Enhancement of Astronomy and Earth Science Teaching Using High Resolution Immersive Environments
January 2016-December 2020
Evaluation Summary

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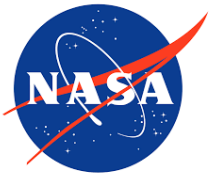

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Executive Summary

This report includes a summative evaluation of the Fiske Planetarium-led NASA Science Activation project titled "Enhancement of Astronomy and Earth Science Teaching Using High Resolution Immersive Environments". Throughout this project, evaluation was performed to track the achievement of stated project goals. This evaluation report includes information from (1) tracking of download requests of the planetarium/full-dome versions of the videos, (2) dissemination efforts via social media, YouTube, and the Fiske Productions website, (3) script alignment assessments (aligning each script with the NASA Science Mission Directorate (SMD)'s goals and objectives), (4) front-end online NASA interest surveys; (5) ongoing public audience surveys, (6) planetarium manager feedback surveys, and (7) the partner/subject matter expert survey.

Videos. Eight short videos on various topics for use in planetariums were created and disseminated over the course of the project. These videos highlighted NASA science and featured NASA subject matter experts, especially focusing on current NASA projects and topics.

Reach. The videos had a wide dissemination with planetariums (368 download requests submitted by 224 planetariums locations around the world, requesting 1,032 downloads of Explorations videos). The videos were also heavily viewed online (almost 7,000 YouTube views) and the video website was frequently visited (almost 2000 visitors viewed 13,000 pages).

Content. Content assessments showed the videos met many of the NASA SMD goals for public outreach. Audience assessments showed that the content was absorbed from the videos: three out of four audience surveys showing significant increases in audience understanding of the video content (the fourth survey also showed increases but the differences weren't significant).

Surveys. Feedback from planetariums and partners were overwhelmingly positive. Planetariums discussed how the short videos were useful for playing before or after larger dome shows and with educational audiences. They also appreciated the content showcasing current NASA science. Partners discussed that the team was good to work with and that the videos would be useful to planetariums. One quote from a planetarium manager was:

"…these films provide important information about the Universe in a memorable fashion. They are an important part of our operation which serves minority audiences and seeks to inspire the next generation of scientists and engineers. I hope that many more such videos will be made available in the future."

Introduction

The program evaluation was conducted by an evaluation team at the University of Colorado's Cooperative Institute for Research in Environmental Sciences (CIRES). The evaluation of this program has been reviewed by the University of Colorado Institutional Review Board; the evaluation has been certified Exempt (Protocol 16-0230). Funding for this work was provided by NASA. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.

The multidimensional project evaluation includes: (1) the front-end online NASA interest surveys conducted during 2016; (2) ongoing public audience surveys; (3) the planetarium manager feedback surveys implemented in 2019 and 2021; (4) script alignment assessment (aligning each script with the NASA Science Mission Directorate's goals and objectives); (5) the monthly evaluation reports of the dissemination efforts—via social media, YouTube, and the Fiske Productions website; (6) the national and international maps showing the number of institutions that have requested downloads of the planetarium/full-dome versions of the videos.

Eight episodes of the Explorations videos have been released to date. They are as follows:

- ***Explorations 1—GRACE: Earth's Hidden Water***
- ***Explorations 2—CubeSats: Big Science, Small Packages***
- ***Explorations 3—MU69***
- ***Explorations 4—Parker Solar Probe***
- ***Explorations 5—Apollo's Legacy: Rocks from the Moon***
- ***Explorations 6—The Dawn of Orion***
- ***Explorations 7 – TESS: Discovering New Worlds***
- ***Explorations 8 – SOFIA: Learning from the Invisible****

*Please note that SOFIA was released during 2020, the year of the COVID-19 pandemic when many planetariums closed. The SOFIA release methods were altered compared to those used for previous videos due to these circumstances. Therefore, the video analytics were not tracked for SOFIA.

Starting in 2019, one-page Educator Guides have been created for each video as it is released. The guides are included in Appendix III. These guides provide additional information and resources about each video, as follows:

- The Fiske Productions website URL
- A one-paragraph text summary of the key points of the video
- Information on highlighted science content experts interviewed during the video
- Additional educational resources, including the NASA Mission website, data portals, etc.

***Please note that testimonials from the planetarium surveys line many pages of this (italicized in gray) and more are listed on pages 16 & 18. Planetarium feedback was considerably positive.*

Dissemination of Completed Videos

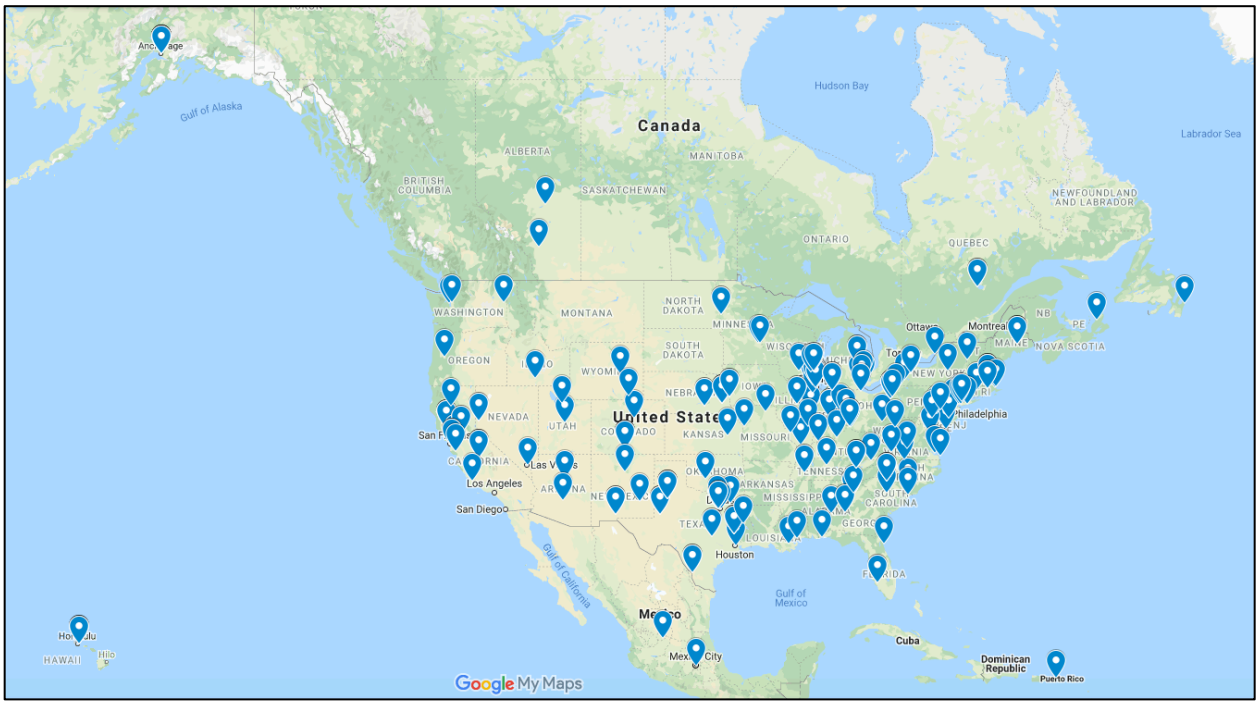
When a new video was released, the information was distributed to email lists (e.g., Dome-L) and social media (e.g., Twitter and Facebook); the video was also added to the Explorations section of the Fiske Productions website.

Download Requests from Planetariums and Other Institutions

One way that dissemination was tracked was via the download request forms that Fiske has received for the full-dome versions of the videos. Between November 1, 2018, and December 31, 2020, there were 368 requests submitted, requesting 1,032 downloads of Explorations videos. These requests came from 224 planetariums locations around the world, as shown in the figure below.

"They are great shows to supplement our main program. They leave the audience with the idea that NASA isn't dead and still exploring."

Below is a map for the United States data, showing the 243 download requests of 570 Explorations videos from 137 cities between November 1, 2018, and December 31, 2020.



The table below shows the number of download requests received for each full-dome video through December 31, 2020.

Video	Full-Dome Download Requests
Explorations 1—Gravity Recovery and Climate Experiment	177
Explorations 2—Big Science, Small Packages	178
Explorations 3—MU69	194
Explorations 4—Parker Solar Probe	208
Explorations 5—Rocks from the Moon	135
Explorations 6—The Dawn of Orion	90
Explorations 7—TESS Discovering Distant Worlds	50

*Please note SOFIA was released to planetariums in January 2021, after the official end of the project. Download requests after the project end were not tracked.

Fiske Productions Website

The Fiske Productions website (https://www.colorado.edu/fiske/about-us/fiske-productions) highlights each video and its Educator Guide (Appendix III) as they become available. The site provides links to the flat-screen version of the Explorations videos on YouTube. This provides the general public with an accessible portal for viewing the videos.

