frontiers | Frontiers in Communication

TYPE Brief Research Report
PUBLISHED 11 September 2025
DOI 10.3389/fcomm.2025.1622230

OPEN ACCESS

EDITED BY
Ataharul Chowdhury,
University of Guelph, Canada

REVIEWED BY
Adalberto Fernandes,
Politechnic of Porto, Portugal
Alison Cawood,
Smithsonian Environmental Research Center (SI), United States

*CORRESPONDENCE
Katherine King
katie.king@ceismc.gatech.edu

RECEIVED 02 May 2025
ACCEPTED 07 August 2025
PUBLISHED 11 September 2025

CITATION
King K, Kessler T, Nimox K and Alemdar M (2025) Science communication in action: lessons from a mixed-methods case study of a large science festival. *Front. Commun.* 10:1622230. doi: 10.3389/fcomm.2025.1622230

Science communication in action: lessons from a mixed-methods case study of a large science festival

Katherine King*, Talia Kessler, Kari Nimox and Meltem Alemdar

Center for Education Integrating Science, Math, and Computing (CEISMC), Georgia Institute of Technology, Atlanta, GA, United States

Introduction: Science festivals are a mechanism for connecting public audiences with science topics. Scholars have identified best practices for science communication (Peterman and Young, 2015), facilitating research on how and to what extent effective science communication occurs in the context of science festivals.
Methods: This mixed-methods evaluation case study centers the experiences of exhibitors (i.e., science communicators) at a large science festival event. We use a convergent parallel mixed methodological approach with an intent to triangulate observation, survey, and group interview data.
Results: Observation data documented the use of effective communication practices by exhibitors, such as clear messaging and engaging activities. Best practices for science communication were documented more frequently by exhibitors from educational institutions and non-profit or other organizations, compared to exhibitors from large corporate sponsors. Exhibitors described positive impacts of participating in the event, which provided valuable professional development, reinforced their communication skills, and fostered a sense of community.
Discussion: The findings of this study have implications for those involved in recruiting and training scientists to participate in outreach events. Future festivals should continue to prioritize hands-on, interactive methods, while offering support for science communication best practices, particularly for volunteers who are less practiced in communicating science, such as those outside academia. In addition, this work highlights the value of robust evaluation and research to understand the impacts of science festivals, not just on attendees, but on those tasked with communicating science.

KEYWORDS

science communication, science festival, evaluation, mixed methods, case study

1 Introduction

Science festivals are an increasingly popular arena for connecting public audiences with scientific concepts and activities (Bultitude et al., 2011). The structure and scope of science festivals varies, but a necessary component is sharing science with attendees, generally assumed to be a lay audience. This situates science festivals within a larger effort to build public understanding of science (Bauer et al., 2007). Kappel and Holmen (2019) offer a conceptual framework for science communication that involves two paradigms: a "dissemination paradigm" and a "public participation paradigm" (p. 2). In a dissemination paradigm, science

is communicated to a passive public by experts, such as through panel discussions with sciences, as documented by Rose et al. (2017). This is similarly illustrated in Fogg-Rogers et al.' (2015) longitudinal study of a health science festival, which found that lectures were routinely the most attended and preferred format of science festival activities. In a public participation paradigm, science is communicated via discussion between members of the public, experts, and policymakers, enabled by hands-on activities and interactive demonstrations (e.g., Illingworth et al., 2015; van Beynen and Burress, 2018). In their analysis of 55 science festivals, Ramsey and Boyette (2021) found that all but two offered hands-on activities, indicating that interactive science communication is a common approach at festivals. Some festivals offer a mix of different activities that align with both paradigms (Wiehe, 2014).

While public understanding of science has historically focused on developing science knowledge, attitudes, or trust (Bauer et al., 2007), science festivals are characterized by a focus on engagement and the "celebration" of science topics (Bultitude et al., 2011, p. 167). Science festivals provide opportunities for families to engage in hands-on science together (Idema and Patrick, 2019), building awareness and interest in STEM careers (Canovan, 2019; de Leon and Westerlund, 2021), and offering real-world connections to science (Illingworth et al., 2015). Festivals also provide a mechanism for community engagement, wellbeing, and leisure (Frew and Makua, 2023). Thus, an important aspect of science communication at festivals is sparking curiosity and wonder to better engage attendees (Davies, 2019; Jensen and Buckley, 2014). Strick and Helfferich (2023) conducted a factor analysis in their quantitative study of a European festival, finding that the most impactful science communication involved "personal relevance [to attendees], accessibility, and interactivity" (p. 8). Similarly, Peterman and Young (2015) identified a series of best practices for science communication at festivals, such as using hands-on activities, avoiding jargon, and connecting content to real-world examples. In accordance with this literature, we define "effective" science communication in the context of our study as that which employs these best practices, illustrated by hands-on activities or demonstrations, connecting to real-world examples, engaging the attendee through questioning and inviting questions from attendees, and avoiding the use of jargon (Peterman and Young, 2015; Strick and Helfferich, 2023).

