Theory-based Science Communication at Comic Cons

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Abstract

The majority of research concerning science communication happens in spaces where people already have a vested interest in or knowledge of science, such as museums and science cafes. Thus, there is a gap in understanding what theory-based science communication looks like in non-science-centered spaces. This qualitative research study, which featured cosplaying science communicators at comic conventions, offers insights into what science communication practices occur within everyday spaces. We conducted observations of and semi-structured interviews with 15 cosplaying scientists, examining how they utilized effective framing and narrative structuring when communicating science at comic cons in cosplay. Across 700 coded utterances, cosplaying scientists most often used effectively framed messaging which allowed for visitors to unite their interests with STEM topics. Alternatively, we rarely witnessed cosplaying scientists using messaging that assuaged or addressed politically polarized scientific topics, such as climate change. While not originally within the scope of data analysis, we also noted that cosplaying scientists indicated that varied aspects of their identities, such as their gender and ethnic backgrounds helped or hindered their science communication practices at comic conventions. Our research provides evidence how science communication changes when it occurs in everyday spaces and indicates avenues for future study in these spaces.

Keywords: science communication, pop-up museum, effective framing

Word Count: 8718

Introduction

Our contemporary society is deeply dependent on applications of science in daily life. Scientific inquiry and findings affect everything from the clothing we wear, commutes we take, and how we engage with work or hobbies. People are often exposed to scientific concepts in artificial or incoherent ways, leading to persistent disconnects between scientific concepts and their everyday applications, meanings, and importance (Fischoff, 2013). Even when communicators sought to make science more accessible through professional development, audiences perceived such communicators as ineffective (Rubega et al., 2021). To create links between scientific concepts and the general public in ways that the audience perceives as effective, we need practical solutions that draw on audiences' interests (Dahlstrom, 2014). While others have postulated that superheroes can be used to communicate science (Zehr, 2014) or that communicating science at popular culture conventions can affect identity (James, 2020), we focus on cosplay.

Cosplay, a blended word combining costume and play, is the process of dressing up like a character from popular culture and attending events, such as comic book conventions (i.e. comic cons) (Gittinger, 2018; Yamato, 2020). Cosplay is becoming increasingly widespread with many ages, ethnicities, race, gender, education, and occupational backgrounds represented in the cosplaying community (Rosenberg & Letamendi, 2018), including educators seeking to engage audiences on a range of scientific topics (Patterson et al., 2024; Stoneburg et al., 2020). However, like many spaces, cosplay is often a challenging space for people from diverse backgrounds, meaning underserved populations who are less often reached in traditional informal learning spaces (Dawson, 2014; Ramirez, 2017). A dichotomy exists for comic con visitors and cosplayers from diverse backgrounds: they are included at comic cons with panels such as "Cosplaying with Disabilities" and "Coming Together: Honoring AANHPI Voices in Pop Culture" (Liao, 2017) while at the same time are being vilified and

ostracized for cosplaying as characters who are of a different race (Small, 2019). Thomas (2023) offers perspective on attending cons as a Black woman, writing, “the presence and bold audacity of marginalized others to simply exist, walk through, and stumble upon these spaces is a transgressive and even subversive act that chips away at the unspoken canonical rules that structure [cons]” (p. 261). Thus, perspectives that Ramirez (2017), Liao (2017), Small (2019), and Thomas (2023) offer indicate that comic con spaces are complex for comic con visitors and cosplayers from diverse backgrounds.

As researchers who also attend both comic cons and traditional informal learning spaces like museums, we saw a distinct difference in the types of visitors within each space, with comic cons featuring what we perceived to be more diverse individuals versus museums. In light of this anecdotal evidence, we sought empirical evidence for our personal experiences. We found there is limited, large-scale demographic data available on comic con visitors due to the proprietary nature of these monetized events. Some small-scale available data points towards increased gender and age parity in visitors compared to museums as well as increased LGBTQ+ representation (Jenson, 2015). Kingston (2015) delved further into demographics, indicating that the majority of comic con convention visitors are between the ages of 18-35, with a higher indication of LQBTQ+ sexual orientation, although ethnicity data is missing from her analysis. Thus, comic cons and cosplay are spaces that show potential for science communication with audiences that are less often reached in traditional informal spaces (Dawson, 2014; Dewitt & Archer, 2017).

The nuances of the comic con and cosplaying experience as it relates to science identity creation and informal STEM experiences can be used to glean important insights into broader issues of access and equity. In particular, marginalized groups along racial, gender, and socioeconomic identities face additional barriers to both informal and formal science education in the dominant Western culture (Avraamidou, 2020). By leveraging popular culture through cosplay, science educators may facilitate experiences that are engaging, as well as accessible, just, equitable, and inclusive, leading to the development of greater science capital and encouraging lifelong learning for a diverse audience. Currently, there is a dearth of research connecting cosplay to

STEM education as well as a lack of established best practices in place for educators interested in using cosplay as a form of outreach and education. Next, we describe topics that highlight the importance of considering the intersection of informal STEM education and cosplay.

