

NASA's IGTV: Why do Social Media Science Communication Strategies Need to improve It's Strategies for Online Public Engagement?

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Abstract

In the last decade, social media became a strategic communication conduit for science communication. Moreover today, it is considered an useful tool to promote public engagement under the notions of dialogic communication models. However, still, science communication needs to overcome frequent practices of deficit based-models such as massive and unilateral dissemination of scientific data to audiences of non-experts without considering opportunities for mutual interaction and dialogue . This deficit-based practice has been also reproduced in social media practices of science communication, leading to audiences' lack of interest, and negative engagement of audiences. However, social media, such as Instagram, as in the case of this study, offers many tools for content creation and direct interaction with audiences that could be applied to build positive engagement of audiences through direct dialogue and mutual learning. This study analyzed audiences' reactions and responses to NASA's use of the IGTV feature for science communication through a qualitative content analysis. Data was interpreted under the lens of science communication models for public engagement through dialogic paradigms. The results evidence that NASA focused its science communication strategy on developing content around their work in space exploration by using the IGTV to succesfully reach numerous views, positive and negative audience comments, and interactions among users. However, the opportunities to take advantage of audiences' interest was missed by not attending timely and frequently to NASA's followers and users' comments. In our discussion, we will present how science communication strategies in social media could be improved to generate positive audience engagement through direct interaction.

Keywords: Science communication for public engagement, Social Media, NASA, Instagram, Engagement.

Introduction

Science communication practices and research are currently evolving towards seeking strategies that promote public engagement. In the past decade, science communication practitioners and scholars turned their attention to social media as a tool for science communication (Kahle, Sharon, & Baram-Tsabari, 2016). Most science communication studies focus on the use and associated benefits for scientists and science communication practices of platforms such as Facebook, Twitter, YouTube, and in fewer cases the use of Instagram (Sheldon & Bryant, 2016) and its feature formats. Although, some studies had analyzed the use of social media to promote public engagement for science museums (Brown Jarreau, Dahmen, & Jones, 2019; Budge & Burness, 2018; Weilenmann, Hillman, & Jungselius, 2013).

Nonetheless, the existent research that analyzes Instagram is still relatively new for science communication studies. Moreover, even less research focuses on the use of particular platform features, such as Instagram TV (IGTV), stories, live broadcasts, and the video/picture feature posts and the responses it creates on their users/followers to communicate science context. In specific, this study focuses on analyzing how the use of the IGTV feature of NASA's Official Instagram account promotes and practices -or not- science communication for public engagement around space exploration and NASA's scientific work.

The prior studies listed above focused on the use of image or video posts, and the combined use of hashtags to motivate audience engagement. Nonetheless, its findings coincide with evidence that Instagram has been used mostly as a promotional tool to attract visitors to museum exhibits. A newer study evaluated audiences' engagement on Instagram and TikTok and evaluated its educational science content (ESC) and how it promoted user awareness and overall engagement ([Habibi and Salim 2021](#)). This study analyzed how audiences' engagement through likes, comments, shares, saves, and views

revealed higher interaction with content that was presented in dynamic ways with a component of experimentation.

However, public engagement strategies for science communication still require more strategic work to attract the audience's interest and foster meaningful engagement. In this study, we specifically chose NASA's videos posted on the IGTV feature as the main focus of analysis because of its incorporation into the platform in 2018. Currently, there are no available studies to date on science communication that address how audiences responded and interacted through their comments around NASA's spatial missions, projects, and informational content.

Literature Review

Science Communication: A Evolving Discipline

Science communication research and practice have dramatically evolved in the last two decades, for this reason, its concept has changed and evolved constantly (Holliman et al. 2009). To conceptualize science communication, it is crucial to mention the different research movements that had been part of its evolution and practice. Some of these had been scientific dissemination, scientific culture, or informal education of science (Rocha, Massarani & Pedersoli, 2017). Another of the main research and practice movements in science communication is the public understanding of science (PUS), which emerged in the mid-1980s (Stilgoe & Wilsdon, 2008). PUS focuses mostly on disseminating science content to society guided by one-way communication models, assuming that scientists have superior expertise and knowledge than the public of non-experts (Gregory & Miller, 1998). Therefore, under dissemination, PUS, and informal science education the public lacks the skills to understand and appreciate science, which is understood as the deficit model (Bowater & Yeoman, 2013). Consequently, through the deficit model research and practice movements, there was no opportunity for audiences to intervene, interact with scientists, or either to establish a dialogue between scientists and society.