Despite the enthusiasm for science festivals, scholars have critiqued previous research for the substantial variations in the descriptions of festival structures and impacts (Ramsey and Boyette, 2021). The lack of detail provided on festival scope and format presents challenges for contextualizing the findings of festival research. In addition, most research on science festivals focuses on attendees, rather than those tasked with communicating science (Peterman et al., 2020; Dippel et al., 2016). This paper builds on the existing body of research, detailing a mixed methods case study of the Atlanta Science Festival (ASF), a large festival located in a major metropolitan area in the southeastern United States. Specifically, we focus on the festival's culminating event, a day-long Expo, featuring over 100 booths at which exhibitors share science demonstrations and information. The study centers Expo exhibitors, who are science professionals working in outreach, industry, and academia (university faculty, staff, and students), to explore effective science communication using the following research questions:

> *RQ1*: In what ways do Expo exhibitors engage attendees with scientific content?
>
> *RQ2*: To what extent is this science communication effective?
>
> *RQ3*: In what ways are exhibitors impacted by their participation as science communicators at the Expo?

2 Methods

This research employs a case study design (Yin, 1992) with a convergent parallel mixed methodological approach (Creswell and Plano Clark, 2018) used to triangulate data from several sources (observations, surveys, and interviews). This provides an in-depth examination of a phenomenon (science communication) within a real-life context (Denzin, 2012). The unit of analysis for this case study is the 2024 ASF Expo. Subunits of analysis were defined as individual booths, at which exhibitors interacted with attendees to present scientific content. In alignment with a convergent parallel mixed methodological study, qualitative and quantitative data were collected and analyzed separately before being merged to present overarching findings generated from all sources (Creswell and Plano Clark, 2018, p. 155).

2.1 Background context

Now in its 12th year, ASF is "an annual celebration of the world-class learning and STEM career opportunities in metro Atlanta," mirroring the characteristics of science festivals documented in the literature (Bultitude et al., 2011; Science ATL, 2025a). In 2024, ASF included 165 events held over 2 weeks, culminating in a day-long Exploration Expo, described by the organizers as "one big science party" (Science ATL, 2024, 2025b p. 1). This free event is held in a large public park in the city center and typically attracts thousands of attendees. The 2024 Expo included over 100 booths, at which exhibitors were expected to lead a science-based activity or present a scientific demonstration that could engage both adults and children. Booths reflected a variety of exhibitor types: Educational Institutions (including K-12 schools and universities), Organizations (including non-profit and other organizations), and Large Corporations. Given that exhibitors' scientific backgrounds varied, ASF leadership offered a pre-Expo webinar to describe logistics for the event and online resources for designing an engaging booth experience that could effectively communicate scientific topics.

Each year, ASF leadership and external evaluators work collaboratively, guided by Patton's (2008) utilization-focused evaluation framework, to design a responsive evaluation that supports decision making. Accordingly, ASF leadership are invited to review data collection tools and plans each year to ensure alignment with the festival and evaluation goals as they evolve over time. In prior years, evaluation efforts included administering surveys to attendees, which yielded the emergent slogan "I'm a data point"—a phrase that was subsequently adopted by similar festival evaluations across the country. The evaluation for the 2024 Expo centered the exhibitors themselves.

2.2 Data collection

This study involves secondary analysis of data previously collected during the 2024 ASF evaluation via observations of Expo booths, post-surveys, and interviews. Trained data collectors used a structured

"mystery shopper" observation protocol (Peterman and Young, 2015), engaging with booth staff as if they were an Expo attendee, then completing the protocol on an iPad. Booths were purposively sampled to represent a range of exhibitor types. Of the 110 booths featured at the Expo, 50 booth observations were included in the analysis.

Following the Expo, an online survey was sent to all exhibitors to understand their experiences with ASF and as science communicators. Survey respondents were informed that their responses would be kept confidential and would only be reported anonymously and in aggregate. A total of 100 Expo exhibitors (23% of those invited) participated in the survey. At the end of the survey, respondents were asked if they would like to participate in a 30-min virtual follow-up conversation. Based on availability, interviews were completed via Zoom with 11 exhibitors (79% of the 14 survey respondents who expressed interest), two of which were group interviews due to availability. Participants were offered a free ASF t-shirt, a common incentive in evaluation contexts used to encourage participation and thank them for their time. At the beginning of the interviews, participants were reminded that their participation was voluntary and their responses would be anonymized and kept confidential from festival leadership.