Informal STEM Experiences and Science Communication

Science communication is a field that "inform(s) people about the benefits, risks, and other costs of their decisions, thereby allowing them to make sound choices" (Fischoff, 2013, p. 14033). It has also been defined as "the exchange of information and viewpoints about science to achieve a goal or objective" (National Academies of Science, p. 2). The practices science communicators use are rarely studied; instead a larger focus is given to backgrounds, expertise, and personal experiences of communicating science (e.g. Jarreau et al., 2019; Calice et al., 2022). Such personal experiences and background cannot be divorced from the practices that science communicators utilize, and yet, the two remain divided. Additionally, while the tradition of doing science communication spans at least 50 years, theoretical foundations for science communication research are nascent (Gerber et al., 2020). Studies like the one described here have potential to develop both theoretical and practical insights for novel informal STEM learning and science communication.

Previous science communication research has focused on more "traditional" informal STEM learning environments such as aquaria, museums, and science cafes (Childers et al., 2021; Hetland, 2019; Katz-Kimchi & Atkinson, 2014). These informal STEM learning environments are often inaccessible to wider audiences as they cater to people with a pre-existing interest in STEM learning (Archer & DeWitt, 2016) or to those from privileged backgrounds (DeWitt & Archer, 2017). This inaccessibility and inequity can be addressed through interacting with wider audiences in novel informal STEM learning spaces (Falk et al., 2018). We focus on novel informal STEM learning environments, sometimes characterized as "everyday spaces" (Stofer et al., 2019), in which visitors are not necessarily focused on gaining STEM content knowledge. Such spaces include bars, laundromats, and comic cons. While Stofer and colleagues (2019) explored informal learning environments of laundromats and bars, we focus on comic

cons, which are yearly events held in multiple cities and where thousands of visitors share their interests in movies, comics, video games, or popular culture. For this study, scientists who participated in the act of cosplaying communicated science at comic cons. Following a description of our conceptual framework, we will further describe the context and participants within our study.

Conceptual Framework

We integrated two conceptual frameworks, effective framing (Druckman & Lupia, 2017) and narrative structuring (Dahlstrom, 2014), to describe aspects of educative science communication efforts that occur at comic cons featuring cosplaying scientists (Table 1). Effective framing emphasizes specific components of information that can be used to help people construct opinions (Druckman & Lupia, 2017). It has been used to analyze portrayals of climate change within science textbooks (Román & Busch, 2015; Busch, 2021, 2017, 2016) as well as in scientific fields like environmental conservation (Jacobson et al., 2018). Tenets of effective framing include competition for attention, political polarization, and politically induced status quo bias (Druckman & Lupia, 2017). Narrative structuring of science communication "describes the cause-and-effect relationships between events that take place over a particular time period that impact particular characters" (Dahlstrom, 2014, p. 13614). The narrative structuring conceptual framework includes three main elements: causality, temporality, and character. Narrative structuring has been used by scientists and public health communications to change opinions on vaccines (Brodie et al., 2001), environmental beliefs (Dahlstrom, 2010), and HIV/AIDS (Vaughan et al., 2000). With this two-pronged conceptual framework in mind, our research sought to answer the question, *In what ways do cosplaying scientists' science communication practices at comic cons align with or deviate from theoretically-established science communication practices?*

Table 1. Definitions of Effective Framing and Narrative Structure

Code	Code Description
Effective framing (EF)	emphasizes specific components of information that can be used to help people construct opinions
EF: Politically-induced status quo bias	framing science as consensus-based to overcome narratives that are created by politicians to uphold existing state of affairs
EF: Political polarization	framing information so people pay attention to the informational content of science-based messages so they can reconcile their politized beliefs with scientific consensus
EF: Competition for attention	ways that scientists can supply pieces of information that can take the place of other extensive information (i.e. heuristics) to simplify decision-making
Narrative Structure (NS)	the cause-and-effect relationships between events that take place over a particular time period that impact particular characters
NS: Temporality	an identifiable structure (beginning, middle, end) where events are related
NS: Character (C)	includes actors (humans or otherwise) that act within a narrative
NS-C: Character in cosplay	a scientist or the person they're interacting with is a character (ex. Leia costume)
NS-C: Character in a story	a scientist uses a character in a story (ex. A jedi)
NS-C: Reflection on interaction	an interaction with a visitor OR another scientist who was meaningful to them (ex. Drake got me into cosplay)
NS: Causality	statements that are linked to each other by successive causes and consequences
Other	participant describes something that does not fit into other codes but is worth noting
Total	

Materials and Methods

Recruitment and Context

We partnered with Cosplay for Science, an established science communication and educational initiative that invites learners to unite their pop culture interests with STEM topics (Stoneburg et al., 2020). Cosplay for Science's specific aims are: to foster science appreciation through the use of nerd and pop culture; to make science more relatable to audience's everyday lives and interests; to make scientists more approachable and trustworthy; and to create a community that acknowledges the importance of science and appreciates it. To date, Cosplay for Science members have

reached nearly 17,000 visitors at 13 comic cons where they have worked with cosplaying scientists and created pop-up museum booths. With Cosplay for Science, cosplaying scientists usually spend two days at pop-up museum booths at comic cons, where they are dressed as characters from media and have scientific materials that relate to their cosplay, such as fossils, that comic con attendees can interact with.