YouTube counts views of videos. The totals as of January 4th, 2021, are shown in the table below.

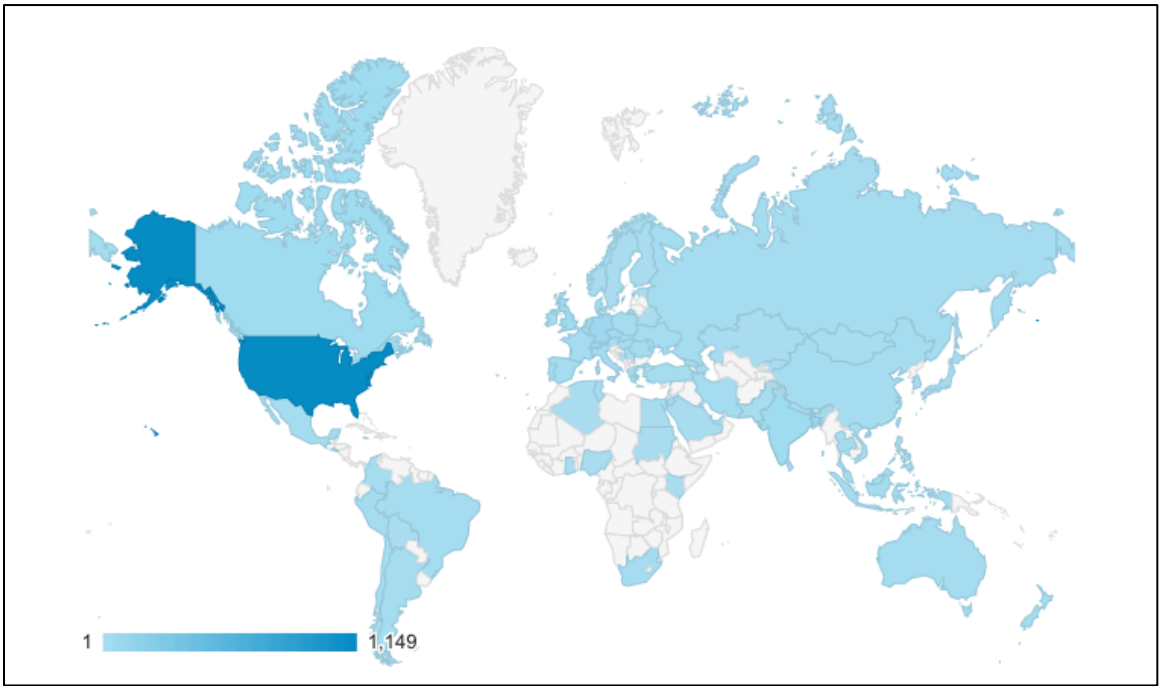
Video	Total YouTube Views
Explorations 1—Gravity Recovery and Climate Experiment	474*
Explorations 2—Big Science, Small Packages	317
Explorations 3—MU69	360
Explorations 4—Parker Solar Probe	4,983
Explorations 5—Rocks from the Moon	458
Explorations 6—The Dawn of Orion	266
Explorations 7—TESS Discovering Distant Worlds	105

*Please note that on April 5th, 2020 an update occurred to the YouTube channel page and previous views counts were reset for Explorations 1. The last report prior to that change was made on April 3rd, 2020 so there may be some views that occurred between April 3rd, 2020 and April 5th 2020 that were lost. The new count for total views on the YouTube page of Explorations 1 as of 1/4/2021 is 101 (the last count before the transfer was 373).
**Please note that SOFIA was added to the YouTube and released on the Fiske Productions page in January 2021. Video views after the project end were not tracked.

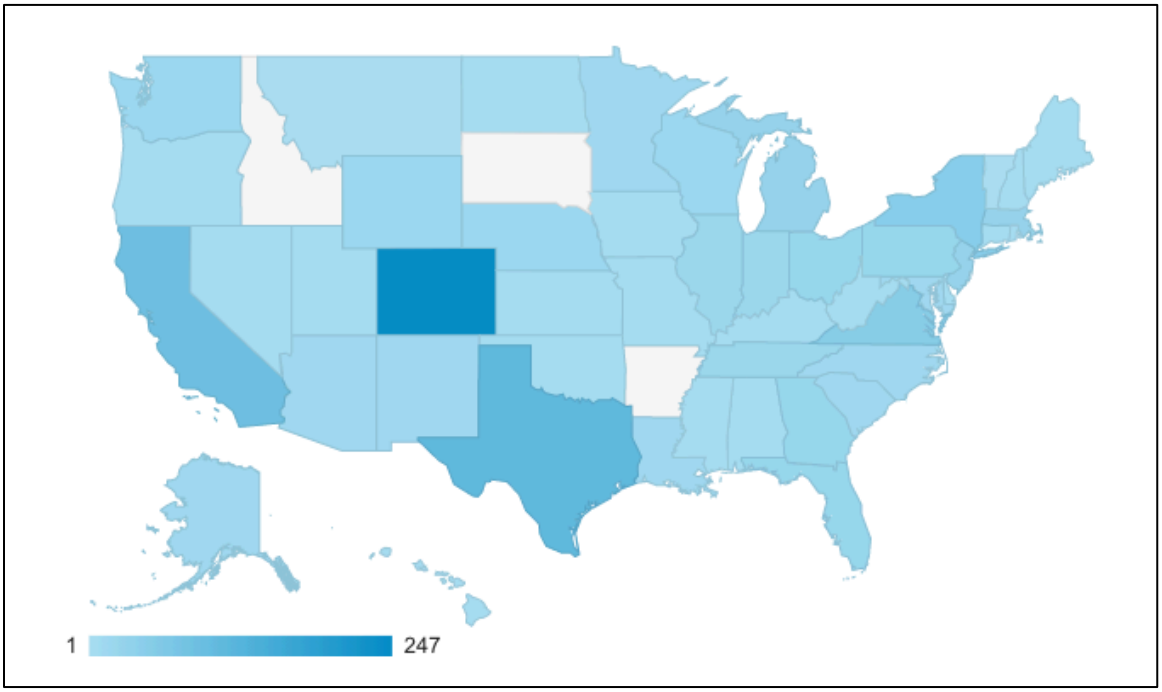
As of December 31, 2020, there were 1937 visitors to the Fiske Productions website. During their visit, they averaged almost five website pages viewed per visit (a total of 13,122 Pageviews), with an average session duration almost five minutes. The bounce rate was around 50%. About 23% were return visitors to the Fiske website. About 44% arrived via a referral (e.g., from another website), 36% arrived via a direct method (e.g., a bookmark or typing the URL directly into the browser window); 15% arrived via a search (e.g., Google or Bing); and 5% came via social media.

"*Students get a lot of questions because they really don't know much about these explorations, so it leads to interesting discussion afterwards.*"

Fiske Productions website visitors' ISPs were located in 83 different countries; in the map below, the color coding is by number of users from that country (maximum=1,149 from U.S.).



U.S. visitors were located in 48 different states.



Alignment of Videos with NASA SMD Goals

The project evaluation team monitored project achievements using an alignment matrix to analyze surveys/interviews and videos/scripts along NASA goals and topic areas. During development, each video's script was processed using the alignment matrix. The NASA SMD Goals and topic areas are listed below; items addressed by the Explorations video scripts are highlighted in green. Most of NASA's SMD goals were addressed by the various videos developed throughout the project.

SMD Top Level Goals

- Enable STEM Education – Document benefits/improvement of including NASA Science experts, content, and authentic experiences to learners of all ages
- Improve US Scientific Literacy – Statistical Improvement of Science and Engineering Indicators 2014 by 2020. At a minimum
    - Understanding of scientific process
    - Earth Processes
    - Sun-Earth relationship
    - Universe beginnings
- Advance National Educational Goals- Supporting Co-STEM goal achievement by 2020
- Leverage Through Partnerships – Document benefits/improvement of including NASA Science and collaborative approach

SMD Divisions https://science.nasa.gov/about-us/smd-vision

- Earth Science https://smd-prod-admin.nasawestprime.com/earth-science
- Planetary Science https://solarsystem.nasa.gov/
- Heliophysics https://smd-prod-admin.nasawestprime.com/heliophysics
- Astrophysics https://smd-prod-admin.nasawestprime.com/astrophysics

NASA Science is Interconnected diagram (https://science.nasa.gov/about-us)

- How did the universe begin and evolve, and what will be its destiny?
- What drives variations in the Sun, and how do these changes impact the solar system and drive space weather?
- How did our solar system originate and change over time?
- How and why are Earth's climate and environment changing?
- How did life originate, and are we alone?
- Impact of the Sun on planetary bodies
- Impact of the Sun on Earth
- Evolution of surface and atmospheres; Co-evolution of climate and life
- Star formation and evolution; Cosmology and galaxy formation
- Planet habitability
- Planet formation and evolution
- Exoplanet characterization; Origins of life

Science by the Numbers (https://science.nasa.gov/about-us)

- Spacecraft
- CubeSats
- Balloon Payloads

- Sounding Rocket Flights
- Earth-Based Investigations
- Technology Development
- Research

Gap analysis of the matrix data provided the project team with information about topic areas that could be addressed in videos, as well as documentation of NASA topics that have been covered to date. Alignment tables for each script are shown below.

