. The Exploratorium implemented all proposed activities as promised. Evaluation findings are positive.

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Summary

With resounding success, the Exploratorium planned, promoted, and produced a one-hour livestream, and two three-hour telescope only feeds of the complete eclipse event during the total solar eclipse in the United States on August 21, 2017, contributing to NASA Science Mission Directorate’s (SMD) funding of public engagement in science.

From broadcast sites in Madras, Oregon and Casper, Wyoming, the Exploratorium provided one-hour live educational broadcasts in English and Spanish, as well as two live telescope feeds. Sonification—a live musical score based on data created by the sun’s light as it was covered by the moon—was transmitted from the Exploratorium. The livestream was disseminated through NASA websites, NASA TV, the Exploratorium website, and apps for iOS and Android, reaching an estimated 120 million people. Over 60 major media providers rebroadcasted the livestream.

Evaluation Design

The Exploratorium commissioned Edu, Inc., an external evaluation firm, to design a study to monitor project activities and gather data concerning the reach and impact of the livestream.

The mixed-method study combined descriptive statistics from Google Analytics and social media metrics with a user experience survey. Rich qualitative stories from interviews with users, expert reviewers, and Exploratorium staff provided further insights. Document review illustrated the use of the livestream in museums, libraries, and schools.

Evaluation Questions

1. How many unique users viewed the livestream by which media channels?
2. What is the sentiment and use of STEM¹ terms in the eclipse conversation on social media?
3. How and in what ways did the Exploratorium promote the eclipse livestream and programs?
4. What factors led to the successful planning, production, and distribution of the livestream?
5. What are the successes of and lessons learned from Spanish-language programming?

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



Main Findings

Where is the advanced thinking coming from?

The Exploratorium clearly demonstrates advanced thinking and leadership in the area of producing, transmitting, and distributing a media-based informal science learning experience.

On August 21, 2017 the Exploratorium, a San Francisco based science museum, engaged the public in informal science learning via live streaming of the August 2017 solar eclipse that reached over 63 million people. On-demand videos on eclipse science topics—presented in English and Spanish—reached a total of 2.75 million people.

The key finding is that **the livestream is the experience**. Through the livestream and on-demand video, the Exploratorium delivered a museum experience to online, mobile, and social media users anywhere in the world. The outcome was promoting public engagement in science by **going to people where they are, when they want** – live or on demand.

In compiling this report, Edu finds five core observations to answer the evaluation questions.

First, **the NASA-sponsored livestream had historic reach** for both NASA and the Exploratorium. Over 63.3 million people viewed the Exploratorium's livestream, the Exploratorium website served 2.45 million views in August, and the Exploratorium's solar eclipse app served 591,000 sessions.

Second, **social media played a catalytic role** in engaging users in the eclipse. Analysis of 16.5 million tweets showed positive sentiment and heightened use of “STEM words” indicating active discussion of STEM topics on Twitter.

Third, **the Exploratorium's strategic, professional promotion** of the 2017 solar eclipse garnered significant national, San Francisco Bay Area, and online media coverage.

Fourth, **the Exploratorium implemented successful programs**. The Exploratorium again demonstrates the technical capacity to produce and distribute high-impact and innovative live STEM education programs and on-demand videos featuring eclipse content.

Fifth, **the Exploratorium provided outreach to Latino and Spanish speaking audiences**. The project produced the first NASA-sponsored one-hour live eclipse programming in Spanish. Exploratorium leadership provided resources for a professional Spanish-language production team on par with the English-language production team.



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REACH

NASA reports that over 120 million people were exposed to the 2017 solar eclipse through digital media – livestream, on-demand video, and live education programs.

Analytics

Question – How many unique users viewed the Exploratorium livestream and on-demand video through which channels?

Finding – The 2017 solar eclipse livestream produced historic reach for both NASA and the Exploratorium. Over 63.3 million people viewed the Exploratorium's livestream in August 2017. During August the Exploratorium website served almost 2.45 million views, and the solar eclipse app served 591,000 sessions. Over 250,000 people viewed Spanish-language videos and 200,000 watched live programming in Spanish.

AT A GLANCE

NASA reported 120 million website views of eclipse content and coverage. NASA social media accounts received over 1.5 billion visits on August 21. NASA eclipse websites' views and social media use were the highest in the agency's history.

The Exploratorium was diligent in collecting data on livestream views, use of the livestream by broadcast media, views of on-demand videos on eclipse content via the Exploratorium website, and promotion and engagement on eclipse topics through social media.

- Over 63.3 million people viewed the Exploratorium eclipse livestream
- On-demand videos received almost 2.5 million views in August 2017
- 450,000 people viewed Spanish-language programming and on-demand videos
- The Total Solar Eclipse app was downloaded 228,000 times, with almost 600,000 app sessions on August 21

The Exploratorium compiled metrics from several sources. A detailed independent review by evaluators aggregated data and verified the legitimacy of the project's reporting methods.



Analytics Overview

This section summarizes data regarding the reach of the eclipse livestream, on-demand videos, app, and public programs. NASA and the Exploratorium Eclipse 2017 Digital Metrics Report Report² provided data.

Livestream

Channel	Views
Livestream via NASA.gov	34,000,000
Livestream via Broadcast Media	25,600,000
UStream via NASA.gov	946,000
Exploratorium Website	1,690,000
App Sessions	591,000
Facebook Live	182,000
YouTube Live	45,211
Total	63,054,211

Spanish Language

Channel	Views
YouTube – Telescope Livestream via Spanish Broadcast Media	1,218,820
NASA Spanish Live Program	200,000
Exploratorium Website – Videos	195,000
YouTube – Videos	56,796
Total Views	1,670,616
<i>Que es un eclipse solar?</i> Third most viewed video. 56,796 views.	

On-Demand Video

Channel	Views
Exploratorium Website	1,636,200
YouTube - Top 10	763,417
Facebook	92,378
Total	2,491,995

App Downloads

Measure	Number
iOS	162,785
Android	59,976
Total Downloads	228,000
Sessions	591,000
Average Session	7:25 minutes

Sonification

Channel	Views
Facebook Live	182,000
Exploratorium Website	77,600
NASA Feed	374,000
Total Views	633,600
129,000 minutes viewed on Facebook Live. NASA reports 31,000 peak users.	