Moreover, several scholars argue that following the PUS model leads to frequent issues in science communication such as misinformation of scientific content on media (Friedman, Dunwoody & Rogers, 1999; Bowater and Yeoman, 2013), and the lack of audiences interest, attention, and participation in science (Bucci, 2008). Consequently, science communication scholars advocated for evolving from the deficit model movements to develop new strategies in research and practices that seek to promote dialogue among scientists and society to foster public engagement (The Royal Society, 2006; Wynne, 1998).

As a result, science communication for public engagement emerges as a new research movement that promotes the active involvement of all the actors in the process of communicating science -researchers, practitioners, audiences, and key stakeholders- in order to promote an open dialogue among them (Jensen & Holliman, 2009). Moreover, dialogue practices seek to promote mutual benefits and understanding of society's needs to motivate the collaboration among scientists, policymakers, and citizens or communities into tangible actions and efforts that lead to solutions to contribute to social change (Wynne, 2006).

In the last decade from 2010 until the present, one of the communication tools science communication for public engagement has used is social media as an interactive conduit to facilitate direct information and dialogue among scientists and audiences.

Social Media: New Conduits for Science Communication and Audience Engagement

Science-related discussions are currently happening through social media (Brossard, 2013). In practical terms, Facebook, Twitter, YouTube, and Instagram now have been used by scientists, universities, and research institutions as new media conduits to disseminate scientific information through different format genres such as video, images, infographics, and microblogging (Pavlov et al., 2018). Moreover, public audiences can interact with scientific content on social media platforms by commenting and sharing information about their interest with their own social media network (Geiß, Leidecker & Roessing, 2011).

Nonetheless, newer science communication research and practice argue that in order to create a meaningful process for science communication, dialogic communication models must be considered to overcome the issues of the deficit model such as unilateral dissemination and not responding to the needs and concerns of the audiences (Leach, Yates, & Scanlon, 2008; Stilgoe & Wilsson, 2008).

Overcoming The Deficit Model Through Social Media

If we revisit the deficit and dialogue models' foundations, the deficit model sustains exclusively the dissemination of science content mostly through one-way communication that merely disseminates messages to audiences with no opportunity for interaction or dialogue. Additionally, the deficit model assumes that non-expert audiences cannot understand scientific content (Bucci, 2008). Alternatively, dialogic communication models motivate audience engagement and two-way communication among scientists and public audiences that seek to create mutual understanding (Wood, 2011).

New dialogic communication strategies for science communication use social media platforms to promote audience engagement and dialogue among researchers and the public, by providing educational resources to society about multiple topics. Available studies reveal several strategies that support science communication and public engagement by using social media. For example, social media offers the opportunity to establish dialogue among researchers and the public for collecting opinions, and feedback about society's needs and concerns that can inform specific research topics (Liang et al., 2014). Twitter has helped researchers to communicate their work by sharing the links to their published journal articles, getting information about academic events such as conferences, and also the opportunity to network with other academics (Bik & Goldstein, 2013).

Consequently, social media offers an opportunity for establishing a dialogue with audiences about science and moving towards developing meaningful initiatives for public engagement. Do social media as a conduit for science communication tactics been used to motivate meaningful dialogue among the scientific community and society? or just as a mere deficit-based dissemination strategy?

Social Media: A missed Opportunity for Audience Engagement in Science Communication?

Public and private organizations use social media to increase interactions with the public through the frequent interchange of information (Sundar, 2007). And as public relations strategy to facilitate the cultivation of positive relations (Smith, 2010). Moreover, social media provides different ways that promote and motivate relationship cultivation among an organization and its key publics, such as the usefulness of information, feedback loops, ease of interface, conservation of visitors, and generation of new visits (Kent, Taylor & White, 2003).

Social media, as a two-way communication conduit, offers multiple strategic opportunities to cultivate sustainable and trusting relationships between scientists and society. Although, there is evidence that in the specific case of social media, some studies argue that these new media conduits had been used by scientific government institutions as platforms for disseminating information - reproducing the issues of deficit- rather than facilitating two-way dialogue and consequently audience engagement. In this way, also public research institutions that use social media conduits are missing the opportunity to establish audience engagement around scientific content (Lee & VanDyke, 2015).

Instagram as a Social Media Conduit for Science Communication

Instagram made its way as a social media app for smartphones in 2010 that first mostly functioned through photo-taking and photo-sharing and filters with image editing tools (Frommer, 2010). Later on, the platform allowed to film and share short videos. Instagram was bought by Facebook in 2012 by 1 billion dollars ([Lee et al. 2015](#)). By 2015, Instagram users grew from 3.4 million smartphone to 400 million users worldwide, and 80 million images were shared daily ([Manovich](#)). To date the app offers multiple interaction forms to its users to engage around content of their interest through likes, share content that is self-produced or produced by others. Some of the content creation formats offer video features such as stories, reels, IGTV, save or bookmark content, and live streaming ([Pham 2021; Aalto and Valtanen 2018](#)).