At comic cons, artists, merchants, and scientists have booths where visitors can interact. Such booths, when transformed into pop-up museums and staffed by scientists who are dressed in cosplay that aligns with the science content featured in the pop-up museum, have the potential to become spaces that offer opportunities for informal STEM learning. Scientists affiliated with Cosplay for Science were interested in sharing science with diverse communities to foster science appreciation using nerd and pop culture. Under Utah State University IRB Protocol #12842, we recruited participants by emailing scientists who our contact at Cosplay for Science knew were going to attend and communicate science at pop-up museum booths at comic cons. Thus, for this research, we focus on delineating the science communication practices of cosplaying scientists at comic cons.

Scientists consented to participate after filling out a survey (supplementary material) that asked their scientific expertise and demographic information including age range, gender, sexual orientation, ethnic heritage; demographic questions were included as we were curious of the composition of cosplaying scientists, since a great majority of traditional science communication takes place in spaces which often feel unwelcoming for people from diverse backgrounds (Dawson, 2014; DeWitt & Archer, 2017). Scientists were compensated for their participation with a $75 Visa gift card. We studied 15 cosplaying scientists who communicated about science at pop-up museum booths at four comic cons within the western United States.

Pop-up museum booths designed by Cosplay for Science varied in theme and reflected fantasy or science fiction worlds, such as Dungeons & Dragons, *Game of Thrones*, *Star Wars*, and *Pokémon*. For the four comic cons we studied, the pop-up museum booth was called The Galactic Archive, where cosplaying scientists shared museum specimens such as crinoid fossils, dire wolf and American lion skulls, and geological specimens to represent the flora, fauna, and planets of the *Star Wars*

universe. Scientists were then dressed in cosplay as characters from the *Star Wars* universe such as jedi, X-Wing pilots, and Princess Leia.

Data Collection

Data were collected in two phases: observations at comic cons and post-comic con semi-structured interviews. We also conducted focus groups with the cosplaying scientists following comic cons, but in analyzing these focus groups, we found that the cosplaying scientists were using the space to debrief on the comic con experiences (e.g. which booths and programs they attended) and discussing ways to improve the museum booth (e.g. adding additional specimens) versus discussing science communication practices. Thus, the focus groups were excluded from analysis.

At pop-up museum booths, multiple scientists dressed in cosplay and were present to talk with comic con visitors about the pop-up museum's artifacts and stories. Scientists were randomly selected for observation through giving each a number (e.g. Ashoka = 1, Sabine = 2, etc.), rolling a 20-sided die, and observing the scientist that corresponded with the number rolled. To prevent observation bias, scientists were not told if/when they were being observed. Using a data observation sheet that included definitions of elements of narrative structuring, effective framing, and other, observers wrote detailed notes during the observation period (Supplemental material). Each scientist was observed for 30-minutes multiple times during the comic con, as scientists would take 30-minute shifts at the pop-up museum booth. When possible, two observers would observe the same scientist as a form of data checking (Spradley, 1980).

In the second phase, we conducted one-on-one, ZOOM-based, semi-structured interviews after each comic con (Supplemental material). While we attempted to schedule interviews in the week that followed comic cons, due to scientists' schedules, we completed interviews with all scientists within three weeks of each comic con. These interviews lasted approximately 45 minutes and contained questions that asked scientists to reflect on their experiences at the comic cons, expanded on researchers' observations at the comic cons, and related to elements of narrative structuring and effective framing, such as, "Think about or imagine a time at a comic con when you've

used a story to explain a scientific concept. Please share." Interviews were transcribed in otter.ai and then listened to by a research team member to make corrections; this also served as a first pass at data analysis as the researchers made initial notes about the interviews. Transcripts were uploaded into MAXQDA for coding; the coding scheme was based on elements of effective framing (Druckman & Lupia, 2017) and narrative structuring (Dahlstrom, 2014), with the category of other used to capture aspects that were meaningful but did not fall into the original conceptual framework. Coded segments ranged from a sentence to a paragraph. Each researcher individually read each interview transcript, coded it, and then the research team met to code to consensus (Richards & Hemphill, 2018), which entailed discussing how each person coded the data while examining the definitions of codes from Druckman and Lupia (2017) and Dahlstrom (2014).

Results

The 15 participants we observed and interviewed had varied scientific backgrounds, professional expertise, ages, genders, sexual orientations, and ethnic heritages (Table 2). The varied gender identities, sexual orientations, and scientific expertise were important when these scientists represented themselves and their science to public audiences. As we saw in some of their interviews, cosplaying scientists' gender identities became an especially important part of the ways in which they communicated science.