Social Media Snapshot

Platform	Posts	Engagement	Likes	Shares	Followers / Fans
Facebook	104	249,000	24,000	11,000	136,000
Twitter	100+	1,873			98,700
Instagram	40	65,100			50,800
Total	144	315,973	24,000	11,000	285,500

Social Media Top Posts

Platform	Views
Facebook	35,100
Twitter	8,883
Instagram	7,964
Total	51,947

² Exploratorium Press & Blog Reach reported by Cision Analytics
 Exploratorium Web Analytics reported by Google Analytics
 Exploratorium Social Media Analytics reported by Union Metrics
 App install data reported by iTunes Connect and Google Play Publisher
 NASA website data reported by NASA
 Broadcast media data reported by adweek.com.



Social Media Listening

Analysis of 16.5 million tweets on the topics of eclipse science, NASA, and Exploratorium reveal positive sentiment and rich use of “STEM words”.

Question – What is the sentiment of and the use of “STEM words” in the eclipse conversation on social media?

Finding – Social media played a catalytic role in engaging users in the eclipse. Analysis of 16.5 million English-language tweets related to the eclipse, NASA, and the Exploratorium showed extremely positive sentiment and active, frequent use of “STEM Words” in the discussion of eclipse and STEM topics.

Twitter had a large, active conversation about eclipse topics. The evaluation team used sophisticated software to understand the sentiment (mood) and use of “STEM words” (discussion of STEM topics) from 16.5 million tweets on eclipse-related topics.

AT A GLANCE

SENTIMENT

- Overall sentiment was extremely positive and peaked the day after the eclipse
- Positive sentiment peaked on August 22nd – the day following the eclipse
- Sentiment was most positive from the hours of 8 am to 12 pm Pacific on August 22nd

“STEM WORDS”

- STEM content peaked on August 22nd, yet remained higher in the days following the eclipse than during the days preceding the eclipse
- 10 am to 11 am Pacific (the time of totality) was the peak of “STEM word” tweets on August 21st
- The richest STEM discussion (highest concentration of “STEM words”) began at 11 am Pacific August 21, the day of the eclipse, peaked the evening of August 22, and remained significantly above average until the morning of August 23



Deep analysis of Twitter

Evaluation used a proprietary process³ to capture and analyze social media posts to understand the sentiment of the “eclipse conversation” and details of the discussion of STEM topics. We focused on deep analysis of Twitter data as an indicator of sentiment and “STEM words”.

Eclipse tweets

Our process scraped Twitter data to capture “eclipse tweets”. Scraping is a data mining technique that uses a computer program to extract useful information. “Eclipse tweets” contain one or more of 20 eclipse-related words, phrases, or hash tags. (For example: solar eclipse, NASA, Exploratorium, totality, corona, umbra, diamond ring, #Eclipse2017, #SolarEclipse2017, #pathoftotality.)

Scraping Twitter produced a data set of 16.5 million eclipse tweets.

Eclipse topics active on Twitter

Excluding “retweets” we analyzed text and metadata from over 4.3 million distinct eclipse-related tweets (eclipse tweets) from June 20th, 2017 to September 1st, 2017. Including “retweets” we analyzed over 16.5 million eclipse-related tweets. We collected 2.5 million tweets on August 21st, the day of the eclipse, and 2.5 million additional tweets on August 22nd.

ABOUT ANALYTICS

Social media analytics gathers and analyzes data from social media services to provide insight into the sentiment and topics of the social conversation. It’s a structured way of deriving an understanding of the main categories, patterns, concepts or themes, within a large data set.

Human judges review a large pseudo-random sample of tweets on the topic being investigated to corroborate the accuracy of the software analysis.

³ We analyzed 16.5 million “eclipse tweets” using four measures of sentiment and one measure of STEM content.

The sentiment measures were a general text sentiment based on the Affective Norms for English Words (ANEW) dictionaries [1] and the python NLP code. ANEW provides a set of normative emotional ratings for a large number of English-language words grouped in four dictionaries: Pleasure, Happiness, Arousal, and Dominance.

The “STEM words” measure assigned a “STEM score” to each eclipse tweet based on matches to two or more words or phrases from three dictionaries of astronomy terms. [2] Please see references at the end of this report.



“STEM words” indicate “talking about” science

The words we use define the topic of any conversation. Social media listening identifies what is being said about a topic on the Internet. Edu used social media listening to track Twitter posts that contained “STEM words” particularly words from the field of astronomy.

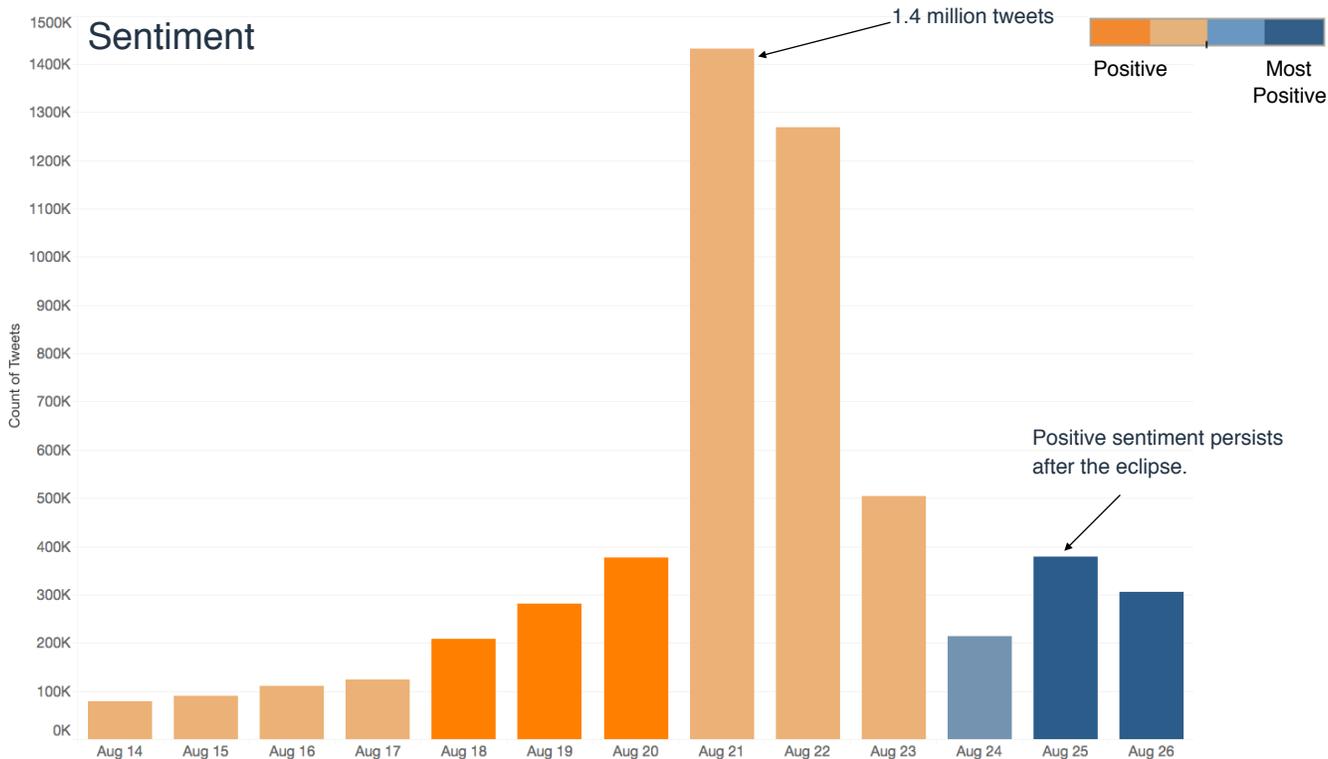
Almost half the tweets—more than 8 million—contained multiple words from astronomy or eclipse-related science. Software assigned each tweet a STEM score based on presence of “STEM words”. Tweets with a high concentration of “STEM words” scored higher than tweets with few “STEM words”. Human judges reviewed and confirmed that tweets with a high concentration of “STEM words” did in fact discuss science or eclipse-related topics.