In recent years, Instagram is being used by professionals, businesses, and scientists. Here scientists from astrophysics, public health, climate change, science communication and many

disciplines have become active content creators that share their work to the public ([Habibi and Salim 2021](#)). However, there are only a few studies that analyzed which type of scientific content drives audiences positive engagement which evidence that videos of experimental activities to explain complex science data are more engaging to audiences by registering greater number of views, comments, and likes than static posts such as scientists pictures or infographics ([Habibi and Salim 2021](#)).

A study developed by Kent and Taylor about the potential of Instagram to foster dialogic communication around social change ([2021](#)), presents evidence criteria about user expectations. Regarding user expectation, some criteria emerging from this study addressed the science communication users' opinion on which criteria are crucial to them for fostering meaningful audience's engagement are: i) choosing known and reachable moderators of dialogue ii) clear rules for ethical and respectful interactions; iii) acknowledging people's opinion and responding to their questions; iv) using prompt questions to initiate dialogue and develop an on-going conversation with social media users; v) create opportunities for face-to-face events and interactions with scientists; vi) penalize users or followers who act with violence and discrimination towards others points of view by blocking them to not access social media content ([Kent and Taylor 2021](#)).

Social Media and NASA's Space Exploration Science Communication Studies

In the specific case of NASA, space exploration has been largely studied by science communication scholars. In specific, even more through social media studies that address the use and audience perceptions, and their response to the different platforms for communicating scientific space science exploration. Some of these studies addressed the use of Facebook and Twitter for space outreach and education programs (Denis, Klein & Gueguen, 2014); young audience engagement through NASA's Twitter strategy (Lesley, 2014); the framing of science on social media for raising public awareness of space exploration through videos and public responses on YouTube (Sinha, 2017);

the psychological predictors' analysis of audiences' social media engagement on Facebook and Twitter (Hwong et al., 2017).

However, to date, there are no available science communication studies that address the use of Instagram and its publishing features used to engage audiences around science communication in NASA's space exploration. For this reason, this research paper aims to contribute to science communication studies by analyzing the social media use of NASA's IGTV for building public engagement around space science work and projects.

Social Media Metrics

Social media presents different metrics to measure, interpret and represent the audience's reach, interaction and engagement. Metrics emerged as measures for evaluation studies that help to interpret the audiences' interactions on social media and evaluate the performance and reactions towards social media content formats such as videos, posts, images, and stories ([Wouters et al. 2019](#)). Engagement as a social media measure metric refers to the audience's or content consumers' positive individual dispositions towards a brand, institution, or content creator that is expressed through different affective, cognitive and behavioural manifestations that go beyond exchange or interactions ([Dessart et al. 2015](#); [Dessart 2017](#)).

Currently, engagement is seen as the most valuable measure for audiences engagement in social media. However, audience engagement can be positive or negative. On one hand, positive engagement, as described before, organizations benefit their institutional image, positioning through audiences acceptance and support in social media([Dessart 2017](#)). On the other hand negative engagement refers to unfavorable audiences' thoughts, feelings and behaviors around the content generated on social media by an organization or a person ([Lievonon et al. 2018](#)). Moreover, negative engagement is related to online crisis that confronts opposite ideas or critiques ([Timothy Coombs and Holladay 2012](#))

On Instagram, we can find different measures of positive engagement, such as likes, views, and comments ([Heathcote 2021](#)), bookmarks which are saved publications by users and also represent

another mode of audience engagement in which audiences can save and share valuable content of their interest ([Quesenberry 2020](#)).

Research Questions

RQ1. Does NASA's social media scientific content through IGTV enacts audience engagement practices that create a dialogue with their audiences?

RQ2. Which are the feedback reactions and tone of users' and followers' responses through Instagram IGTV to the videos posted by NASA?

Methodology

By using qualitative content analysis we will examine the comments that followers and Instagram users posted on the videos of NASA's IGTV from June 2018 through July 2019. We aim to explore how Instagram-based science communication strategies of NASA, through IGTV work for fostering dialogic two-way communication with its social media audiences for motivating public engagement.

Qualitative content analysis has been widely used as a method to analyze user reactions and responses on social media platforms (Sinha, 2017). Moreover, in the context of this study, it enabled us as researchers to analyze if there is any evidence of dialogical communication between NASA's experts and scientists, and the social media users of their institution's Instagram profile, as evidence of the practice of science communication for public engagement.