Table 2. Pseudonyms and demographics of participating cosplaying scientists

Pseudonym	Scientific expertise	Professional expertise	Age range	Gender	Sexual orientation	Ethnic heritage
Keo	Astronomy	Graduate Student	25-34	Agender	Aromantic, Asexual	White
Maz	Astronomy	Graduate Student	18-24	Woman	Bisexual	Asian, White
Leia	Chemistry	Professional	25-34	Woman	Straight	Asian, White
Tala	Earth Science	Professional	25-34	Woman	Straight	Asian
Ashoka	Herpetology	Professional	25-34	Woman	Fluid	Black
Jyn	Biomedical engineering	Professional	25-34	Women	Queer	Asian, White
Bantha	Paleontology	Professional	25-34	Nonbinary	Queer	Hispanic
Ben	Paleontology	Undergraduate student	18-24	Man	Straight	Hispanic, White
Cassian	Paleontology	Professional	25-34	Man	Straight	White
Drake	Paleontology	Professional	25-34	Man	Bisexual	Asian

Ezra	Paleontology	Professional	25-34	Man	Straight	White
Hera	Paleontology	Professional	25-34	Genderqueer	Pansexual	White
Max	Paleontology	Graduate student	25-34	Man	Straight	Hispanic, White
Luke	Plant sciences	Professional	25-34	Man	Bisexual	White
Sabine	Psychology	Professional	25-34	Woman	Straight	White

Across all interviews and observations, we coded 701 segments (Table 3). We most often saw the code of competition for attention (n = 113), followed by effective framing (n = 102), and causality (n = 96). Competition for attention was most observed in observations (n = 45) whereas effective framing was the most observed code in the interviews (n = 71). The least common code we saw in the study was politically induced status quo bias (n = 11). We now contextualize our findings by sharing quotes from participants.

Table 3. Coding Framework and Number of Codes

Code	Interviews	Observations	Total
Effective framing (EF)	71	41	112
EF: Politically-induced status quo bias	10	1	11
EF: Political polarization	17	3	20
EF: Competition for attention	65	48	113
Narrative Structure (NS)	26	16	42
NS: Temporality	44	13	57
NS: Character (C)	8	18	26
NS-C: Character in cosplay	25	0	25
NS-C: Character in a story	42	0	42
NS-C: Reflection on interaction	29	0	29
NS: Causality	66	30	96
Other	99	29	128
Total	502	199	701

Effective Framing and Narrative Structuring: How Scientists Encouraged People to Interact with Science

Participants highlighted their usage and strategies for effective framing, which is defined as emphasizing the specific components of information that can be used to help people construct opinions (Druckman & Lupia, 2017) and how that applied to their work at comic cons. Drake, a paleontologist, highlighted this in the way that he talked about the design and choices of objects he used for the pop-up museum booth. He explained that within *Star Wars*, there were fruits on the planet Tatooine called black melons, which

stored water. When we observed him at a comic con, we saw Drake explaining to audiences,

> So this black melon instead stores water inside of its hard exterior shell. And that's how they adapted and evolved. To [explain that in the *Star Wars* universe] the creators of *Star Wars* and *The Book of Boba Fett*; they looked at sea urchins. And sea urchins are super weird. They've got this weird exoskeleton. And so they took that and turned it into a fruit--the black melon in *Star Wars.* (Drake, observation)

In our interview with Drake, we asked him to explain how he was thinking of communicating the black melon/sea urchin connection to comic con visitors. He said that he liked being able to tell the "story of how something on Earth got adapted into something completely unrelated in the *Star Wars* galaxy…It was fun getting to explain the chain of events that led to a sea urchin painted black in the pop-up museum booth" (Drake, Interview, December 14, 2022). In a similar vein, Hera, a paleontologist said, "a phrase that I find myself, and that I saw other people using a lot on the booth is like the real animals we have here are way weirder than anything in the *Star Wars* universe…So, it's like [a] truth is stranger than fiction kind of a concept" (Interview, December 14, 2022). For Drake and Hera, who connected their knowledge of paleontology and biology to the booth's *Star Wars* material, a way to build interest in an interaction was to communicate about just how strange many beings and processes are in the natural world.

Ashoka, a herpetologist, built on the idea of "truth is stranger than fiction" in showing aspects of her science that many visitors likely never had the chance of interacting with. Ashoka would show visitors a preserved lizard tail that she collected during a research trip to generate questions, saying that a booth visitor might say, "'Yeah, I've seen a tail before' [so] I'll be like, 'okay, but have you seen a preserved one? Like, have you seen one close up? Like, do you know…what it is that makes it so they can drop their tail?'" (Interview, December 21, 2022). These instances of scientists sharing science with comic con visitors in a way that generated interest are examples of theory-based science communication in the everyday space of comic cons. The scientists engaged in effective framing here using connections to the booth theme, *Star*

Wars, and real-world beings, such as fruit or animals, to emphasize specific scientific information and allow visitors to construct their own opinions.