2.2.1 Mystery shopper protocol

Observations at the 2024 Expo were conducted using a mystery shopping protocol, including both fixed response and open-ended items, adapted from Peterman and Young (2015). With origins in market research (further described in Peterman and Young, 2015), mystery shopping observations were used to provide a structured method for data collectors to discreetly observe booth activities and interactions between Expo exhibitors and attendees. The protocol included items assessing the use of best practices identified in the literature for science communication at festivals, such as the use of hands-on activities, connecting content to a "big idea," and using real-world examples to contextualize science topics (Peterman and Young, 2015). Guidance for assessing these elements was provided within the protocol and discussed with data collectors during training to ensure a shared understanding of terms like "real world" and "big idea." Some items assessed logistical aspects of the Expo, such as wait times or the length of booth activities. A question was added to the protocol to assess data collectors' knowledge of the content in their booth. This modification was made to better contextualize ratings of the exhibitors' science communication abilities, but data collectors were instructed to assess the interaction as if they were unfamiliar with the content being presented. Some data collectors attended the Expo with their children, visiting booths together as a family. Thus, protocol language was modified to ask how exhibitors engaged with "you or your child."

2.2.2 Exhibitor survey

The authors developed a 20-item Exhibitor Survey to collect data on exhibitors' perceptions of their booth activities, communication practices, and impact. Some items were designed to gather descriptive information on the exhibitor's booth (e.g., type of hosting organization, activities conducted, their role at the booth). Other items assessed their years of experience as an exhibitor, sense of preparedness for the Expo, and past experiences and comfort with science communication. Fixed-response items assessed participants' perceptions of the extent to which their participation in the Expo resulted in possible new partnerships, collaborations, funding opportunities, and ideas for future festivals.

2.2.3 Exhibitor interviews

Interviews were conducted by two members of the evaluation team using a semi-structured protocol, designed to gather a rich description of exhibitors' experiences at the 2024 Expo. The protocol consisted of 10 questions that assessed participants' background and experience at the Expo. Of particular interest in this study are items that assessed their science communication experiences, both in their daily lives ("In your day-to-day life or work, how often do you have the opportunity to communicate science topics to the general public? In what ways does this occur?") and at the Expo ("During the Expo, did you feel you were able to successfully communicate your booth topic with attendees? Why or why not?"). Participants were asked to share any impacts of their Expo participation on themselves professionally or personally, as well as possible impacts of the Expo on the broader community.

2.3 Analysis

Quantitative data collected via observation and surveys were analyzed using descriptive statistics (e.g., frequencies, means, standard deviations). To identify potential patterns in science communication practices among exhibitors, both observational and survey data were disaggregated by booth exhibitor type (i.e., Educational Institutions, Organizations, and large Corporate Sponsors). Interviews were audio recorded and transcribed. All qualitative data were thematically coded by two members of the evaluation team to identify common themes within the data. For interviews, deductive analysis was conducted by one member of the evaluation team to generate themes based on the interview protocol. A second member of the evaluation team reviewed and verified the emergent themes. Findings from observations, surveys, and interviews were then compared, with the goal of informing best practices for engaging in science communication with large public audiences in informal settings.

2.4 Ethics approval statement

The data used in this study were initially collected for evaluation purposes, with considerations for participants' rights described above. The secondary analysis of anonymized evaluation data used in this research study was approved by the Georgia Institute of Technology Institutional Review Board.

3 Results

Almost all booth interactions began with exhibitors greeting the data collector upon arrival (90%) and interacting enthusiastically with the data collector (88%). This welcoming environment is important for helping festival attendees build curiosity and interest in science (Jensen and Buckley, 2014). At most booths, the science topic was conveyed via brief, hands-on activities (53%), a demonstration (15%), or both (24%). Hands-on activities lasted an average of 4 min, though some activities took only 30 s to complete, allowing only brief

opportunities for science communication at each booth. However, most of the observed activities were completed with guidance from exhibitors (71%), presenting frequent opportunities for dialogue between scientists and attendees.