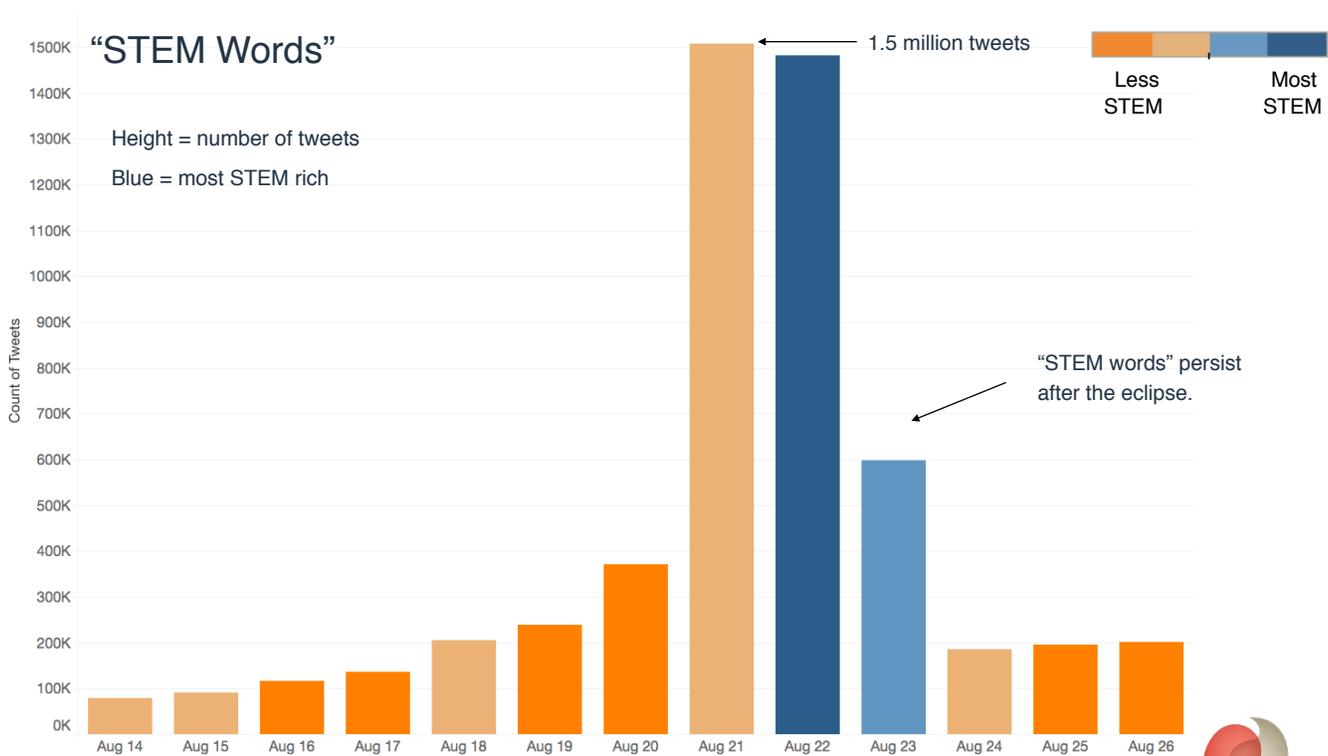
“STEM WORDS” – ASTRONOMICAL TERMS OCCURRING IN OVER 8 MILLION ENGLISH-LANGUAGE TWEETS ABOUT THE 2017 SOLAR ECLIPSE.

WORDS IN A LARGER FONT APPEARED MOST FREQUENTLY.