Additionally, cosplaying scientists often supplied pieces of information that helped comic con visitors in discovering or learning about science, which was defined as *competition for attention*. Ashoka's interactions that revolved around her lizard tail are examples of this. While she first effectively framed science for visitors by showing them the lizard tail, she then continued to help visitors engage with scientific information about the lizard tail by comparing vertebrae to something many visitors have familiarity with: the plastic building blocks known as Legos. When we were observing, we saw Ashoka prompt a visitor, "you know what Legos are, right? The lizard tail…like the vertebrae connecting to each other--they're like Lego bricks!" (Ashoka observation). In this interaction, Ashoka helped the visitors learn about the lizard tail vertebrae by focusing their attention using an illustrative example from a material they likely already had experience with. The visitors had their attention on the tail specimen, and she connected that to scientific concepts and practices from their everyday life. Ben also made sure that visitors could learn about science when he explained that touchable objects enticed visitors. In our observations of him, Ben would say "hey, would you guys want to go ahead and touch a real fossil?" (Ben observation) in reference to a T. rex tooth or a jaw of a fossilized ray. When asked in an interview to explain why he would do this he said, "So we can draw more people in, and present whatever it is and be like 'we have some extra stuff over here in the booth, would you guys want to come in and have a look at it as well?'" (Interview, December 12, 2022). In the comic con context, other booths and people can distract visitors' attention, so Ben introduced visitors to objects they could both see and touch to initiate and further conversations about science. Both Ashoka and Ben recognized the importance of tangible items in the process of competing for attention. Sabine explained the reasons for trying to connect with visitors using objects or their interests by saying that the pop-up museum booth was "catered to *Star Wars* fans, and that was an establishment of common ground" (Interview, December 18, 2022). When cosplaying scientists sought to meet people where they were regarding interest and science content, they were showing empirical

evidence of the theory-based science communication practice of competition for attention.

Narrative structure, defined as the cause-and-effect relationships between events that take place over a particular period that impact particular characters (Dahlstrom, 2014), allowed scientists to tell stories about science that interested both themselves and those with whom they shared science. Scientists often indicated the ways they got into science or how they shared science with others, which fell into the code of *narrative structure*. When describing herself to one of the interviewers, Maz said she was a graduate student who worked on exoplanets, but when she interacted with people at comic cons, she emphasized different pieces of herself, including “the fact that I am interested in science fiction and thinking about overlaps between what's science fiction and what can be real and then talking a little bit about the fact that I work on science of life on exoplanets.” (Interview, December 29, 2022). Similarly, Bantha, a paleontologist, described their story of getting into science, saying they were

> never into science as a kid. I was never into science in high school, I was never into science. Even in college. I started college as a business administration double major, and only took a science class because you need to take one to graduate. So I thought, ‘okay, geology has gotta be the easiest one, you're looking at rocks, how hard can it be?’ And then joke's on me, because you use physics, chemistry, biology, everything in geology. But that's where I learned that, like, you can get paid to go hiking, and you can get paid to dig up dinosaur bones and my entire perspective on what science is completely changed. (Interview, July 27, 2022)

For Bantha, they described a dislike of science during childhood through the beginning of college which shifted when their understanding of the practices of science expanded to include things of personal interest. Bantha’s experience growing up and never liking science and Maz’s overlapping identities as an exoplanet researcher and a science fiction lover are examples of past experiences shaping the ways that they saw the world as cosplaying scientists and thus ways to share science with others. Here, the scientists shared a few meaningful moments created by cause-and-effect relationships related to their own interest in science or connections to popular culture. These narrative

structures are stories the scientists shared with comic con visitors in hopes to make deeper connections across their interactions.

Narratives shared by scientists and pop-up museum booth visitors link people, places, and things together. In our research, this is defined as causality and is a sub-code of narrative structure. Bantha, when talking about how they communicated with visitors illustrates causality when they said, "...I start there [with peoples' interests], because that really informs how I communicate science and how I talk about science. Because I love when I hear people say that they always were interested in science and Jurassic Park inspired them…" (Interview, July 27, 2022). With this quote Bantha explains why they feel the need to start with interest, as it is a way to link to the science components. In another example, Sabine described how she would talk about the dynamics of planetary systems in *Star Wars* and their relation to real-world planets:

> [S]ome of the faculty that I work with discovered Tatooine-like planets that actually orbit binary stars. So, if [booth visitors] were like looking at the Tatooine stuff, I'd be like, 'oh, …this is a really dry planet. And like, why? How do you think the two suns from Tatooine affected this?' …Like taking an element that I know about the story about *Star Wars* and being like, did you know that like, these kinds of planets actually exist in the real world? (Interview, December 18, 2022)

Sabine discussed characters such as the faculty she worked with, the booth visitors, and the plants like Tatooine, as well as the causal relationship between suns and the planet. With such examples, we saw that scientists were connecting the narrative structure of science and of their lived experiences in the world.

Unexpected Findings Concerning Gender, Minorities, and Cosplaying

Cosplaying scientists' experiences came to the forefront when they discussed aspects that we did not anticipate in our original coding scheme. We included a coding category called "other" for such instances. While not the main focus of this research (i.e. theoretically established science communication practices), we find it worthwhile to report on these aspects, as they clearly affected our participants. Leia and Sabine, who identified as cisgender women, and Keo, who identified as agender, all described the

interplay between gender and cosplaying either as being advantageous or having disadvantages.