Improve US Scientific Literacy – Statistical Improvement of Science and Engineering Indicators 2014 by 2020.

Script	Scientific Process	Earth Processes	Sun/Earth Relationship	Universe beginnings
GRACE		x		
CubeSats	x	x	x	
MU69	x			
PSP			x	
Moon Rocks		x		
Orion				
TESS				
SOFIA	x	x		x

SMD Divisions https://science.nasa.gov/about-us/smd-vision

Script	Earth Science https://smd-prod-admin.nasawestprime.com/earth-science	Planetary Science https://solarsystem.nasa.gov/	Heliophysics https://smd-prod-admin.nasawestprime.com/heliophysics	Astrophysics https://smd-prod-admin.nasawestprime.com/astrophysics
GRACE	x			
CubeSats	x	x	x	
MU69		x		
PSP		x	x	
Moon Rocks	x	x		
Orion		x		
TESS		x		x
SOFIA		x		x

NASA Science is Interconnected diagram (https://science.nasa.gov/about-us)

Script	GRACE	CubeSats	MU69	PSP	Moon Rocks	Orion	TESS	SOFIA
How did the universe begin and evolve, and what will be its destiny?								
What drives variations in the Sun, and how do these changes impact the solar system and drive space weather?				x				
How did our solar system originate and change over time?			x		x			
How and why are Earth's climate and environment changing?	x							
How did life originate, and are we alone?								
Impact of the Sun on planetary bodies		x						
Impact of the Sun on Earth		x						
Evolution of surface and atmospheres; Co-evolution of climate and life			x		x		x	
Star formation and evolution; Cosmology and galaxy formation							x	x
Planet habitability		x	x			x	x	
Planet formation and evolution		x	x		x			
Exoplanet characterization; Origins of life							x	

Science by the Numbers (https://science.nasa.gov/about-us)

Script	Spacecraft	CubeSats	Balloon Payloads	Sounding Rocket Flights	Earth-Based Investigations	Technology Development	Research
GRACE	x				x	x	x
CubeSats	x	x				x	x
MU69	x					x	x
PSP	x					x	x
Moon Rocks	x						x
Orion	x					x	x
TESS	x					x	x
SOFIA					x	x	x

"I think these films provide important information about the Universe in a memorable fashion. They are an important part of our operation which serves minority audiences and seeks to inspire the next generation of scientists and engineers. I hope that many more such videos will be made available in the future."

Survey Data Methodologies and Results

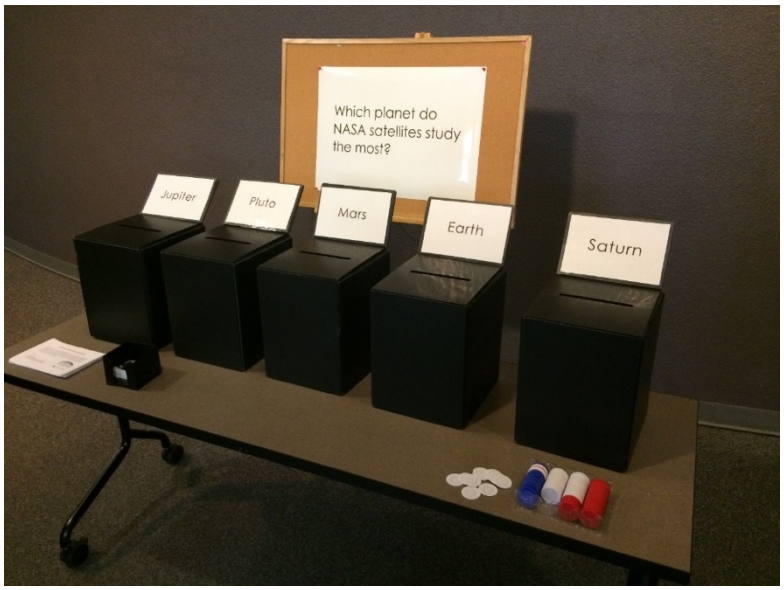
Online surveys, audience surveys, and undergraduate student surveys were implemented as part of the project evaluation to assess the video science content. The total number of respondents to the various survey methods are listed by category in the table below.

Respondents	Totals
Undergraduate University of Colorado Astronomy Students	357
Fiske Planetarium Public Visitors (Interviews &"Bucket" Surveys)	894
General Public (2016) and Implementation (2019) Online Surveys	564

Audience and Undergraduate Student Video Feedback Surveys

Brief public interviews were conducted by Fiske Planetarium staff before and after public shows (Appendix I). These qualitative data are collected to inform audience interest in and knowledge of video topics. They were also used to refine multiple-choice survey questions (Appendix II) that were implemented to gather audience ("Bucket" and Undergraduate Pre/Post) survey data. At Fiske Planetarium, the videos were shown before regular planetarium shows.

"Bucket" Survey Method: After selected public Fiske Planetarium shows, a multiple-choice question was presented and audience members were invited to, on their way out of the planetarium, go to the question response table in the lobby and deposit one token (poker chip) in the box that illustrates their response to the question. A planetarium staff member was there to supervise the process. For some implementations, different color tokens were distributed to audience members (1) who arrive in time to see the video before the planetarium show and (2) who arrive after the video has been shown. See the figure below for the question response table setup.



Undergraduate Astronomy Class Pre/Post Surveys

Another survey method implemented for the project involved undergraduate astronomy classes held at Fiske Planetarium. Surveys were implemented during two class sessions that were several weeks apart. As they assembled in the planetarium, students were provided with clickers. Survey questions were provided at the beginning of the astronomy class and students used the clickers to select their multiple-choice responses. During the first class, the Explorations video(s) was(were) shown immediately after the survey. During the second class, the survey was implemented at the start of the class.

Video Feedback Surveys to Date

Several surveys were implemented at Fiske Planetarium during 2018 and 2019; the data gathered were used to assess the effectiveness of the Explorations videos. Surveys were conducted for episodes 1, 2, 4, and 5 (GRACE, CubeSats, Parker Solar Probe, and Rocks from the Moon). The short timeline involved in the development and dissemination of Explorations 3—MU69 (before the 1/1/19 flyby) did not allow for any surveys to be conducted. Surveying for episodes 6-8 (Orion, TESS, and SOFIA) were interrupted by the COVID-19 pandemic and were not completed.

For all surveys where pre/post or video/non-video comparison groups were used, understanding of the video topics appears to have been enhanced by watching the videos. Post-only surveys also showed a good comprehension of video topics by most audience members. Survey and interview implementations are listed below.

Explorations 1—Gravity Recovery and Climate Experiment

- Surveys of Fiske audiences after a planetarium show from fall 2018
- Pre/post survey during spring 2018 undergraduate class; although correct responses increased, a t-test showed that increases were not significant at a $p<.10$ level.

Explorations 2—Big Science, Small Packages

- Survey (and video) informed by brief interviews with Fiske audience members in 2017
- Pre/post survey during spring 2019 undergraduate classes; a t-test showed that increases in correct responses were significant at a $p<.10$ level.

Explorations 4—Parker Solar Probe

- Survey (and video) informed by brief interviews with Fiske audience members in 2017
- Pre/post survey during spring 2019 undergraduate classes; a t-test showed that increases in correct responses were significant at a $p<.10$ level.

Explorations 5—Rocks from the Moon

- Surveys of Fiske audiences, comparing those who saw a video with those who did not before a planetarium show from summer 2019
- A chi square analysis across the groups (those who saw the video and those who didn't) showed that increases in correct responses were statistically significant at a $p<.05$ level.

"Keep them coming. They are a wonderful addition especially to our classes in astronomy. Great videos to play before a main show."

Online Surveys

Online surveys were used for front-end (2016), implementation (2019), and summative (2021) evaluation work.

Front-End Evaluation Surveys

The 2016 surveys were developed to gather a broad range of information from the public regarding their interest in and attitudes toward NASA and its missions. The surveys were distributed to space-interested audiences via email lists (including audience members of Fiske Planetarium and Mather Planetarium in West Chester, Pennsylvania). The data collected provided the project team with information about topic areas that could be addressed in videos, dissemination strategies, as well as planetarium activities and formats.