The qualitative content analysis process is used as a method to describe and interpret the written productions of social groups (Marshall & Rossman, 2016). Therefore, the analysis of the interactions among users and the videos posted by NASA is the focus of interest of this study. In specific, (a) to establish how audience engagement was motivating, and if it facilitated or not dialogical practices around NASA's scientific work, and (b) the tone of user comments that evidenced the different audience perceptions about the audiovisual content.

Sampling Criteria

As mentioned above, we took the pool of all 38 videos posted on NASA’s IGTV from June 2018 through July 2019. Out of this pool, all the videos were organized on a database matrix by date and the total of follower’s comments (61716). As a sampling strategy, we used systematic probabilistic sampling (Lopez, 2004) using the total of the followers comments. The systematic sampling procedure was selected because it provides the criteria to select a representative number of comments out of the datasets at regular intervals.

The formula to obtain the sample (Yamane, 1967) applied to this study was: $n = \frac{N}{1 + N(e)^2}$ n = sample size, N = overall number of user comments on NASA’s IGTV, and e = precision level taking the 95% of the confidence interval. The corresponding values to this study in the formula equation were: $n = \frac{61716}{1 + 61716(0,05)^2}$ and the resulting sample size was the following $n = 397.42$.

To prepare the dataset we applied the sampling out of the comments of the total of 38 videos (as seen in Table 1)[1], we were required to analyze 397 comments and for this purpose, we selected 10 comments on each video posted between June, 2018, to June, 2019 (397/38).

Table 1.

Database of NASA’s IGTV videos June 2018-June 2019

Date	Title	Time lenght	Topic/Content	# of Views	Number of Comments
2018					
June 1	<i>What's up in the night sky in June 2018</i>	2:23	Sky viewing: Venus highest altitude, when to observe Jupiter, Saturn, Mars (the best hours to view)	1,193,453	423
June 1	<i>Earth view from the space station</i>	4:53	Space station	620,753	488
June 30	<i>Astronomy nerds, assemble!</i>	1:04	Planetary defense team	326,384	126

June 26	<i>Science at 17,500 miles per hour</i>	1:59	Microgravity science in the space International space station	455,770	339
July 1	<i>What's up in the night sky in July 2018</i>	2:31	Mars closer to Earth	336,892	135
July 4	<i>Happy Forurth of July from NASA</i>	0:47	Focus on the US flag	290,704	200
July 10	<i>Operation IceBridge offers an unusual view of Earth's Icy Reaches</i>	2:01	Planes over ice, NASA monitors from air and space	311,568	91
July 13	<i>New pilot simulations are so real they have a BARF Meter</i>	2:22	Collaboration with the Navy, simulators, future safety in all forms	327,627	109
July 16	<i>5 Ways we are getting back to the Moon</i>	6:03	Glenn Research Center (50 years later) Spacecraft, the power to explore, resource utilization. reinventing the wheel, the gateway	230,361	196
July 17	<i>NASA celebrates baseball All-star game in nation's capital</i>	2:00	What NASA does, taking to the ballgame seen from the astronaut perspective	302,422	95
July 20	<i>Surface tension in space</i>	1:06	Reduced-microgravity experiments with astronauts on the international Space-Station	970,000	580

July 24	<i>Take a high-definiton tour of the Moon</i>	4:42	Video Tour through the Lunar Reconnaissance Orbiter (LRO)	667,000	1,168
July 27	<i>Hubble's new view of Mars and Saturn</i>	1:24	Hubble's new view of Mars and Saturn though its telescope	528,000	237
August 1	<i>What's up in the night sky in August 2018</i>	2:17	Meteor Shower	295,000	137
August 7	<i>Mars helicopter</i>	1:22	Mars Helicopter Technology that will be part of the 2020 Rover Mission to demonstrate the viability and potential of heavier-than-air vehicles on the Red Planet.	421,000	337
August 7	<i>Mars helicopter: technology demonstration</i>	1:22	Demonstration of the Mars Helicopter Technology that will be part of the 2020 Rover Mission	116,000	107
August 10	<i>Views of the Sun</i>	3:02	Watching the Sun in extreme ultraviolet light with satellites shows solar activity with events that affect the entire solar system	1.2 Million	3,330
August 15	<i>Crews for the first commerical flight</i>	0:56	Presentation of the First Crew for Commercial Spacecraft flights	206,000	70

August 24	<i>A NASA field reseracher empties his pockets</i>	1:53	Field researcher shows tools that carries to an exploratory mission on Greenland	338,000	81
September 1	<i>What's up in the night sky in September 2018</i>	2:30	Views of constellations along the Milky Way, plus great views of Venus, Jupiter, Saturn, and Mars.	673,000	371
September 19	<i>3D printing revolutionarizes human space exploration</i>	1:54	3D printing to create a pace Launch System rocket manufactured in the International Space Station	519,000	162
October 1	<i>What's up in the night sky in October 2018</i>	2:07	Moon observations night events of the october month	520,000	206
October 7	<i>From space to ground: a videos journey</i>	1:11	Process of how NASA processes and shoots videos of space footages and stores it for different purposes	495,000	120
October 18	<i>Our Dawn mission nears the end</i>	0:59	Dawn Spacecraft mission resuming at the expected end of the mission on Vesta and Ceres	514,000	304