Keo, Leia, and Sabine all described their experiences as cosplaying scientists in ways that we interpreted as being disadvantages. Keo indicated that cosplaying as someone not of their gender was a challenge while Leia and Sabine both mentioned that they confronted issues as women who were cosplaying.

One aspect related to gender that Keo described was the idea of cosplaying as a character which did not match their gender or personality. Keo described their experience cosplaying as Han Solo who, in the Star Wars canon, has a “suave, roguish personality” which Keo did not think they themselves had (Interview, January 18, 2023). Because of their perceived lack of these characteristics, Keo did not feel comfortable using characteristics associated with Han Solo to interact with comic con attendees. Keo then went on to say that if they were to use a character to talk to comic con attendees, they would “pick a character [they] felt [they] could more easily embody. Someone perhaps like Princess Bubblegum where [they] could affect that sort of scientific demeanor” (Interview, January 18, 2023). Keo’s analysis of how Princess Bubblegum would be an easily embodied character for them while Han Solo would not speaks to the different ways that Keo considered gender roles for themself as a cosplayer. Additionally, Keo focused on how cosplaying as a character that already had some degree of scientific acumen, like Princess Bubblegum, was easier for them versus porting scientific knowledge into a non-scientist character like Han Solo.

On the other hand, Sabine and Leia described perceived expectations for them as women cosplaying scientists, which included playing as characters that are sometimes sexual or risqué in their costuming. Leia and Sabine experienced the feeling of being sexualized or objectified regardless of the style of cosplay they are dressed in. Both in the past and at the present, Sabine witnessed Leia experience uncomfortable or even “terrible” interactions. Similarly, Leia shared “inappropriate” motivations for people coming up to her in cosplay, specifically wondering, “Are [people] really interested in science, or they just kind of want to argue, because you're a scientist? Do they get a kick out of arguing with the scientists, or are they just chatting you up because you're a woman?” (Interview, December 27, 2022). For Leia, beyond considering such things as

the public's knowledge and interest in her science communication, she was often aware of other motives. She felt some may have had hidden reasons for interacting with her as a cisgender woman. The question of if someone interacted with her to actually learn science or simply for "chatting [her] up" is something she considered internally.

Women scientists wished to step out of conversations where they were uncomfortable as sexualization or objectification of their cosplaying affected what types of costumes they chose to wear. Leia further described:

> When you are a woman in cosplay… there's always categories, and one really big category is the sexy cosplay and… you're just like, "how do I want to navigate this? How do you do that at a con?"... Cause like, you know, sometimes people will just like, touch you and like that's not cool. (Interview, December 27, 2022)

Here Leia explains her understanding of the cosplay norm of the "sexy cosplay" category and some of the problems she perceives arise from it, in particular non-consensual touching. Leia positioned herself in opposition to this as "classic Leia, so [she is] covered up" (Interview, December 27, 2022) yet despite this distinction she expressed that she encountered situations she did not feel comfortable with. Both Leia and Sabine were highly cognizant of how others might perceive the cosplays that they chose to wear in the comic con setting as they communicated science. Leia explained that being aware of their cosplays was something that cisgender women cosplayers had as "just one more question that's like in the back of your head as you're like trying to interact with people" (Interview, December 27, 2022).

We note that although we asked all participants similar questions, no cisgender men we interviewed talked about audience perceptions of their cosplays or wondered if they would have to address uncomfortable situations such as audience members inappropriately touching them. Additionally, while we documented women cosplaying scientists' uncomfortableness with being sexualized in our interviews, we did not document this during our observations at comic cons. This does not mean that cosplaying scientists were not uncomfortable or that this did not happen, we simply did not observe it at the comic cons during our observation periods.

There are many aspects to intersections of identity, such as gender, education and profession. In our analysis, we found that the participants' practices in character choice, role play, and outfit selection are frequently considered in light of what they perceived would make them better able to communicate on science. Scientists were highly cognizant of how inappropriate conversation or interactions might be sparked by their perceived gender in a comic con setting. In an attempt to prioritize their science communication practices in the space, the scientists would try to reduce aspects of cosplay, like sexy costuming, that might hinder from their educational efforts with the audience. We saw that scientists brought their lived experiences into their science communication practices. This highlights the unique ways individuals choose to engage as science communicators, or not, in a setting connected to cosplay and science.