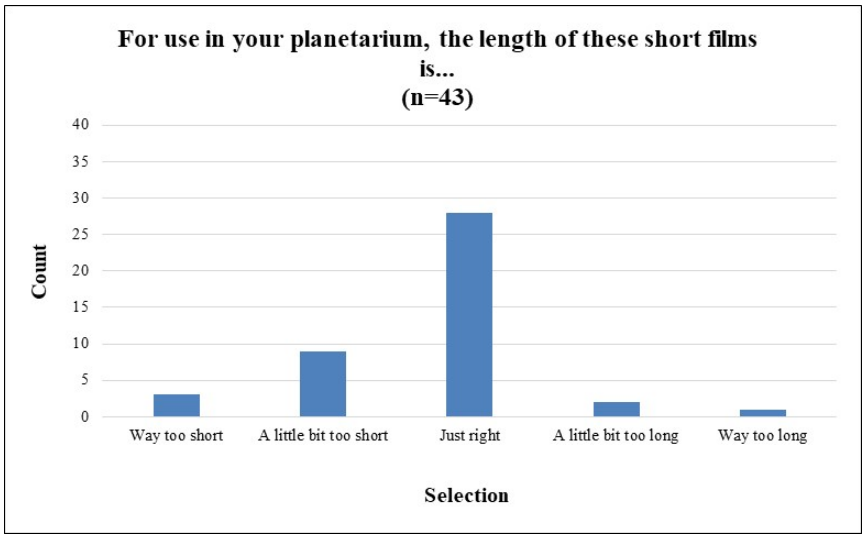
Implementation Survey

A feedback survey was developed to gather input from planetariums that had downloaded and presented Explorations full-dome-format videos in their theaters. During fall 2019, invitations were sent to 120 planetarium managers around the world who had submitted one or more download requests for the full-dome-format Explorations videos. There were 58 responses, a 48% response rate. All the videos had been shown in multiple planetariums, as shown in the table below.

Video Title	Explorations 1--Gravity Recovery and Climate Experiment	Explorations 2--Big Science, Small Packages	Explorations 3--MU69	Explorations 4--Parker Solar Probe	Explorations 5--Rocks from the Moon
Planetariums that have shown the video	18	16	21	17	13

"They are very cool. Having the shorts available to add on for groups or to use standalone in open houses works really well. The timing of them is about perfect for keeping interest/flow of people just about right."

Respondents were very appreciative of the videos and planned to download more as they become available. Most people thought the length was good, as shown in the figure below.



Open-ended comments included the following:

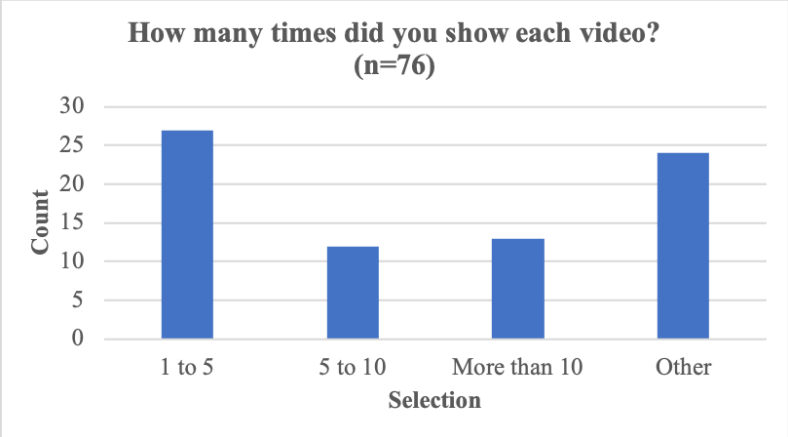
- *...this series is truly fantastic! Thank you for all you do!*
- *Thank you for making these videos available to us. I make a point of showing one before every program. They have been well received by all of our visitors.*
- *Thank you for providing these videos to our school. Aukamm ES is a school in Germany servicing the children of the men and women in the Armed Forces. We appreciate the resources you have for us to use with our military families while stationed overseas.*
- *for a planetarium with a limited budget, these free videos are much appreciated*
- *Thank you so much for providing these shorts they are great supplements to my prerecorded shows.*
- *I support your work and hope you get all the support you need.*
- *Thank you for making these available for free.*
- *Thanks for your work and for the opportunity to use the features.*
- *Thanks you so much for providing these videos for our college. It's truly appreciated and a wonderful asset to our college and our community.*
- *After being glued to the television in the 1960s for every rocket launch, and seeing Neil Armstrong and Buzz Aldrin walk on the Moon, I remember the excitement shared by all of my classmates throughout elementary, middle and high school for space exploration. I see the EXPLORATIONS series as one way to help reignite that passion in our students today.*
- *This is a great way to see my tax dollars out to work. I reference that in anything NASA or NSF.*
- *These series of episodes are ALL wonderful! Keep them coming! Thanks you for providing them to the Planetarium community for us to present, educate, inform and entertain to all our audiences.*

Summative Surveys

At the end of the project, a feedback survey was developed to gather input from planetariums that had downloaded and presented Explorations full-dome-format videos in their theaters. During January 2021, invitations were sent to 243 planetarium managers around the world who had submitted one or more download requests for the full-dome-format Explorations videos. The survey was also advertised on planetarium email lists and message boards. There were 117 responses and results are shown below (a response rate is hard to calculate considering the wide advertising of this message).

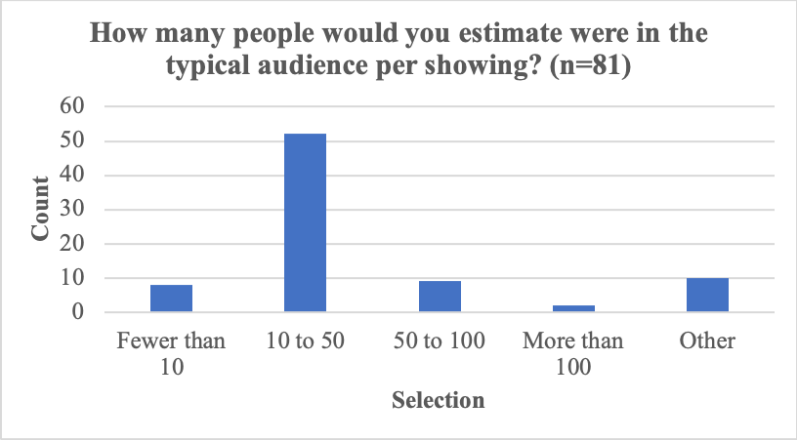
Planetariums: The responses represented a range of planetariums, with about half of responses coming from US-based planetariums (62; 53%) and about half coming from planetariums based outside of the US (55; 47%). There was a fairly even distribution across the size of the cities in which the planetariums were based, and 32 states were represented.

Showings: Most planetariums reported showing at least one video, with many showing several. However, many planetariums reported not having shown the videos yet because of issues related to the COVID-19 pandemic. Most planetariums showed the video between 1 and 5 times (27; 23%), while fewer planetariums reported showing them 5 to 10 times (12; 10%), and more than 10 times (13; 11%). Many planetariums chose 'other' on this question (24; 21%) and mentioned not being able to show them due to COVID-19 closures, although one planetarium reportedly showed the videos 1-5 times *per day*. See figure below.



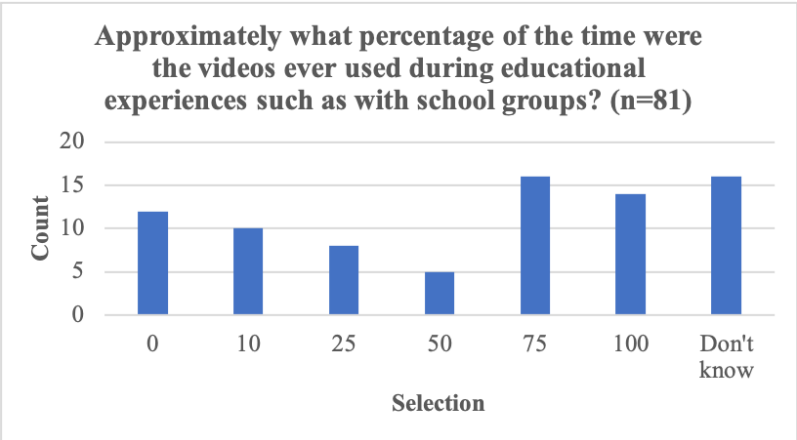
Timing/format: Most planetariums (25; 21%) showed the videos during planetarium shows, while fewer showed them before (14; 12%) or after (10; 9%). Many planetariums chose the 'other' response (28; 24%) and reported either not showing the videos due to COVID-19 closures, showing the videos during school visits or with university classes, and one reported playing the video during a virtual planetarium show.