October 23	<i>The secrets behind Earth's multicolored glow</i>	3:12	Earth's multi-color glow in atmosphere and scientific explanation for its colors and reflections	601,000	327
October 24	<i>NASA explores: Cryosphere</i>	0:42	Cryosphere explorations, the different parts that compose it, and explanation of current ice melting situations	267,000	121
November 16	<i>Moon to Mars</i>	1:06	Mission to explore Moon and Mars from earth	649,000	351
December 7	<i>What's up in the night sky December 2018</i>	2:54	Meteor geminid shower, and tips for night watching from earth and saturn views	572,000	202
2019					
February 4	<i>What's up in the night sky February 2019</i>	2:27	Planets colors explanations in the time of the year	701,000	248
March 2	<i>What's up in the night sky March 2019</i>	2:32	Views of Jupiter and other planets forming a beehive. Explanations of day-time savings and longer days	3.6 million	3457
April 6	<i>What's up in the night sky April 2019</i>	2:25	Moon visits Mars in the evening, and later joins Saturn and Jupiter	4.9 million	3623

April 24	<i>Hubble's 29th anniversary</i>	2:31	Recap of the missions and work the Hubble Space Telescope to explore the planets' atmospheres, and events in the solar system, and other possible contributions to space explorations	304,000	196
May 3	<i>What's up in the night sky in May 2019</i>	2:52	Meteor shower produced by debris from Halley's Comet and some asteroids named after dinosaurs. Apollo 10 anniversary and the blue moon sighting of the month	3.4 million	2522
June 1	<i>What's up in the night sky in June 2019</i>	2:52	Jupiter, Moon orbit, Mars and Mercury close views of the month	2.3 million	20,060
July 13	<i>To the Moon - Then and Now</i>	1:31	Historical images of the Apollo mission to the moon and information about the next mission on 2024	4.9 million	10595
July 16	<i>Hubble and Going Forward to The Moon</i>	4:45	Hubble's participation in the research for the moon exploration that will happen in 2024	7.9 million	40

July 17	<i>Launching to the Moon</i>	1:01	Countdown sequence of Apollo 11 with historical pictures and video	5.3 million	8,894
July 22	<i>What's Up in the Night Sky for July 2019?</i>	3:20	Special edition for Apollo 11 Anniversary, facts about the moon and the arrival of the man to the moon	1.4 million	1,668
				Total of Comments	61716

According to the systematic sampling procedure, we were required to calculate the interval (I) by the following formula, in order to have a procedure to select the 10 comments out of each video to build the dataset for analysis. $I = N/n$, where N= is the total number of IGTV comments, and n= is the sample size. Replacing the values in the formula equation, we obtained, $I = 61716/397$, $I = 155.26 \approx I = 155$. As a result, the dataset was built by selecting the comments at a fixed interval of 155.

The dataset was constructed and stored in a Microsoft Excel spreadsheet, and we used open coding to analyze and categorize the tones of the user comments into broader themes (Marshall & Rossman, 2013; Saldaña, 2015). The comments were coded, categorized, and placed into broader themes according to the tone of the statement (positive, negative, critiques, questions, collective discussions), and the topic of the video shown on IGTV. Emojis were included in the coding procedure to evoke emotions and sentiments present in the comments and followers' interactions ([Dhaoui et al. 2017](#)).

Results

The broader themes this study presents to describe audience engagement and their responses to science communication content that NASA uses. In the time range of this study (June 2018 to June 2019) NASA's IGTV posted content about space missions and topics such as spacial exploration *What's up in the night sky* monthly update; earth views from space stations; climate change and spatial scientific research; moon and planets exploration, astronaut training programs; historic missions anniversaries (The Moon Landing, Hubble Space Telescope, Apollo 11; Mars exploration). In total, this study analyzed 38 IGTV videos.

We found three broader themes groups: positive engagement and support, critical and negative engagement to NASA's IGTV Content, and lack of dialogic engagement.

Positive and Negative Engagement of Audiences and Dialogue

Regarding engagement, this study evidence that NASA's IGTV video posts not only created interest, and motivated audience engagement through likes, views, and comments, but also motivated dialogue around the topic of the videos for positive support and critical questioning. Positive support of followers it's evidenced through the sub-themes of the likeness of content, content as educational support, and aspirational motivation for future scientists. Regarding negative comment thread engagement, this study found the flat earth claims and conspiracy theories sub-themes.