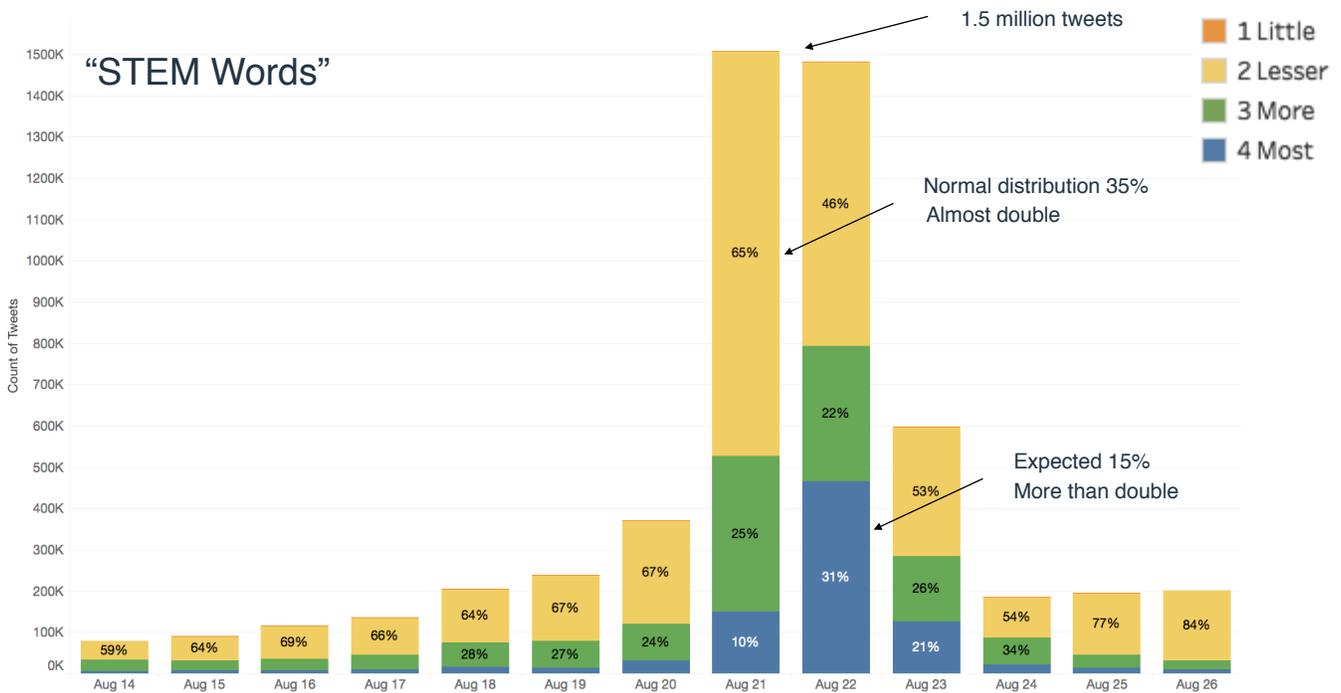




TWEETS ABOUT THE ECLIPSE SHOWED INCREASED POSITIVE SENTIMENT LEADING UP TO THE ECLIPSE. TWEETS WERE MORE POSITIVE (TAN) THE DAY OF THE ECLIPSE AND MOST POSITIVE (BLUE) THE DAYS AFTER THE ECLIPSE.

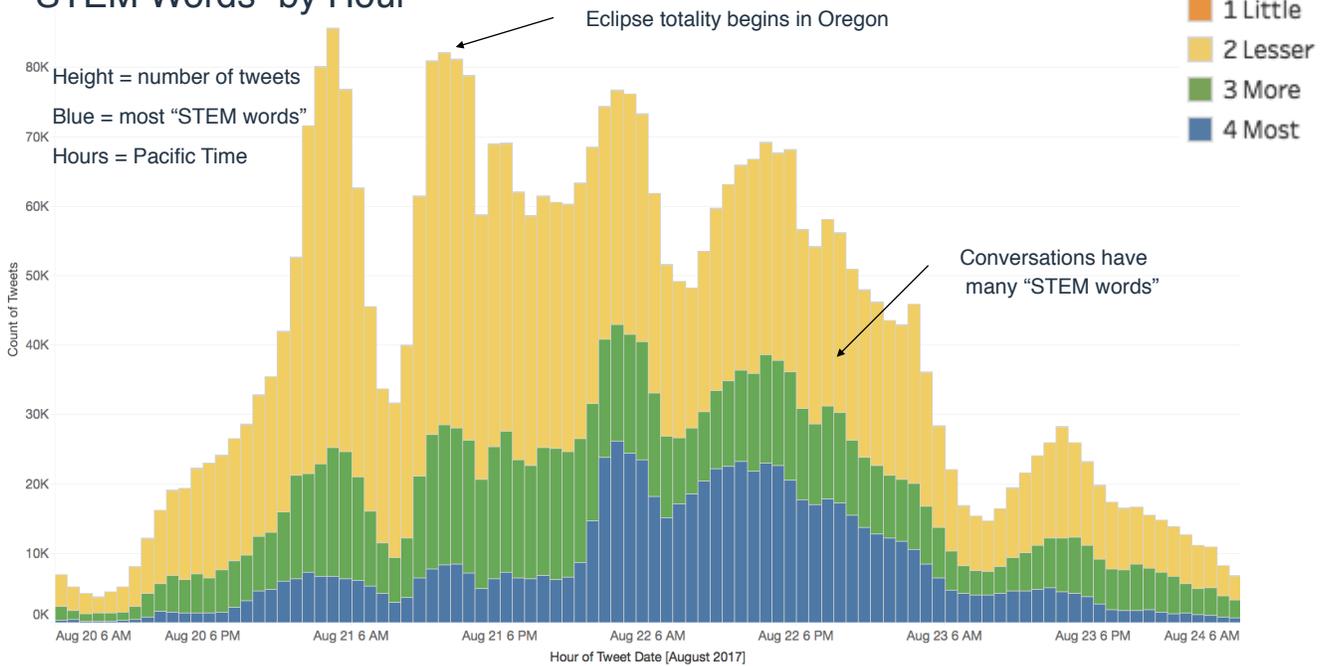


TWEETS ABOUT THE ECLIPSE SHOWED MORE "STEM WORDS" THE DAYS OF AND AFTER THE ECLIPSE. THE RICHEST STEM DISCUSSIONS (BLUE) OCCURRED AFTER THE ECLIPSE.



TWEETS SHOW A SIGNIFICANTLY ABOVE-AVERAGE MEASURE OF “STEM WORDS” IN THE DAYS LEADING UP TO THE ECLIPSE AND IMMEDIATELY AFTERWARD.

“STEM Words” by Hour



TWEETS COLLECTED EACH HOUR SHOW INCREASED AND ABOVE-AVERAGE USE OF STEM WORDS FROM THE NIGHT BEFORE THE ECLIPSE UNTIL TWO DAYS AFTER.

BLUE AND GREEN REPRESENT VERY HIGH USE OF STEM WORDS. THE HEIGHT OF THE BARS REPRESENTS THE NUMBER OF STEM TWEETS COLLECTED DURING THAT HOUR.