Audience size: Most planetariums reported showing the videos to audiences of about 10 to 50 people (52; 44%), while fewer showed them to audiences of fewer than 10 (8; 7%) or 50 to 100 (9; 8%). Two planetariums reported audiences of more than 100 and ten reported 'other' on this question (9%), with most of those specifying they hadn't shown them due to COVID-19 closures. See figure below.



Audience: Planetariums were asked to estimate the audience percentage of underrepresented groups. Most reported about equal percentages across predominant genders (56 or 48% responded that about 50% of their audience included women or girls). Most planetariums reported having relatively low percentages of people of color or other minority groups in their audiences (49 or 42% responded that less than 25% of their audience were people of color or other minority groups while 16 or 14% responded that at least 50% of their audience were people of color or other minority groups). Many planetariums reported not knowing this information or did not respond to the question.

Educational audiences: Planetariums were asked to estimate the percentage of time the videos were used with educational groups. Roughly equal numbers reported low percentages of time and high percentages of time during which the videos were used for educational experiences (30 or 26% responded that fewer than 50% of the time videos were used for educational experiences while 30 or 26% responded that more than 50% of the time videos were used for educational experiences). Many planetariums reported not knowing this information or did not respond to the question. See figure below.



Testimonials: Planetariums were asked to describe any other thoughts they had about the Fiske Explorations videos and their impact on audiences. All responses were positive reviews of the videos and their impacts, although two had suggestions for improvements. Many of the responses are included below (some had similar sentiments as others and were not reported to save space). Please note some responses were altered slightly to address spelling and grammar mistakes:

- *Although we haven't been able to work the Fiske Explorations videos into our shows for a variety of reasons--timing, closure, production time, training, etc.--they are great productions and I'm looking forward to using them in the future.*
- *Thanks for sharing them with us.*
- *I have seen these videos and really enjoy them for both their educational/scientific knowledge and quality of the stories and visuals. I hope to run some of these productions in our planetarium at the [Planetarium name removed to protect privacy] as soon as can be.*
- *I appreciate having these available even though I haven't gotten to use them much yet. It really helps show kids something new and they really got excited about STEM careers*
- *Fantastic programs! We are seriously grateful that Fiske is sharing these wonderful shows with us!*
- *We are grateful to have access to such high-quality educational experiences*
- *Amazing*
- *We found your shows very interesting and engaging. Unfortunately, we were able to show only one of them and only once, due to COVID-19*
- *I like that they cover relatively current events. Often our shows, we will play them for several years. Nice to have fresh content.*
- *I love all the content you produce, and am excited to begin sharing it as we work through the pandemic!*
- *Thanks for making these and sharing them!*
- *They really enjoy the videos. I really enjoy them too. I often use them as a starting point for my live star talk or other concept related show.*

The two suggestions were:

- *If possible, there continues to be very little elementary aged (K-5) content / curriculum available without having to pay huge licensing fees for full dome productions. We are a district level planetarium that does not have any income/budget to provide shows to our in-district students. Most of the content that is "free and available" very in depth for our 5 - 10 year olds. Our goal is to simply provide an amazing free field trip experience within our "race to space" planetarium that was built back in 1972. Thank you for taking this into consideration!*
- *Based on audience reactions, we would like to see more full scenery and less graphics and square slide-like images. Audiences want a more experiential ("you are there") environment.*

Partnerships

Partners at various NASA facilities worked with Fiske to develop materials for the videos. Most videos include an interview with a scientific content expert/subject matter expert; these scientists and engineers have come from a variety of partner institutions. Partners over the entire project are shown in the table below.

Name	Affiliation	Explorations Episode	Partner / Interviewee
Jenni Bonin	College of Marine Science, University of South Florida	Explorations 1: GRACE: Earth's Hidden Water	Interviewee
Chris Moore	Harvard Smithsonian Center for Astrophysics	Explorations 2: CubeSats: Big Science, Small Packages	Interviewee
Chris "Gilly" Gilbert	Laboratory for Atmospheric and Space Physics, University of Colorado Boulder	Explorations 4: Parker Solar Probe	Interviewee
Steve Moijzis	Collaborative for Research in Origins (CRiO), University of Colorado Boulder	Explorations 5: Apollo's Legacy: Rocks from the Moon	Interviewee
Randolph Bresnik	NASA STS and ISS Astronaut and Mission Commander	Explorations 6: The Dawn of Orion	Interviewee
Zach Berta-Thompson	Center for Astrophysics and Space Astronomy, University of Colorado Boulder	Explorations 7: TESS: Discovering New Worlds	Interviewee

Dana Backman	NASA Airborne Astronomy Ambassadors, NASA Ames Research Center	Explorations 8: SOFIA: Learning From the Invisible	Interviewee
Simon Steel	SETI Institute	Explorations 8: SOFIA: Learning From the Invisible	Interviewee
Daniel Burleson	Rancho High School, NV	Explorations 8: SOFIA: Learning From the Invisible	Interviewee
Kathryn Smith	William S. Hart High School, CA	Explorations 8: SOFIA: Learning From the Invisible	Interviewee
Tyler Thompson	West Career & Technical Academy, NV	Explorations 8: SOFIA: Learning From the Invisible	Interviewee
Dawn Minnick-Trujillo	Las Vegas Academy of the Arts, NV	Explorations 8: SOFIA: Learning From the Invisible	Interviewee
Jason (Brant) Dodson	NASA Langley Research Center	Explorations 9: GLOBE (unfinished)	Interviewee
James Mason	MinXSS Project Manager and Systems Engineer	Explorations 2: CubeSats: Big Science, Small Packages	Partner
Amber Jean Watson	Multimedia Editor and Distribution Specialist, Still/Audio/Video Public Affairs, NASA/Kennedy Space Center	Explorations 4: Parker Solar Probe	Partner

Dana Backman	NASA Airborne Astronomy Ambassadors, NASA Ames Research Center	Explorations 8: SOFIA: Learning From the Invisible	Partner
Coral Clark	SOFIA Science Center	Explorations 8: SOFIA: Learning From the Invisible	Partner
Lori Perkins	Data Systems, Sciences and Exploration Directorate, NASA Goddard Space Flight Center		Partner
Ernie Wright	Media Specialist, Sciences and Exploration Directorate, NASA Goddard Space Flight Center	Explorations 6: The Dawn of Orion & Explorations 5: Apollo's Legacy: Rocks from the Moon	Partner
Leif Heimbold	NASA Goddard Space Flight Center	Explorations 6: The Dawn of Orion	Partner
Barbara Adde	Policy & Strategic Communications Director, Space Communications & Navigation, Human Exploration and Operations Mission Directorate		Partner
Sharon Bowers	eClips		Partner
Theresa Schwerin	Institute for Global Environmental Strategies	Explorations 9: GLOBE (unfinished)	Partner
Lin Chambers	NASA Langley Research Center	Explorations 9: GLOBE (unfinished)	Partner
Jessica Taylor	NASA Langley Research Center	Explorations 9: GLOBE (unfinished)	Partner

Allison Leidner	NASA Earth Science Division	Explorations 9: GLOBE (unfinished)	Partner
Tony Murphy	GLOBE Implementation Office	Explorations 9: GLOBE (unfinished)	Partner
Holli Kohl	NASA Goddard Space Flight Center	Explorations 9: GLOBE (unfinished)	Partner
Trena Ferrell	NASA Goddard Space Flight Center	Explorations 9: GLOBE (unfinished)	Partner
Sarah Parsons	The University Corporation for Atmospheric Research (UCAR)	Explorations 9: GLOBE (unfinished)	Partner

Partner Feedback

In February 2021 a survey was sent to ten of the partners with which the Explorations team worked most closely. Six partners responded to the survey (a response rate of 60%) and their responses are highlighted below:

Five out of six respondents (83%) rated their satisfaction with working on the Explorations videos project as "Extremely Satisfied", with one rating it as "Neither satisfied nor dissatisfied". The person who ranked it lower did not expand on their experience in the open-ended questions. When asked why they chose the rating they chose, partners said:

- *It was a fun experience, working with people I already knew to create fun content.*
- *They are real pros; they were completely prepared for their visit to Palmdale and then were flexible as the SOFIA mission schedule changed, and changed again. They were also able to set our teacher participants at ease.*

When asked what they took away from their collaboration with the Fiske Explorations Videos team, partners said:

- *Making videos is fun!*
- *That the Fiske video products (not just ours) will be valuable resources for planetariums.*

When asked for any other comments, one partner said:

"*Wish we could do more, but the project is ending.*"

Appendix I--Fiske Visitor Public Interview Protocol

Each brief interview was conducted by a planetarium staff member. Recorded audio data informed the qualitative survey question design. The Fiske protocol for public interviews is as follows:

1. Wear Fiske nametag. State your name, the date, time, and show for the recorder. Pause recording. Make note of whether you are interviewing before or after the show.
2. Following the show, randomly ask someone in the Fiske lobby if they would be willing to take a short survey about NASA. These surveys will help Fiske develop a new short film series about the projects that NASA does.
3. Emphasize that it is voluntary and that they will remain anonymous.
4. Let them know they will receive a 2-for-1 discount coupon for completing the survey.
5. Let them know you will be recording them on an audio-recorder.
6. Ask for verbal confirmation that they are 18 or older.
7. After, thank them and provide the coupon.