Figure 1.

Themes and Subthemes in Instagram User Comments on NASA IGTV (June 2018-June 2019)

Positive Support Engagement

- Likeness of Content.
- Content as Educational Support.
- Aspirational Motivation for Future Scientists.

Negative Support Engagement

- Flat Earth Claims.
- Conspiracy Theories.

Lack of Dialogic Engagement

Note: Developed by the authors

Nonetheless, critical questioning was evident in topics such as the use of public tax funding for space exploration when the US has latent issues that remain unaddressed. On the other hand, the claims of flat-earth and conspiracy theories also were present among negative comments and often created aggressive discussions that escalated to insults among followers and to NASA and the US government.

Positive Comment Thread Engagement

In terms of audience engagement, we found that followers engaged positively around themes such as their interest to become staff and scientists that work for NASA. In this specific case, dialogue happened among people that supported each other by congratulating them on their life goals and demonstrating support with positive comments and likes. Other positive comment threads happened around specific questions that emerged about scientific experiments, space missions, and explorations. Nonetheless, it is crucial to mention that these scientific questions of audiences were not answered by NASA or any scientific staff that could inform back people about their doubts.

Positive Likeness of Content. Most of the audience's comments were positive. Followers of NASA's official Instagram Account (@nasa) acknowledged positively how interesting, well-displayed, and clearly explained space missions, experiments were to audiences. Moreover, audiences frequently congratulated NASA for entering social media with interesting content. Additionally, followers commented with excitement when NASA reacted back to their comments by liking these. When this

happened people re-engaged in the comment thread by evidencing their satisfaction to be read by NASA through new comments and emojis.

Content as Educational Support. Among the positive interactions between NASA and its Instagram audiences, there were several comments from parents, school and high school teachers mentioning how useful the content is for their teaching and motivating their young students in science and STEM fields. Moreover, the features of the videos such as animations, art direction, graphics, and voice-over narration were a common highlight of user comments. Again, audiences congratulated NASA frequently for the production and content quality.

Aspirational Motivation for Future Scientists. NASA's Instagram followers manifested frequently their admiration for the work and scientific exploration of space that the institution carries. Among the commenters, females, males, and children commenting through their parents' and siblings' accounts told shortly their story and their aspirations of becoming astronauts and scientists in the future. Teenagers and younger adults also commented frequently about their aspirations of becoming astrophysicists, astronauts, scientists, or merely their willingness to work for NASA. These audiences also engaged with each other positively by responding to each other with comments of support and encouragement to people to follow their life goals and dreams. Some users engaged in giving advice about possible degrees and training that could help them to pursue a build a career in NASA.

Negative Comment Thread Engagement

As mentioned in this section users heavily critiqued how public funding were used for space exploration when American society has multiple social issues. Specifically, people engaged through making negative comments that present critiques of how the US government uses funds on conquering space and leave behind latent issues in the United States such as immigration, education, public health that require attention and the work of government agencies. These negative comment threads were largely supported by numerous users with likes and responses that added several critiques around the

topic of how the US government distributes and prioritizes public funding without prioritizing social issues before space exploration.

Additionally, we found two additional sub-themes regarding negative comments around flat earth claims and UFO conspiracy theories that led to aggressions and violent interactions among NASA's IGTV followers.

Flat earth claims and aggressive confrontation. Other negative comment threads that started as critiques and escalated to insults among followers around flat earth claims. These comments were more common on IGTV video posts of the Mars Rover Mission, Earth views from the International Space Station, and the Moon Exploration. Here, a first group of followers claimed that some of the footage of the videos were simulations that were not real and there are theories that evidence that the earth is flat. However, these followers did not cited any specific theory, source, or reliable resource to support these claims. A second group of followers confronted the flat-earth believers by responding to these comments threads by appealing to the lack of evidence for flat earth theories. Consequently, aggression and violent confrontation emerged when the first group -believers of flat earth claims- responded back to the second group of followers -who reject flat earth theories-, with name-calling aggression, and insults in the discussions, enhancing their disgust through the use of upper case words, emojis, and exclamation marks.

UFO conspiracy theories. Another subtheme regarding negative comments directed to NASA's IGTV videos was about claims to show UFO evidence. These Instagram followers sustained that NASA hides information from the public eye about extraterrestrial creatures. Frequently, these claims in combined with comments with aggressive and violent tones, insults, and critiques of NASA's work. However, these claims engaged fewer users in dialogue that developed into comment threads.