Media Coverage

The Exploratorium strategically promoted the livestream through conventional and social media. Over 60 major media providers used the livestream.

Question – How and in what ways did the Exploratorium promote the eclipse livestream and programs?

Finding – The Exploratorium’s promotion of its 2017 solar eclipse digital content garnered significant national, San Francisco Bay Area, and online media coverage.

Martin Rock, Associate Director of Communication at the Exploratorium, explained how the Exploratorium effectively promoted the eclipse livestream through major media providers and social media channels.

AT A GLANCE

- The Exploratorium distributed six press releases to several thousand prominent media providers through a media aggregation service
- Promotion through social media reached and engaged an informal audience through unexpected wide interest in topics like “plan an eclipse party”
- Exploratorium analytics data reports that promotion through social media reached 9.3 million combined users on Twitter and Facebook

Direct contact

The Exploratorium directly contacted several thousand local, national, and international media providers through six strategically-timed press releases. Direct contact with media providers such as The New York Times, BBC, NPR, ABC 7 KGO and The Discovery Channel generated interest from local, national, and international media outlets. Martin Rock reports: “. . . we hit every level of awareness that you hope for, which is big national stories and also the individual local things that really push downloads for the app.”

The Exploratorium reports that a press release promoting the launch of the Exploratorium App, entitled, “Host a Summer Eclipse Party with The Exploratorium App,” was sent to



2,765 news outlets and 196 individual writers. This press release was an unexpected success that led to major news outlets CNET, Fox News, and Space.com featuring the app.

Though it is difficult to measure the exact number of articles generated due to the Exploratorium's direct contact with media providers, Rock, using the news aggregator, *Cision*, conservatively estimates that direct contact led to over 1,000 articles with a reach of approximately 11.21 million people from June to August 2017.

Media Coverage



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

Social media

The Exploratorium reports that its eclipse social media posts reached a combined estimate of 9.3 million views through Twitter and Facebook. Comments, likes, and shares across social media channels showed broad engagement and interest in the topic. The Exploratorium's eclipse-related Facebook posts garnered 24,000 likes and 11,000 shares.

Evaluators reviewed both the Exploratorium's social media press plan and its social media posts, concluding that the posts were creative, professional, concise and they appealed to the Exploratorium's target audience. The tweet and Facebook post with the most engagements (5.2k and 35.1k, respectively) explained how to make an ad hoc eclipse viewer. It read: "#eclipse2017 chasers! Your task: Find household items with tiny holes. Pinholes show image of sun & will be crescents when eclipse starts".



IMPACT

Programming

The livestream provided an experience to engage the public in science.

Question – What factors led to the successful planning, production, and distribution of the livestream?

Finding – The Exploratorium implemented dynamic and successful live programs. The Exploratorium again demonstrated the technical capacity to produce and distribute high-impact and innovative STEM education programs and content.

Exploratorium leadership—Dr. Rob Semper; Associate Executive Director, Robyn Higdon; Director of Museum Experience, Nicole Minor; Director of Moving Images, and Rob Rothfarb, Online Project Director at the Exploratorium—discussed the successes and lessons learned from planning, producing, and broadcasting the livestream.

AT A GLANCE

EXPERIENCE

- The livestream is the experience – allowing over 120 million visitors to experience the eclipse while promoting public engagement in science
- 586,905 online viewers watched the live English-language broadcast
- 200,000 viewers watched the live Spanish-language broadcast

PRODUCTION

- Transmission and distribution served a complex and essential role in production
- Early scouting, detailed logistics, and professional contractors were vital to success

DISTRIBUTION

- The Android and iOS apps show continuing potential for using mobile devices to reach a wide audience
- Promoting free digital feed to broadcast media via The Switch, a long-haul fiber optic network, increased use of the livestream by providing free access to broadcast media



Exploratorium implemented successful programming

Interview and analytics data confirms that the Exploratorium again demonstrated the capacity to produce and distribute high-impact and innovative STEM education programs that present big ideas of eclipse science to a wide and diverse national audience.

“The Exploratorium and NASA educators were very good. There were a wide variety of scientists from NASA.”

“Robyn Higdon was great – the most consistent presenter along with Leslie Garrison from NASA.”

“Robyn's speaking was clear and really captured the excitement of the experience. She seemed very precise with facts and her knowledge as a whole.”

“Leslie Garrison's ‘Eclipse 101’ interview helped clarify the basics of eclipse science.”

“An engaging, exciting feed that was relevant to nearly any audience.”

– External reviewer comments

The Experience – Public engaged in science

One of the Exploratorium's founding principles was to allow hands-on experiential learning. The livestream served as an internationally-available surrogate field trip that allowed over 120 million visitors to experience the eclipse. The livestream leveraged digital and broadcast media to become a free museum experience outside of the museum.

The live program engaged learners of many ages by providing them access to NASA science experts, content, and authentic experiences. Excitement surrounding the event drove engagement, and helped to create a genuine shared moment where people came together to learn and talk about science, and to have a positive experience with investigating science and the natural world.

The Exploratorium worked to project its museum sensibilities into the media world. The Exploratorium was the only museum to organize and implement live coverage of the eclipse.

The Exploratorium-produced NASA asset of the telescope video served as the prime backbone for events across major media spaces: broadcast news, schools, libraries, and via the internet, mobile app, and social media integration.



Sonification – Art meets science

Expressing art with science was an unexpected successful method for engaging the public in science. An example would be the highly successful sonification, where data generated by the sun's light as it was covered by the moon was translated into a musical score.

Sitting at the intersection of art and science, the sonification of the eclipse provided an emotionally engaging soundtrack to the Exploratorium's livestream, becoming some of the Exploratorium's most viewed content.

The Exploratorium's sonification data bears out the notion that people are responsive to the combination of art and science. The Exploratorium Facebook Live stream was viewed by 182,000 people and the NASA Live Streaming of the sonification was seen by 374,000 unique viewers.

The Exploratorium's unique combination of art and science provided a window into the content for people that may not have found the science engaging by itself. The sonification exemplifies a technique to engage the public in science through art.

Empowered the museum

Leadership reported that the eclipse project gave Exploratorium staff an opportunity to contribute to a single project, bringing the institution together and internally reaffirming the power of collaboration on a single project.