Appendix II--Fiske Visitor and Student Survey/Interview Questions

Explorations 1—Gravity Recovery and Climate Experiment

Pre/Post Questions

Have you heard about NASA's GRACE satellites before?

- Yes
- No

NASA's GRACE satellites **monitor**

- Evaporation rates
- Humidity
- Weather patterns
- Underground water
- All of the above

What do the GRACE satellites **measure**?

- Gravity
- Surface minerals
- Pressure
- Humidity
- Temperature

In the video, there is a colored grid/map shown. What do the red and blue colors represent?

- Temperature variations
- Amount of water based on gravity
- Elevation of landforms
- Vegetation coverage

About how many gallons of water per person are pumped every day in the state of California?

- 1-10 gallons
- 20-30 gallons
- Hundreds of gallons
- Thousands of gallons

What's the most direct cause of underground droughts?

- It has not rained enough in the last few years
- We are pumping water out faster than it comes in
- Climate change

"Bucket" Questions

Before seeing the GRACE video, did you know that NASA satellites monitor how much water is underground?

- Yes

- No

What's the most direct cause of underground droughts?
- It has not rained enough in the last few years
- We are pumping water out faster than it comes in
- Climate change

What have the GRACE satellites measurements told us about polar ice?
- The ice is getting thinner
- The ice is getting heavier
- The ice is getting polluted

Additional question, possibly for summer:
Which planet do NASA satellites study the most?
- Earth
- Mars
- Jupiter
- Saturn
- Pluto

Explorations 2—Big Science, Small Packages

Interview Questions

[Describe] what a satellite is, or what you think of when you think of satellites.

What sorts of things do satellites do?

How big do you imagine [satellites] to be?

Do you think it's important for us to study the sun, and why or why not?

Pre/Post or "Bucket" Questions

What is a CubeSat?
- A miniature satellite
- A camera with six sides
- A radio transmitter
- I don't know

What is one advantage of CubeSats?
- Less drag in their movements
- Greater power than other satellites
- Greater accessibility for students
- Nuclear power cell provides more energy
- I don't know

What do MinXSS instruments study?
- Earth's ozone layer
- Solar flares
- Infrared radiation
- I don't know

What is the CubeSat Lunar Flashlight looking for?
- Mineral deposits on the moon
- Possible lunar landing sites
- Ice on the moon
  I don't know

What makes up part of the MinXSS antenna?
- Tape measure
- Duct tape
- Barbed wire
- I don't know

Explorations 3—MU69

Pre/Post or "Bucket" Questions

This fall, how fast is New Horizons travelling?

- Between 300 and 400 miles per hour
- Between 3,000 and 4,000 miles per hour
- Between 30,000 and 40,000 miles per hour
- I don't know

One reason New Horizons' images of Pluto were a surprise to astronomers was...

- they showed lakes of liquid water
- they revealed few craters on the surface
- they were very bright in the infrared
- I don't know

A single picture of MU69 sent by New Horizons...

- will arrive faster than a picture from Pluto
- will take hours to reach Earth
- will take weeks to reach Earth
- I don't know

How did astronomers figure out the size of MU69?

- They measured its gravitational pull on Pluto
- They studied its spectral light with telescopes
- They studied its shadow passing over the Earth
- I don't know

The MU69 flyby is important for learning...

- more about the formation of the solar system
- how Pluto developed its mountains of ice
- how its shadow passes over Earth
- I don't know

Explorations 4—Parker Solar Probe

Interview Questions

How much do you think scientists know about the sun on a scale of 1 to 10?

What is the sun made of?

[...] what do you know about [solar flares]?

Have you heard of the term, 'solar wind'? Could you try describing what you think it is?

Do you think it's important to study the sun? Why or why not?

What's the closest distance a spacecraft has ever been to the sun?

Pre/Post or "Bucket" Questions

The solar corona can be seen...

- Only by the Parker Solar Probe
- Only during a total eclipse
- During total eclipses and also by space probes or satellites
- I don't know

Why are we so interested in flying through the sun's corona?

- We want to bring a sample of the corona back to Earth
- We want to understand how the solar wind comes off of the sun
- We want to test new solar panel technology near the sun
- I don't know

Why isn't the Parker Solar Probe going to melt under such high temperatures?

- It has special instruments that can survive high temperatures
- A carbon composite shield shades its instruments
- The average temperature of space is very cold
- I don't know

Why do we care about the solar wind?

- The sun is gradually losing matter and shrinking and we need to understand why
- The solar wind can damage ecosystems on Earth when the sun has "solar flares"
- It contributes to global climate change
- The solar wind can damage satellites in orbit around the Earth
- I don't know

Why does the Parker Solar Probe orbit very close to Venus 7 times?

- To conserve energy while going to the sun

- So that the probe can also study Venus
- To make the mission longer
- I don’t know

Explorations 5—Rocks from the Moon

Interview Questions

What happened to most of the moon rocks that were collected by the Apollo mission?

Why are scientists studying moon rocks?

How often do astronauts go to the moon?

Do you think we should put more resources into going to the Moon or to Mars?

Pre/Post or "Bucket" Questions

After studying the Apollo Moon rocks, what did NASA do with them?

- They gave them to museums to be displayed
- They were sold to various groups to help fund NASA
- They were given away to schools across the country
- NASA is still studying most of them
- I don't know

When have astronauts gone to the moon?

- Not since the 1970's
- Not since the 1950's
- They go every few years
- Regularly until the Space Shuttle stopped flying
- I don't know

Studying the Moon rocks has helped us understand that...

- Rocks on the surface of the Moon are younger than those on the Earth
- The Moon was an asteroid that was captured by the Earth's gravity
- The Moon formed from the debris when something smashed into the early Earth
- The moon rocks are very different from any rocks on Earth
- I don't know

What are the lunar maria?

- Ancient oceans on the moon
- Dark regions of solidified lava
- The largest impact craters
- The Soviet lunar landers
- I don't know

Appendix III--Fiske Planetarium Manager Survey Questions

Planetarium Manager Mid-Project Implementation Survey Questions

What planetarium are you with? (open-ended responses for each)

- Facility Name:
- City:
- State/Province (or enter N/A)
- Country:

Have you shown the GRACE video (Explorations 1 – Gravity Recovery and Climate Experiment) in your planetarium theater?

- Yes
- No

Have you shown the Cubesats video (Explorations 2 – Big Science, Small Packages) in your planetarium theater?

- Yes
- No

Have you shown the MU69 video (Explorations 3 – MU69) in your planetarium theater?

- Yes
- No

Have you shown the Parker Solar Probe video (Explorations 4 – Parker Solar Probe) in your planetarium theater?

- Yes
- No

Have you shown the Apollo video (Explorations 5 – Rocks from the Moon) in your planetarium theater?

- Yes
- No

How did you use the GRACE video in your programming?

- The video was shown before a planetarium show
- The video was shown after a planetarium show
- Other (please specify)

How many times or how often has the video been shown? (open-ended)

How many people, on average, were in the audience per showing? (open-ended)

What questions or comments from the audience or your staff were generated by the video? (open-ended)

We are assembling supplementary materials for each video. What additional information on the video topic would be helpful? (open-ended)

How did you use the Cubesats video in your programming?

- The video was shown before a planetarium show
- The video was shown after a planetarium show
- Other (please specify)

How many times or how often has the video been shown? (open-ended)

How many people, on average, were in the audience per showing? (open-ended)

What questions or comments from the audience or your staff were generated by the video? (open-ended)

We are assembling supplementary materials for each video. What additional information on the video topic would be helpful? (open-ended)

How did you use the MU69 video in your programming?

- The video was shown before a planetarium show
- The video was shown after a planetarium show
- Other (please specify)

How many times or how often has the video been shown? (open-ended)

How many people, on average, were in the audience per showing? (open-ended)

What questions or comments from the audience or your staff were generated by the video? (open-ended)

We are assembling supplementary materials for each video. What additional information on the video topic would be helpful? (open-ended)

How did you use the Parker Solar Probe video in your programming?

- The video was shown before a planetarium show
- The video was shown after a planetarium show
- Other (please specify)

How many times or how often has the video been shown? (open-ended)

How many people, on average, were in the audience per showing? (open-ended)

What questions or comments from the audience or your staff were generated by the video? (open-ended)

We are assembling supplementary materials for each video. What additional information on the video topic would be helpful? (open-ended)

How did you use the Apollo video in your programming?