Another aspect we saw in our codes was the emphasis some cosplaying scientists gave to their status as minorities, which they felt gave them some advantages in science communication at comic cons. For instance, Drake, an Asian paleontologist, indicated that he was "a different representation of science" who was "more accessible to a brown person, than like, Ezra" who was a white paleontologist (Interview, December 14, 2022). Drake additionally recalled an experience he had at a comic con, saying that he met a Filipino family who chatted with him in Tagalog and thanked him for being there. Drake said, "it really meant a lot that I could inspire a little Filipino kid and also represent because I myself had never met a Filipino scientist at all growing up either" (Interview, July 29, 2022). Bantha, a Hispanic paleontologist, described how they saw a family speaking Spanish while looking at objects in the booth, but not engaging with scientists, "[they were] clearly interested but also guarded, like I could see they were trying to hold themselves back, I think they were worried we would ask a question, and then they wouldn't be able to answer." Bantha approached them and started a conversation in Spanish. They said, "you could see like, bodies relax and the faces open up and be like, 'oh, we don't have to just look at the pictures here. And now we can actually really learn what is this crazy table about'" (Interview, July 27, 2022). Maz, an Asian astronomer, cited the Draw a Scientist activity in which children are asked to draw what they think a scientist is, and in many cases, children draw white men in lab coats (Miller et al., 2018). She said that she would never be a white, male scientist in a

lab coat, so she was “really interested in getting out there and being like, ‘I’m a scientist’” (Interview, December 29, 2022). Thus, cosplaying scientists were excited to represent what a scientist could be comic cons and were thoughtful about how their status could inspire others at comic cons.

Not Getting Political About Science

Two theoretically based aspects of effective framing, politically induced status quo bias and political polarization, were less frequently seen in our observations and interviews. Regarding *political polarization*, which is defined as framing information so people pay more attention to the informational content of science-based messages so they can reconcile their politized beliefs with scientific consensus (Druckman & Lupia, 2017), we saw very little evidence in our observations of scientists attending to or being confronted with this (n = 20, 3.39%). As Luke and Ezra indicated, they were not attempting to “change minds” (Luke, Interview, December 8, 2022; Ezra, Interview, December 13, 2022) about scientific information. Therefore, the scientists provide information to the comic con visitors with a conscious effort to provide listeners with the choice in how to reconcile the scientific information with their own belief systems. An overarching value for the scientists was to provide information from their respective specialist fields, but not to do so in a way that had persuasion as an objective. The rare instances of political polarization that occurred in observations were with Ben, when he would preempt conversations surrounding dinosaur fossils on display, saying, “yes, [dinosaurs] had feathers, no we don’t know what is going on with Spinosaurus” (Ben, observation). Ben’s indication that paleontologists at the booth did not know about Spinosaurus stem from the fact that it is a popular, charismatic megafauna featured in the *Jurassic Park* movies and that it was a dinosaur whose few fossilized remains cause debate in the field about its locomotion and aquatic (or not) lifestyle. When Ben preempted audiences’ questions, he was attempting to frame information to get them to pay attention to scientific content as opposed to attending to information presented by the media regarding scientific messages.

We also saw a lack of codes related to politically induced status quo bias, which was defined as framing science as consensus-based to overcome narratives that are

created by politicians to uphold existing state of affairs. We only saw this code appear 11 times in interviews and observations, which accounted for 1.5% of the total codes. Keo lamented in their interview, “It's hard to convince people who are set on something that doesn't have a scientific backing” (Interview, January 18, 2023). Leia, a chemist, explained that she rarely felt the impetus to overcome political narratives about science, as she tended “to stick to areas of chemistry that the general population don't always think about…I'm not studying climate change. I'm not making drugs. I'm not testing vaccines. I'm not studying evolution, like those controversial subjects” (Interview, December 27, 2022). Again, we saw the scientists position themselves as communicators who are not controversial or striving to make their visitors change their own beliefs, attitudes, or viewpoints. The scientists recognized that visitors with entrenched beliefs which compete with their own scientific viewpoints were unlikely to change their beliefs during the course of one interaction. Additionally, the scientists chose conversational topics that were less likely to produce controversial interactions, such as lesser-known areas of chemistry. Thus, although both politically induced status quo bias and political polarization were key aspects of the theory of effectively framed science communication as theorized in the literature, within the everyday setting of comic cons, scientists rarely explored, explained, or communicated science in these ways.

Discussion

In our research, we sought to characterize how cosplaying scientists’ science communication practices at comic cons aligned with or deviated from theoretically established science communication practices. Overall, we found that cosplaying scientists often employed theoretically based science communication strategies, such as effective framing and narrative structuring when communicating science at comic cons.

Aligned with previous research about effective framing (Dahlstrom, 2014), scientists effectively framed “real world” science by situating what was known about the universe and relating it back to audiences’ interest in fictional stories—such as Sabine connecting astronomers’ work on binary star systems with the *Star Wars* planet of

Tatooine. However, previous work on effective framing (e.g. Dahlstrom, 2014) has focused on traditional informal STEM learning spaces. With this work we showed that scientists employ some theoretically based science communication components, specifically, effective framing in the form of competition for attention and narrative structuring in the form of temporality, character, and causality in the everyday space of comic cons. In alignment with Jacobson and colleagues' (2019) previous work on message framing, we saw that cosplaying scientists oriented their scientific content as stories that would resonate with audience members. This orientation allowed cosplaying scientists to storytell and connect their own scientific interests to the pop culture that resonated with audience members.