Lack of Dialogic Engagement

NASA's IGTV video posts attracted audiences of all ages, gender, and nationalities with content about scientific labor and space exploration. Audiences performed different types of social

media engagement such as comments, likes, and a large number of views in the dataset selected for this study (from 206.000 views as a minimum up to 5.4 million views as a maximum). Therefore it is evident that people were attracted to the content and interacted with it. Most forms of engagement were positive, although, as described above, there were topics that raised negative engagement and interactions between followers and NASA's IGTV content.

Several Instagram users were interested in the scientific content and space exploration missions and raised specific questions they had about each project NASA showed on IGTV. These questions were not answered at any time by NASA's experts or their social media communication teams. Among the overall 38 videos, there were only 8 questions addressing scientific topics, although these were not answered. However, these also engaged other users in dialogue around science and space. Followers frequently requested NASA to reply to their questions, although they were not attended. These missed opportunities could motivate meaningful dialogue and consequently foster audience engagement.

However, the only answer from NASA in the timeframe of June 2018 to June 2019, was to greet the critical opinions of users and invite them to keep following their content. This response happened around a flat earth negative and aggressive discussion among users on the video *What's up in the night sky March 2019*, which explains the views of Jupiter and other planets forming a beehive, and describes what happens in space with day-time savings and longer days. However, this response came late to several discussions and arguments among NASA's followers and/or users that happened in prior months and did not answer any of the questions around science topics at all.

Discussion

Effective Social Media Engagement: A Pending Duty for Scientists and Research Institutions

The scientific community since the 1990s and 2000s recognizes the need to explore methodologies and initiatives to meaningfully engage with audiences and citizens for promoting dialogue (Dudo & Besley, 2016) and collaborations around social issues or topics of public interest (Bowater & Yeoman, 2013).

Different science communication research streams from deficit and dialogic models, such as PUS and science communication for public engagement encourage researchers to explore different strategies to share scientific content with non-experts. However, PUS, from a deficit-based paradigm mostly supports open science dissemination through mass media, and communication campaigns (Stilgoe et al., 2014). Moreover, PUS research and practice are largely critiqued for portraying audiences as ignorant, and not providing audiences the opportunity to dialogue with scientists (Bowater & Yeoman, 2013; Stilgoe et al., 2014). Alternatively, from dialogic models paradigms, science communication for public engagement encourages active and direct dialogue among scientists and citizens from different research groups through events (Holliman et al., 2009), workshops (Cooke et al., 2017; Miah, 2017), and social media (Cooke et al., 2017; Miah, 2017).

Different universities and research institutions have started different initiatives to promote citizen engagement in their scientific endeavors. Some of these initiatives include outreach events, and the use of social media accounts on Facebook, Twitter, Instagram, YouTube, and more recently TikTok. Social media is strategic communication as a conduit for online direct dialogue between an organization and its target audiences. Although, still social media is carried through deficit-model practices that do not promote dialogic practices (Lee & VanDyke, 2015). Instead, it is more frequent to find research institutions, research departments, and even scientists who use social media for exclusively disseminating their academic work, key research findings, and self-promotion, than an articulated strategy that promotes open dialogue with their audience of followers. This issue represents a missed opportunity for establishing meaningful relationships with audiences around topics of mutual interest, as seen in this study.

The Potential of Social Media for Scientists

As mentioned in the literature review section, the use of social media for scientists represents multiple opportunities, such as networking with other researchers and initiating dialogue with public opinion around topics of public interest with scientific-based information (Liang et al., 2014). We

believe that NASA's scientists could also benefit themselves by interacting more actively to their online followers by responding to their questions, acknowledging positive comments regarding people's congratulations or their career aspirations, or clarifying any emergent misinformation. Audiences' engagement could be increased by demonstrating their interest to dialogue directly with them. Consequently, audiences could be more positively engaged and supportive to the scientific endeavors of NASA.

Nonetheless, currently, science communication through the Internet and social media is still mostly carried out unidirectionally and serves mostly to disseminate the findings of scientific research. Although still, some scientists are reluctant to use social media, some arguments are the lack of confidence in their social media and content creation skills and the fear of appearing unprofessional to their academic or research peers (Osterrieder, 2013). In the five years, science communication scholarship is advocating for including science communication skills (public speaking and engagement for non experts) as part of the training of future researchers around different fields, specially public health and STEM disciplines ([Brownell et al. 2013](#); [Baram-Tsabari and Lewenstein 2017](#)).

Social Media use and Missed Opportunities to Engage Audiences and Scientists in Dialogue

The use of social media for science communication has developed multiple opportunities to share scientific content with the broader public of non-experts. As science communication raises awareness about its potential to involve in public discussions that require demystification through offering scientific-based information to the public opinion. Although, still science communication on social media through scientists' and experts' interaction in real-time has never been so porous and fluid as in the present time (Bucchi, 2019).