Planning and producing the Spanish-language program was also empowering for the institution. Dr. Isabel Hawkins commented that "everybody cared and cooperated," and that it helped to empower the Exploratorium team to embrace the museum's Spanish-language audience.

Mobile app

The mobile app served as a utility to address the digital divide by providing access to the solar eclipse for people without access to the internet or cable television. The app also allowed viewers to experience the eclipse while mobile and outdoors.

The app helped the Exploratorium to deliver an experience, in this case the idea of an exhibit-free museum, by providing accessible live coverage of an incredible natural



phenomenon that populations outside of the path of totality would otherwise be unable to experience.

Transmission

Transmission and distribution serve a complex and critical role in production. Without them, there would be no livestream to 120 million people. The eclipse livestream exemplifies the complexity of implementing and delivering a media experience at national scale through broadcast media and mobile devices.

One of the Exploratorium's unique advantages as an institution is its ability to combine multiple competencies in media planning and production to execute live programs with technical skills to transmit a live broadcast and video telescope feeds, and to make the signals available to media outlets for broad distribution.

The livestream was an extremely complex project that required team members to coordinate two satellite feeds, two production sites, and bilingual English and Spanish programming. Distributing the programs and making them accessible through live closed captioning in both languages was a major accomplishment.

Distribution – Free content through The Switch

By making the only real-time telescope feed of the eclipse available to broadcast media for free via a broadcast quality, stable, and reliable feed the Exploratorium increased reach by 21 million people, including 1.2 million views of eclipse footage on Spanish-language channels.

The Exploratorium provided some of the the first imagery of the eclipse telescope feed and the primary imagery used by major media providers, where it formed a backdrop for coverage. The footage was made available to the media through satellite feed and The Switch, a digital and fiber-optic network which allows broadcast television to move imagery between stations. It is extremely unusual to offer professionally-produced, unencrypted digital content on The Switch and free use.



High-quality professional contractors

In many ways the success of the program hinged around the high quality of the crew, including an Academy Award winning cinematographer and numerous camera and crew members used to working on live television events like the Super Bowl and live sports.

Staging and filming live content in accessible locations also helped. A crew of 60 professionals were in the field covering the 2017 eclipse, compared to the crew of 15 who covered the 2016 eclipse in Micronesia.

Early logistics and site scouting

The Exploratorium sent people into the field to scout locations a year in advance. Early arrival, weather analysis, and good site planning were extremely beneficial in support of NASA's goal of creating strong broadcast media, and provided understanding of the vital role local communities would play in a successful broadcast.

The Exploratorium worked with NASA to anticipate and understand what official viewing sites would require in the way of logistics and traffic planning, and to empathize with local communities about the impact that the influx of visitors would have on the community. NASA distributed their talent along the path of totality, creating multiple official viewing sites.

Robyn Higdon pointed out that many major networks scouted broadcast sites for eclipse coverage only weeks before the eclipse. The Exploratorium's early scouting and logistics allowed them to offer knowledge, technical assistance, and logistics support. For example, ABC News ended up sharing the Exploratorium's media truck, which provided a satellite uplink ABC used to transmit live coverage from Casper.

Being positioned to provide quality assistance early helped Exploratorium and NASA to achieve their goal of generating a strong media presence.



External review of programming

A panel of ten external reviewers watched English- and Spanish-language programming and provided feedback in response to a structured list of questions. Reviewers include four evaluators, a teacher, and five individuals ranging from age 19 to 59.⁴

A summary of the reviewers' comments follow.

REVIEWERS PROVIDE POSITIVE FEEDBACK

"I like how the program changes to multiple people's views and shows different equipment. The pace is not too slow and keeps me hooked."

MAIN CONCEPTS WERE CLEAR

What are the big ideas?

Reviewers understood most STEM concepts that correspond to the program learning goals.

Their takeaways include: solar eclipse, viewing safety, different telescopes provide different kinds of images, NASA scientists' expertise, and STEM concepts: totality, corona, diamond ring, eclipses can be predicted, seeing planets, and drop in temperature during totality.

"When the moon covers the sun and you can see the corona."

What do you not understand?

Several technical ideas were unclear to reviewers. For example: What is a hydrogen alpha filter and why does it keep getting mentioned? What is the significance of sunspots and what role do they play in an eclipse? Why does the shadow of the eclipse change locations around the world every year?

"It's hard to grasp all the concepts of the stream because I don't understand all the terminology."

TALKING SCIENTISTS – GOOD BUT MIXED REVIEWS

All reviewers felt that the NASA scientists added significant value to the program.

Reviewers agreed that the "woman in blue NASA shirt [Leslie Garrison] was probably the best NASA presenter, and "the man in the grey shirt [Dr. Hakeem Oluseyi] is charismatic."

⁴Please see Appendix One for additional comments from reviewers.



Reviewers agreed that some scientists had a difficult time presenting technical content in plain language that average people could understand.

“I notice every time the scientist goes into detail about the sun and the magnetic field of the earth I lose interest. The average viewer and most young people, we can't relate.”

SPECTATOR INTERVIEWS ADD HUMAN INTEREST

Reviewers felt that spectator interviews successfully shared people's impressions of the eclipse. Interviews introduced different types of interest across varying demographics, particularly by age. Showing children's art exemplified an eclipse enjoyed by all ages.

“An eclipse is an amazing and breathtaking experience. I saw people's reactions to the beauty of the eclipse, how rare it is.”

ACCOLADES

What should the Exploratorium be most proud of?

Reviewers complimented the resources that the Exploratorium gathered in terms of people and technology to simultaneously livestream the eclipse from multiple locations while educating viewers.

“They kept the stream pretty engaging and at a good pace, which is hard to do when recording something live.”



Spanish-Language Program

Exploratorium prioritized bilingual and bicultural outreach.

Question – What are the successes of and lessons learned from Spanish-language programming?

Finding – The Exploratorium produced the first NASA-sponsored one-hour live eclipse programming in Spanish. Exploratorium leadership provided resources for a professional Spanish production team on par with the English-language production team.

Dr. Isabel Hawkins, a bilingual (English/Spanish) and bicultural educator and astronomer at the Exploratorium, shared several insights on effectively integrating bilingual and bicultural outreach.