Previous work explored science communication and learning in spaces where audiences already have an interest in science learning, such as science cafes (Childers et al., 2021) and thus, scientists' communication does not have to bridge gaps between everyday interests and science interests. In characterizing science communication within the everyday space of comic cons, we show evidence that the theoretically based science communication strategies of effective framing and narrative structuring can be used in everyday science learning spaces (Stofer et al., 2019). Framing science concepts as connected to audience members' established interests can further build on Falk and colleagues' (2018) work on aspects that influence public interest in science. Their work examined specific aspects that contributed to public interest in science, including reading, watching television, using the internet to find information, and attending science centers. Novel spaces, like comic cons, were not explored. Our work, along with that of James (2020) and Stofer and colleagues (2019) explore novel everyday spaces where science learning can, and does, occur. We postulate that such everyday learning spaces are underexplored and undervalued regarding building public interest in science.

One unexpected aspect that came up in our analysis was how some women and agender cosplaying scientists felt they had to attend to audiences' gendered assumptions while cosplaying for science. For these cosplaying scientists, audience perceptions of their roleplay and costumes were sometimes at the forefront of their minds even when they were discussing scientific topics. We envision a future research

direction in which researchers could further examine the connections between female cosplaying scientists' intersections of identity as cosplaying scientists and their science communication practices.

Science communication is still overwhelmingly white, male, and euro-centric (Guenther & Joubert, 2017), but researchers (i.e. Canfield et al., 2020) are calling for inclusive approaches that emphasize intersectionality, asset-based methods, and cultivating belonging and engagement with diverse perspectives. Cosplaying scientists we observed embraced their identities (e.g. as a woman, or as a Filipino scientist) to make connections with comic con visitors. Thus, in this study, cosplaying scientists were embodying Canfield and colleagues' calls for cultivating belonging in science communication. James (2020) noted that science communicators and audiences experienced identity changes while attending comic cons. His research and ours builds on Avraamidou's (2020) conceptualization of science identity, in that cosplaying scientists' identities as science communicators, scientists, and cosplayers intersected. Our unexpected findings show the varied aspects that cosplaying scientists had to attend to in addition to figuring out how to best convey scientific messages to audiences.

While the scientists' varied gender identities, sexual orientations, and scientific expertise were important, what was less important during interactions with comic con visitors and during their interviews was the idea of professional expertise. During observations, we witnessed some instances of a cosplaying scientist telling a visitor that they were a paleontologist, a chemist, or a herpetologist, but this did not seem to be limited to those who were professionals. This relates to previous findings in science communication research where science communicators come from more varied backgrounds (Davies & Horst, 2016; Trench, 2017). We see overlaps in our findings to those of Fischer and Schmid-Petri (2023) who found that while there is a typology of science communicators with different agendas, they all draw from a common set of building blocks. We anticipate future research that could situate cosplaying science communicators within the typology of science communicators developed by Fischer and Schmid-Petri (2023). However, we acknowledge that our study lacked representation in scientists who were over the age of 35 and/or in senior academic positions (e.g.

associate or full professors). Future work would benefit from recruiting participants from these demographics to understand how their professional expertise affects science communication at comic cons.

As noted in the findings, we saw little evidence of the theoretically based science communication practices of political polarization and politically induced status quo bias. Perhaps one reason why we did not see cosplaying scientists employing these practices is that they are mostly tied to traditional informal STEM learning environments. Political polarization and politically induced status quo bias are well-covered in traditional informal STEM learning environments, e.g. exhibits on climate change (Thompson, 2022), framing messaging about healthcare (Lundgren et al., 2019; Stofer et al., 2019), and training future science communicators (Heslop et al., 2021), but they were not as apparent when communicating science in an everyday space like a comic con. The fact that some scientists avoided or claimed that their science was not subject to politics is counter to the call many scientists or scientific advocates resound of science is political (Shearer et al., 2020). We theorize that these aspects are not what allow for scientists to make connections with audiences at comic cons. After all, political polarization and politically induced status quo bias are based in “traditional” science communication efforts in which people are coming to events and spaces with the goal or understanding of seeking out science (Hetland, 2019; Katz-Kimchi & Atkinson, 2014). These political components of theoretically based science communication do not account for the ways that interest can modify the science communication experience.

Conclusion

This research focused on understanding how cosplaying scientists communicated science within the everyday spaces of comic cons. We found that scientists tended to use stories and frame science as interest based as opposed to exploring ways that science topics could be integrated with (or divorced from) political views. We add to understanding about theoretically based science communication in spaces where people are not necessarily seeking to learn about science or interact with scientists. This addition is important, as most science communication research occurs in places where people actively go to gain science content such as museums, science cafes, and

science festivals. Our future research will further explore science communicators' identity and how it affects participating in communicating science in "everyday spaces" such as comic cons and if there are regional differences regarding science communication at comic cons as well as build on our previous understanding through incorporating perspectives from audiences who visit pop-up museum booths at comic cons.

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Declaration of interest statement

The authors have no conflicts of interest to disclose.

Ethics statement

This data was collected under Utah State University IRB Protocol #12842.

Supplementary material

Supplemental material for this manuscript may be found at https://osf.io/vf8ne/?view_only=7366967881d045ea9671bf71633d2414. Supplemental material includes the informed consent survey asked of scientists, observation protocol, and semi-structured interview questions. Interview and observation data are available by request.

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