Still, scientific organizations and scientists tend to use social media as one-way conduits of communication and underutilize the potential these conduits offer to create potential dialogue and audience engagement (Lee & VanDyke, 2015). In this study, we can evidence that NASA's IGTV has successfully motivated audiences to interact with their content. The content of each video was carefully

developed, scripted, and produced through animations, simulations, and video footage of great quality to explain NASA's projects and missions. Although, NASA did not have a strategy to manage responses to questions, and comments from its followers. In one year of analysis, we could only find one response from NASA, only to manage a discussion about negative critiques about space exploration and public funding that they receive when the US might have other priorities. However, positive opportunities for public engagement were missed. Audiences' questions and positive comments remained unanswered or addressed by NASA. Consequently, dialogue between NASA and its Instagram followers was not established to reach the ultimate goal of building public engagement around their scientific work.

Engaging Science Communication on Instagram

Engaging audiences around science communication can be a challenging task. For this reason, we present several considerations collected from prior studies in order to suggest strategies to foster and take advantage of Instagram to create meaningful audience engagement.

Followers or user comments represent an opportunity to engage audiences through their thoughts, needs, concerns, critiques, or disapproval ([Habibi and Salim 2021](#)). However, responding to followers or user comments opens dialogue opportunities for mutual learning about what is interesting for audiences. Moreover, dialogue in science communication opens the opportunity to reduce misinformation and build trust among scientists and people. For these reasons, we highly recommend to plan ahead to have an expert in the discipline that can be accessible that could manage specific questions of audiences to respond to these questions timely, or to support the work of social media managers that respond from the official Instagram account of the institution.

In this study, we could evidence positive comments of people who were inspired by NASA's work and could be engaged even more positively through a motivating response from the institution. However, NASA did not stay totally neutral to followers' aggressive interactions and responses by appreciating people's critiques but by raising awareness about respectful dissent. It was evident that

responding even a few times or liking comments of users benefit NASA towards a more positive engagement by demonstrating truthful interest in audiences' opinions, or not staying neutral to aggressions among its followers by calling out followers' attention to respectful interactions and dissent ([Kent and Taylor 2021](#)).

Instagram features and tools such as live streams, reels, and stories could be used to invite audiences to post their comments, questions, ideas around NASA's work. Moreover, audiences comments and questions can provide useful feedback that could provide useful insights to develop engaging social media strategies for NASA. Moreover, audiences ideas, questions and comments will be more effectively attended, which can lead to their positive engagement around space exploration and scientific endeavors of the agency.

Conclusions

Instagram offers several tools for content creation that present different opportunities to attract audiences' interest in order to create dialogue that leads toward reaching the goal to engage audiences around scientific content. Although, we can agree that developing social media strategies for science communication implies not only careful research, content curation, scripting, and production. In order to complete a social media strategy, it is also necessary planning response strategies to the audiences comments. If an organization, such as NASA, is developing meaningful efforts and investments in order to design messages to present the efforts of scientific research and data through high-quality videos and animations, it also requires to set a team of social media managers that observe, respond, interact with audiences around their questions, needs, and concerns, or emerging online crises (such as aggression or critiques), in order to promote meaningful engagement of audiences. Moreover, to use the lessons learned from audiences interactions to develop more effective content and management strategies of their online communities.

Frequently, when audiences do not see that the organization is attentive to the comments and feedback provided, they might become disengaged, which means that they can lose interest in what the

organization has to present to them in the future. A prior study of science communication that uses Instagram to develop engagement strategies for public health institutions in Portugal and Brazil for health promotion, evidence that audiences' feedback and questions in comments should be considered to create content that is interesting and engaging to audiences, instead of using Instagram only to disseminate general messages of public health guidelines that do not respond to audiences needs ([Pinto et al. 2021](#)).

Science communication has still a long way to go regarding the effective use of social media for public engagement strategies. Although, as we have argued in this study, it's a matter of understanding social media as means for dialogic communication that can provide deliberative spaces to identify key issues that affect people around specific topics ([Willis 2016](#)). Moreover, dialogic communication applied as a science communication model can benefit from following guidelines for social listening instead of focusing only on disseminating messages. In this regard, social listening ([MacNamara 2015](#)) imply a framework that considers notions of active involvement of organizations with its audiences by: i) to create a *culture of openness* that seeks and values inputs of their stakeholders and audiences. ii) Demonstrate the *willingness to listen* by assimilating others' opinions and reflecting on how to use these for future communications , and iii) *to have structures and processes in place for large scale listening* that leads, which can be translated to attend to audiences needs, interests and concerns when planning and developing social media strategies y to develop engagement around scientific content.

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