“I really appreciate that our Exploratorium leadership gave the Spanish-language effort an entire complete production and implementation team.” – Dr. Isabel Hawkins

AT A GLANCE

- Highly professional live Spanish-language broadcast, website, and videos
- 200,000 viewers watched the live Spanish-language broadcast
- 250,000 visitors accessed on-demand videos in Spanish on the Exploratorium website
- The broadcast in Spanish strengthened the bilingual / bicultural mission of the Exploratorium

Dr. Isabel Hawkins hosted a live 60-minute Spanish-language broadcast of the eclipse from Casper, Wyoming with Univision’s Kira Vilanova, an Emmy-award winning anchor. The Spanish-language broadcast combined an interview and informal conversation.

Three Spanish-speaking evaluators watched the broadcast and viewed Spanish-language web content. Edu conducted an extended interview with Dr. Hawkins.

Evaluators noted that this broadcast reflects the Exploratorium’s commitment to:

- Providing resources for professional production to engage Latino audiences
- Teaching science with culturally authentic examples from Latino culture and history
- Diversity as a priority that brings the museum together in a cooperative effort



Production team

Dr. Hawkins attributes the success of the Spanish-language broadcast to having resources for a professional production team of 12 people. She says, “The fact that we had a full and very professional team with experience in Spanish-language sports was essential. We had a director, producer, four cameras, a drone, an image person, and a runner assigned to us.”

Dr. Hawkins continues “It makes sense to hire experienced teams. We hired a team that was very experienced working in remote locations and difficult situations. They were very resilient in the field. Stuff moves very fast and you don’t have a lot of second chances. The eclipse is only two and a half minutes and if you miss it, you miss it.”

Effect on the museum

Several people evaluators spoke with said that the Spanish-language effort was internally empowering for the Exploratorium and showed that diversity and inclusion is a priority. Dr. Hawkins commented, “Everybody cared and cooperated. It helped empower the Exploratorium team to embrace the museum’s Latino audience. It supported and built the bilingual mission internal to the Exploratorium and was inspiring, especially for staff from Latino backgrounds. It was so empowering.”

Culturally authentic

Cultural interpretation was central to the success of Spanish-language programming. The Exploratorium planned a “full-on effort” versus putting Spanish subtitles or Spanish voice-over on an English-language program. Dr. Hawkins emphasized, “It’s not just about language”.

The Spanish-language team made intentional decisions to formulate intentional cultural touchstones. For example, we wanted to focus on the history of astronomy in Latin America. The team wanted to stress the idea that science is not just a product of the European presence in the Americas, but there is a legacy of science and of astronomy in Latin America.

What would you tell the funder?

“I want to say thank you, gratitude for making this happen, for trusting the Exploratorium.”

Another message was to put the Spanish-language effort completely on par with the English-language. “Without resources, bilingual / bicultural programing becomes a veneer.”



User Experience

Users report positive Quality of Experience watching the livestream through a browser or mobile app.

An expert panel of five evaluators from across North America monitored and reported on the Quality of Experience (QoE) during the livestream on August 21, 2017. Evaluators monitored 25 test sessions of the livestream on different bandwidths, operating systems, browsers, and mobile devices.⁵

Livestream Ratings	
Picture 4.5 stars	
Sound 4.5 stars	
Stream 4.5 stars	
Interest 3.5 stars	

Positive experience

Reviewers consistently reported a positive experience with the quality of picture, quality of sound, and continuity of the eclipse livestream across operating systems, browsers, mobile devices, and channels.

SATISFACTION 25 REVIEWS

Users said that they were interested, engaged, and they understood many of the big ideas of eclipse science presented in the livestream. Testers said the quality of presenters was generally good although some scientists spoke quickly and used unfamiliar technical terms. Testers noted human interest videos that portrayed people from different demographics, ages, and places.

Testers rated the livestream on a five-point Likert scale every ten minutes during the one-hour live production. Technical quality averaged 4.0. Interest averaged 3.5. Interest was slightly lower at the start and at the end of the livestream.

Apps had generally positive reviews

Exploratorium iOS and Android Apps received positive reviews for design and ease of use. Both apps performed best on wifi. A reviewer said “I like the simplicity of the iOS app. It seems well-designed, easy to navigate, and the black background really appeals.”

⁵ Methodology – 25 simultaneous live test sessions monitored the livestream from 9:00 am to 11:30 am Pacific Time (16:00 UTC to 18:30 UTC) on August 21, 2107. Tests used a wide combination of operating systems, browsers, and devices. Programs Tested: Live production in English and Spanish, telescope feeds, sonification, App feeds, Facebook Live, NASA TV.

Operating Systems: Windows (Chrome, Internet Explorer, Firefox), MacOS (Chrome, Firefox, Safari), iOS (Safari, App), Android (App).

Devices: Windows and Mac computers, iOS iPad and iPhones, Android tablets and phones.

Bandwidth: Low 5mbps. Average 50mbps. High150mbps.

Testers were located across North America. Testers’ ages ranged from age 19 to 59.



Museums, Libraries, and Schools

The Exploratorium demonstrated the ability to reach many different channels of media with a unique image and live programs. Choosing to deliver the media in the form of a freely-distributed digital feed meant that the same signal could be shared by museums, libraries, schools, and mass media.

The Exploratorium made a concerted effort to promote the eclipse livestream through announcements to school, library, and museum partners. Follow-up by the Exploratorium provided evidence of wide use of livestream by the partners. Total numbers reached are difficult to capture. Representative examples of partners' use of the livestream follow.

The San Francisco Unified School District (SFUSD) thanked the Exploratorium for “your generosity in supporting thousands of SFUSD students who watch the eclipse during their first day of school.”

The Museum Alliance is a large national network of museums run through the Jet Propulsion Laboratory (JPL) in Pasadena. They report that most of their member museums used the NASA webcast that featured the Exploratorium livestream. One museum—The Discovery, a hands-on science museum located in Reno, Nevada—specifically reported using the Exploratorium livestream at an event with 1,500 attendees.

Over 4,000 people attended a live event at the Exploratorium in San Francisco featuring English and Spanish live programs and the live telescope feeds on large monitors throughout the museum.



NINETY PEOPLE ATTENDED A PROGRAM AT THE ALASKA STATE LIBRARY IN JUNEAU FEATURING NASA / EXPLORATORIUM LIVESTREAM.