- The video was shown before a planetarium show
- The video was shown after a planetarium show
- Other (please specify)

How many times or how often has the video been shown? (open-ended)

How many people, on average, were in the audience per showing? (open-ended)

What questions or comments from the audience or your staff were generated by the video? (open-ended)

We are assembling supplementary materials for each video. What additional information on the video topic would be helpful? (open-ended)

What topics would you like us to cover in future videos? (open-ended)

For use in your planetarium, the length of these short films is…

- Way too short
- A little bit too short
- Just right
- A little bit too long
- Way too long

How can we improve this video series for your planetarium? (open-ended)

Do you plan to download future Explorations videos?

- Yes
- No
- It depends on the topic
- Comments:

Please provide any additional comments below. (open-ended)

Final Summative Planetarium Manager Survey Questions

What planetarium are you with? (open-ended)

In what country is your planetarium located? (drop down options)

(If respond US above): In what state is your planetarium located? (drop down options)

In what city/town is your planetarium located? (open-ended)

What is the approximate population size of your city/town?
- 0-10,000 people
- 10,000-50,000 people
- 50,000-100,000 people
- 100,000-250,000 people
- 250,000-500,000 people
- 500,000-1 million people
- More than 1 million people

Which of the Explorations videos have you shown to your audiences? (Check all that apply)
- Gravity Recovery and Climate Experiment (GRACE)
- Big Science, Small Packages
- MU69
- Parker Solar Probe
- Rocks from the Moon
- The Dawn of Orion
- TESS Discovering Distant Worlds
- None of the above

Generally, when were these videos shown most often?
- Before a planetarium show
- After a planetarium show
- During a planetarium show
- Other (please describe): _____

How many times did you show each video?
- 1-5 times
- 5-10 times
- More than 10 times
- Other (please describe): _____

How many people would you estimate were in the typical audience per showing?
- Fewer than 10 people
- 10-50 people
- 50-100 people
- More than 100 people
- Other (please describe): _____

Approximately what percentage of your typical audience included women or girls?

- 0%
- 25%
- 50%
- 75%
- 100%
- I don’t know

Approximately what percentage of your typical audience included people of color or other minority groups?

- 0%
- 25%
- 50%
- 75%
- 100%
- I don’t know

Approximately what percentage of the time were the videos ever used during educational experiences such as with school groups?

- 0%
- 25%
- 50%
- 75%
- 100%
- I don’t know

What questions or comments from the audience or your staff were generated by the videos? (open-ended)

Have you reopened to physical audiences since March 2020?

- No, we have not yet reopened to physical audiences
- No, we are closed permanently
- Yes, we reopened and stayed open
- Yes, we reopened but shuttered again in Fall 2020
- Other, please describe: _____

What are your current plans for reopening or maintaining functions during COVID-19? (open-ended)

Please list any other thoughts you have about the Fiske Explorations videos and their impact on your audiences: (open-ended)

Appendix IV--Fiske Partner Survey Questions

Final Summative Partner Survey Questions

Overall, how satisfied are you with your work on the Fiske Explorations Videos project?

- Extremely Satisfied
- Somewhat satisfied
- Neither satisfied nor dissatisfied
- Somewhat dissatisfied
- Extremely dissatisfied

Please say a little about why you choose [response from above copied in]: (open-ended)

What, if anything, did you take away from your collaboration with the Fiske Explorations Videos team? (open-ended)

Please list any other thoughts you have about collaborating with the Fiske Explorations Videos project: (open-ended)

Appendix V--Educator Guides

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Earth's Hidden Water

https://www.colorado.edu/fiske/about-us/fiske-productions

It's difficult to measure the depletion of water reservoirs when they are underground. NASA has come up with a creative solution -- measuring changes in Earth's gravity from space. Wet ground has more mass than dry ground, just like how a wet sponge is heavier than a dry one. This means that wet ground has a larger gravitational pull than dry ground. By measuring this fractional change, a pair of NASA satellites, called the Gravity Recovery And Climate Experiment (GRACE) mission, have been mapping our remaining underground water reservoirs across the globe.

Interview: Jenni Bonin, University of South Florida, College of Marine Science

Educational Resources

NASA website for GRACE
https://www.nasa.gov/mission_pages/Grace/index.html

GRACE Follow-On, the continuation of the original mission with new satellites
https://gracefo.jpl.nasa.gov

GRACE visualization of data from 2002 - 2016
https://www.youtube.com/watch?v=MaxBOvQ2a_o

Video overview of GRACE and GRACE Follow-On missions
https://www.jpl.nasa.gov/video/details.php?id=1461

Wikipedia entry on GRACE
https://en.wikipedia.org/wiki/Gravity_Recovery_and_Climate_Experiment

GRACE real-time data portal
http://geoid.colorado.edu/grace/

Instruments on GRACE
https://web.archive.org/web/20120225162449/http://www.gpsworld.com/government/natural-resources/instrument-grace-782

NASA's Science Activation Program funds 24 teams to connect NASA science experts, real content, and experiences with community leaders to do science in ways that activate minds and promote understanding. Fiske's Explorations project is one of those teams.

https://science.nasa.gov/science-activation-team/fiske-planetarium

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CubeSats: Big Science, Small Packages

https://www.colorado.edu/fiske/about-us/fiske-productions

NASA is broadening space exploration through a new kind of satellite: the CubeSat. CubeSats are tiny satellites, ranging in size from roughly that of a Rubik's cube to that of shoe or cereal box. To date, more than 800 have been launched into space. Two of these are the Miniature X-ray Solar Spectrometer, or MinXSS, and the Lunar Flashlight. MinXSS was mainly built by graduate students and uses X-ray observations to help us understand how space weather affects Earth's atmosphere, while Lunar Flashlight is searching for frozen water on the Moon's poles.

Interview: Chris Moore, Postdoctoral Researcher at Harvard Smithsonian Center for Astrophysics

Educational Resources

NASA CubeSat resources and videos
- https://www.nasa.gov/mission_pages/cubesats/index.html
- https://www.jpl.nasa.gov/cubesat/
- https://www.nasa.gov/mission_pages/cubesats/videos

NASA initiatives to involve students in CubeSats
- https://www.nasa.gov/content/about-cubesat-launch-initiative
- https://www.nasa.gov/content/about-elana

Articles about K-12 student involvement in CubeSats
- https://www.nasa.gov/feature/first-cubesat-built-by-an-elementary-school-deployed-into-space
- https://www.theatlantic.com/technology/archive/2013/11/some-high-schoolers-built-a-satellite-and-nasa-just-sent-it-to-space/281681/

Nanosatellite and CubeSat database
- https://www.nanosats.eu/#page-top

MinXSS website
- http://lasp.colorado.edu/home/minxss/

Lunar Flashlight website
- https://www.jpl.nasa.gov/cubesat/missions/lunar_flashlight.php

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https://science.nasa.gov/science-activation-team/fiske-planetarium

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MU-69

https://www.colorado.edu/fiske/about-us/fiske-productions

NASA's New Horizons flew by Pluto in 2015 and revealed a fascinating world: mountains made of ice the size of the US Rocky Mountains and smooth areas where impact craters have been erased. Pluto is part of a system of small bodies in the outer solar system known as the Kuiper Belt, where many comets linger. After New Horizons sped by Pluto, astronomers decided to steer the spacecraft toward an even smaller target, a dumbbell-shaped object dubbed MU-69, hoping it can teach us about the conditions of the early solar system. We'll find out what is has to tell us in January 2019.

Educational Resources

Overview of MU-69
https://solarsystem.nasa.gov/solar-system/kuiper-belt/2014-mu69/overview/
https://www.universetoday.com/141349/here-it-is-the-high-resolution-photo-of-mu69-weve-all-been-waiting-for/

NASA New Horizons website and videos
https://www.nasa.gov/mission_pages/newhorizons/main/index.html
https://www.nasa.gov/mission_pages/newhorizons/videos/index.html

Detailed information about New Horizons
https://solarsystem.nasa.gov/missions/new-horizons/in-depth/

Real-time location and trajectory of New Horizons
http://pluto.jhuapl.edu/

NASA Space Place & Pluto tab
https://spaceplace.nasa.gov/menu/solar-system/
https://spaceplace.nasa.gov/ice-dwarf/en/

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https://science.nasa.gov/science-activation-team/fiske-planetarium

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Parker Solar Probe

https://www.colorado.edu/fiske/about-us/fiske-productions

Hundreds of engineers, scientists, and technicians spent nearly a decade constructing the Parker Solar Probe to send it into the Sun's atmosphere where it will study how the solar wind is created. The solar wind is a gas that streams off from the Sun, strong enough to strip away a planet's atmosphere. Scientists currently do not understand how that gas is accelerated away from the Sun. Parker Solar Probe will be able to answer these questions by physically going to the spot where we think the solar wind is created and watching it happen. To do this, the Parker Solar Probe has to go into the outer layers of the Sun, six times closer than Mercury. At this point, the spacecraft will be going 430,000 miles per hour and shielded from temperatures of over 2,500 degrees Fahrenheit.