Photo credit: Michael Penn



Eclipse in a Florida school

“The Exploratorium delivered an experience the kids would not otherwise have.”

A fourth grade teacher

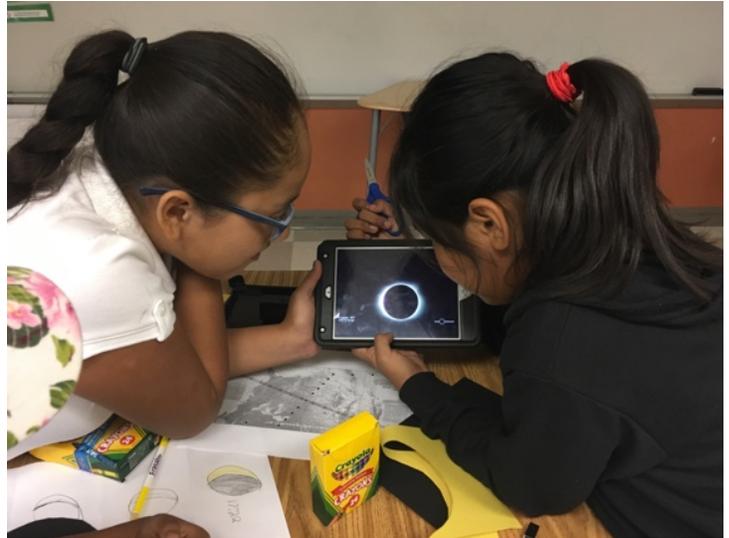
The teacher explains – Our primary school serves migrant families in rural south Florida. All of our students are on free and reduced lunch, and many are the sole English-speaking member of their family.

An experience

Our class of gifted and high-achieving fourth graders watched the livestream to experience the eclipse and to observe and understand the orbit of the earth.

What we did

Our students observed and drew telescope feeds to compare the progress of the eclipse in Oregon with that in Wyoming, raising questions about the orbits of the earth, sun, and moon. The eclipse provided a concrete connection to science, which is often abstract and difficult to understand.



STUDENTS IN FLORIDA USE THE EXPLORATORIUM WEBSITE TO EXPERIENCE A LIVE TOTAL SOLAR ECLIPSE. TOTALITY WAS AN AMAZING AND UNEXPECTED SURPRISE.



STUDENTS OBSERVED, DREW, AND COMPARED THE ECLIPSE IN OREGON AND WYOMING. THE EXPLORATORIUM'S ECLIPSE LIVESTREAM TURNED ABSTRACT SCIENCE INTO CONCRETE EXPERIENCES.

Why the livestream was important to us

The Exploratorium provided an extremely important experience for our class.

Our students had no eclipse glasses, and were not within the path to totality. Having the opportunity to watch the eclipse live was something our kids will always remember. It was like bringing a museum exhibition directly into the classroom.

Keep investing in science! Science develops the kids' critical thinking about the world that they live in.



Appendix

Comments and quotes reflect users' Quality of Experience

“The program shows multiple people’s views and different equipment. The pace is good and keeps me hooked.”

– A reviewer viewing the eclipse programs

MAIN CONCEPTS WERE CLEAR

What are the big ideas?

“No matter where you are in the country, you can participate in the eclipse and see it in different ways than other parts of the country.”

“Nice discussion around sunspots. Good use of images to explain concepts.”

“An eclipse is an amazing and breathtaking experience. I saw people's reactions to the beauty of the eclipse, how rare it is.”

What do you not understand?

“Meaningful questions” help to illustrate ideas that are not completely clear to the learner.

“I find that I can understand what I hear, but I'm not able to retell what I've heard. So I'm not sure how easy it is for the average viewer to understand the technical content.

“What is a diamond ring?”

“What is totality? I heard ‘totality’ from the very beginning. Like I was supposed to know – but it is a new term for me.”

“What is a hydrogen alpha filter and why does it keep getting mentioned?”

“Why does the shadow of the eclipse change locations around the world every year?”

“Why does the moon move so fast across the sun?”

“What causes the moon to line up exactly with the sun and earth and why does it not always line up?”

“What is the significance of sunspots and what role do they play in an eclipse in terms of sight?”

“The conversation on sunspots confuses me and seems off topic when I'm trying to focus on the eclipse.”

TALKING SCIENTISTS – GOOD BUT MIXED REVIEWS

“The quality of presentation seems highly variable: some of the NASA scientists are great, others have been awkward but interesting. Some presenters felt unprepared and rambled a lot.”

“The scientist speaking so quickly really makes it tough for me to comprehend.”

SPECTATOR INTERVIEWS ADD HUMAN INTEREST

The decision to focus on spectators added a human element to the broadcast. The take away was “experiencing an Eclipse can be a fun experience for everyone, and not just scientists”.



In May 2016 the Exploratorium successfully transmitted a solar eclipse and live program from the Western Pacific.

Three evaluators who reviewed both 2016 and 2017 livestreams said that the 2017 program “is a major improvement” and “this year’s content and presentation was much better-planned”.

“2017 is even better than 2016 broadcast. No criticism of 2016, but this year seemed incredibly professional, choreographed, well directed and flawlessly produced.”

ACCOLADES AND CRITIQUE

What should the Exploratorium be most proud of?

Reviewers complimented the resources that the Exploratorium gathered in terms of people and technology to simultaneously livestream the eclipse from multiple locations while educating viewers.

“They kept the stream pretty engaging and at a good pace, which is hard to do when recording something live.”

“The stream seemed well-organized and stood up to the hype surrounding the Eclipse. People knew what they were talking about.”

What can the Exploratorium do to improve future livestreams?

Reviewers had few suggestions for improvement.

“This might be far fetched... but if they added animations that went along with what the scientist were talking about, it might be easier for the average viewer to understand.”

Ending the broadcast could improve next time. The ending was slightly awkward, several speaking mistakes. “Eclipses are predictable, but sudden.”

THE APP HAD GENERALLY POSITIVE REVIEWS

“The Android app video is fine on average, audio is sometimes choppy, and stream frequently artifacts while using cellular data. The stream stops if I switch between horizontal and vertical layout.”

“The Android app used 1.6 gb cellular data during the one-hour live broadcast. A properly encoded one-hour video stream on YouTube uses less than 200 mb of cellular data.”



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