Interview: Chris "Gilly" Gilbert, graduate student at the Laboratory for Atmospheric and Space Physics, University of Colorado Boulder.

Educational Resources

Why won't Parker Solar Probe melt?
https://www.nasa.gov/feature/goddard/2018/traveling-to-the-sun-why-won-t-parker-solar-probe-melt/

NASA Parker Solar Probe overview, images, videos, instruments
https://www.nasa.gov/content/goddard/parker-solar-probe
https://www.nasa.gov/content/goddard/parker-solar-probe-instruments

Parker Solar Probe activities
http://parkersolarprobe.jhuapl.edu/Participate/index.php#Learn

NASA report from first close approach
https://blogs.nasa.gov/parkersolarprobe/2018/11/20/parker-solar-probe-reports-first-telemetry-acquisition-of-science-data-since-perihelion/

NASA Space Place Sun tab
https://spaceplace.nasa.gov/menu/sun/

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https://science.nasa.gov/science-activation-team/fiske-planetarium

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Apollo's Legacy: Rocks from the Moon

https://www.colorado.edu/fiske/about-us/fiske-productions

Weather and geological activity erase Earth's earliest records of how the planet formed, so this information needs to come from elsewhere. Fifty years ago, the Apollo astronauts brought back 840 pounds of moon rocks, pebbles, sand, and dust from six different landing sites. These rocks tell us that the Moon formed from the Earth: billions of years ago, Earth was likely hit by a body the size of Mars, and the Moon formed out of the resulting debris. The chemical composition of the Moon rocks has also taught us about how the Earth itself formed, with the heavier elements sinking down to the planet's core and the lighter elements floating on the top to form the crust.

Interview: Steve Moijzis, Director of the Collaborative for Research in Origins (CRiO), University of Colorado Boulder.

Educational Resources

Hands on activities, videos, and additional resources
http://www.nisenet.org/moon50

Apollo missions directory and information
https://www.lpi.usra.edu/lunar/missions/apollo/

Discovery of the Genesis Rock (Apollo 15 lunar sample)
https://www.hq.nasa.gov/office/pao/History/alsj/a15/a15.spur.html

Lunar Rocks and Soils from Apollo Missions
https://curator.jsc.nasa.gov/lunar/#

Tutorial on how to differentiate different lunar rock types
http://tobyrsmith.github.io/Astro150/Tutorials/MoonRocks/

NASA Space Place: All About the Earth (Moon tab available)
https://spaceplace.nasa.gov/menu/earth/

NASA's Science Activation Program funds 24 teams to connect NASA science experts, real content, and experiences with community leaders to do science in ways that activate minds and promote understanding. Fiske's Explorations project is one of those teams.

https://science.nasa.gov/science-activation-team/fiske-planetarium

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The Dawn of Orion

https://www.colorado.edu/fiske/about-us/fiske-productions

It's been 50 years since NASA last built a human spacecraft. The Orion spacecraft follows in Apollo's footsteps, but with technology upgrades that allow it to support up to six crew members for three weeks. Astronauts will use Orion to conduct a lunar flyby in 2023. Subsequent missions will also be used to construct a lunar space station, termed the Lunar Orbital Platform-Gateway. The Gateway will be used for both manned and robotic exploration of the Moon and extraction of resources, such as mining lunar water ice which can be used to make rocket fuel.

Interview: Randolph Bresnik, NASA Astronaut

Educational Resources

NASA Orion overview and quick facts
https://www.nasa.gov/exploration/systems/orion/about/index.html
https://www.nasa.gov/sites/default/files/fs-2014-08-005-jsc-orion-eft-final.pdf
https://www.nasa.gov/sites/default/files/fs-2014-08-004-jsc-orion_quickfacts-web.pdf

Wikipedia information on Orion and Gateway
https://en.wikipedia.org/wiki/Orion_(spacecraft)
https://en.wikipedia.org/wiki/Lunar_Orbital_Platform_–_Gateway

Orion vs. Apollo spacecrafts
https://www.space.com/5900-orion-apollo-nasa-21st-century-moonshot.html

History of Lunar Exploration
https://www.nasa.gov/50th/50th_magazine/lunarExploration.html

Commercial use of the Moon's resources
https://www.theatlantic.com/science/archive/2018/09/spacex-ispace-moon-commercial-business/571357/

EFT-1 coverage
https://www.nasaspaceflight.com/2014/12/eft-1-orion-historic-launch-atop-delta-iv-h/

NASA Space Place: The Moon
https://spaceplace.nasa.gov/search/moon/

NASA's Science Activation Program funds 24 teams to connect NASA science experts, real content, and experiences with community leaders to do science in ways that activate minds and promote understanding. Fiske's Explorations project is one of those teams.

https://science.nasa.gov/science-activation-team/fiske-planetarium

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TESS: Discovering New Worlds

https://www.colorado.edu/fiske/about-us/fiske-productions

The Transiting Exoplanet Survey Satellite, or TESS, is currently looking all over the sky at 200,000 nearby stars, searching for new planets. It does this by measuring how a star's brightness changes over time. A planet that travels in front of its star will block out the star's light, which TESS will measure as a dimming. This method can also tell us about the planet's size, orbit, and even a bit about its atmosphere.

Interview: Zachory Berta-Thompson, Professor at the Center for Astrophysics and Space Astronomy, University of Colorado Boulder.

Educational Resources

TESS overview and videos
https://www.nasa.gov/content/about-tess
https://tess.mit.edu/
https://svs.gsfc.nasa.gov/Gallery/TESS.html

Latest TESS news stories
https://www.nasa.gov/content/latest-tess-stories

Exoplanets page from NASA Space Place
https://spaceplace.nasa.gov/all-about-exoplanets/en/

Classroom activities on planet finding
https://www.nasa.gov/kepler/education/formal
https://www.jpl.nasa.gov/edu/teach/tag/search/Exoplanets

Helps scientists find planets with the TESS citizen science project from Zooniverse: Planet Hunters
https://www.zooniverse.org/projects/nora-dot-eisner/planet-hunters-tess

Interactively explore exoplanets with NASA's Eyes on Exoplanets app
https://eyes.nasa.gov/eyes-on-exoplanets.html

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SOFIA: Learning From the Invisible

https://www.colorado.edu/fiske/about-us/fiske-productions

By looking at the universe in infrared light, astronomers are able to see objects that are otherwise invisible. However, this infrared light gets absorbed by water vapor low in Earth's atmosphere. To solve this problem, the Stratospheric Observatory for Infrared Astronomy (SOFIA) is a modified Boeing 747 designed to carry an infrared telescope high above Earth's surface. SOFIA is also known for the Airborne Astronomy Ambassadors program, where groups of high school teachers are brought onto the flight to see the teamwork and process involved in scientific research. They then take this unique experience back to their classrooms.

Interviews: Dana Backman, AAA Principal Investigator, SETI Institute; Simon Steel, Senior Director of Education and STEM Programs, SETI Institute; Daniel Burleson, Rancho High School, NV; Kathryn Smith, William S. Hart High School, CA; Tyler Thompson, West Career & Technical Academy, NV; Dawn Minnick-Trujillo, Las Vegas Academy of the Arts, NV.

Educational Resources

SOFIA overview
- https://www.nasa.gov/mission_pages/SOFIA/overview/index.html
- https://en.wikipedia.org/wiki/Stratospheric_Observatory_for_Infrared_Astronomy
- https://www.youtube.com/watch?v=g5z6fZKOtP4

Infrared astronomy resources
- https://www.sofia.usra.edu/multimedia/about-sofia/sofia-mobile-information/infrared-astronomy-more-our-eyes-can-see
- https://coolcosmos.ipac.caltech.edu/page/what_is_infrared
- https://www.youtube.com/watch?v=v4J56lnl1UE&feature=youtu.be
- https://www.youtube.com/watch?v=s-dnEiWJCy4

Airborne Astronomy Ambassadors program
- https://www.seti.org/aaa
- https://www.youtube.com/watch?v=DAVHIckNNd4

Classroom activities on infrared light
- https://www.exploratorium.edu/snacks/infrared-remote
- https://www.nasa.gov/centers/jpl/education/wise-20091123.html
- https://www.sofia.usra.edu/sites/default/files/InfraredResources.pdf
- https://www.zooniverse.org/projects/ssilverberg/disk-detective

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