Observation data indicate that exhibitors were generally knowledgeable about the booth topic (79%) and clearly communicated the booth's "big idea" (62%). With regard to specific science communication practices, exhibitors were able to connect the booth topic to real-world examples and avoid the use of jargon in most cases (Table 1). Exhibitors asked data collectors about themselves, their knowledge, or their interests in only about one-third of all observed interactions. Thus, the use of questioning, which is important for building connections to scientific content and ensuring understanding (Nisbet and Scheufele, 2009; Peterman and Young, 2015), was limited. Effective science communication practices were observed more often at booths hosted by educational institutions and organizations, compared to booths hosted by large corporations. For example, in approximately half of the interactions at educational institution booths and organization booths, exhibitors asked attendees if they had questions, but this occurred only once during interactions at large corporation booths.

On average, booth quality was rated as "good" ($M = 3.20$, $SD = 1.14$). Corporate sponsor booths received lower average quality ratings ($M = 2.92$, $SD = 1.08$), compared to educational institution booths ($M = 3.21$, $SD = 1.03$) and organization booths ($M = 3.37$, $SD = 1.30$). Descriptions of positive ratings often referenced the use of effective communication strategies, such as the use of questioning or a clear scientific message (Table 2).

Exhibitor Survey data were analyzed to understand exhibitors' perspectives of their preparation for and effectiveness of their science communication at the Expo. The sample was predominately made up of exhibitors who worked at booths hosted by educational institutions (57%) but also included exhibitors from corporate sponsors (23%) and organizations (19%). For half of the respondents, 2024 was their first year exhibiting at the Expo. Most respondents (76%) indicated that they were present for most of the Expo, working at least 4 h of the 6-h event.

On average, exhibitors agreed that they felt prepared to effectively communicate booth content at the Expo ($M = 4.28$ on a 5-point scale), even they neither agreed nor disagreed that they regularly communicate science topics to the general public in their day-to-day life or work ($M = 3.60$; Table 3). Compared to exhibitors at other booth types, exhibitors representing large corporations reported that they felt less prepared for the Expo, engaged in regular science communication less frequently, and felt less confident in their ability to communicate science with a lay audience. These findings support observation data in which corporate sponsor exhibitors engaged in effective science communication practices at their booths less frequently.

Interview data further contextualize exhibitors' perceptions of their effectiveness in science communication. Several participants identified previous experience with science communication, noting that it contributed to their booth's success. These exhibitors described sharing their knowledge with other exhibitors who had less experience with science communication. Even among experienced science communicators, there was a general theme of continued interest in improving science communication abilities. Participants saw the Expo as a venue for honing their science communication skills, with one sharing, "*it gets better every year. I felt like as compared to last year, I was able to make a better communication piece, and I was better able to interact with people.*"

Survey data revealed that exhibitors perceived positive impacts on their understanding of the local STEM community through new awareness, partnerships, or interactions with community groups (Figure 1). For 40% of respondents, the experience resulted in new professional collaborations. Exhibiting at the Expo inspired new ideas for future festival events in 53% of respondents, suggesting that at least half of the exhibitors felt compelled to continue engaging with ASF in the future. Most participants (76%) indicated they were 'not sure' if the Expo had resulted in new funding opportunities, which may be a product of the brief period in between the Expo and the survey administration (less than 1 month) or because festivals may not be an appropriate venue for securing new funding possibilities.

In interviews, exhibitors articulated the personal significance of participating in the Expo. A prominent emergent theme was that involvement in the event reinforced and revitalized their own interests in science. It offered exhibitors a unique chance to reinforce their STEM background, sharpen their knowledge, and share their interests, as one exhibitor stated, *"I love sharing science."* Another theme that emerged was a sense of altruism, as exhibitors witnessed the impact of the Expo on attendees, and particularly on children who attended, as in the following examples:

> *I have a lot of childhood memories of attending science festivals like this, and it's awesome to give back in this way. It makes me happy. It's a full circle moment.*
>
> *I think especially with Black and Brown kids who do not necessarily have the exposure to that. I think that is a huge opportunity for kids as well too. Really getting people to think about careers in a different aspect and science is fun. It's not just*

TABLE 1 Use of science communication best practices.

Did the booth team member…?	% Yes			
	All booths ($n = 41$)	Educational institution ($n = 17$)	Organization ($n = 17$)	Large corporation ($n = 7$)
Connect the booth topic to a real-world example?	70%	82%	63%	57%
Ask if you had any questions?	49%	65%	47%	14%
Ask you a question about yourself, your interests, or your knowledge?	45%	59%	41%	17%
Share something about his or her work with you?	43%	41%	56%	14%
Use jargon that you did not understand?	7%	6%	6%	14%

TABLE 2 Overall booth ratings and qualitative excerpts (n = 50).

How would you rate this booth overall? (%)	Why did you pick that rating? (illustrative examples)
Poor (8%)	The big idea was to learn about the school and a NASA program they are involved in. There was no activity just marketing and free swag for their school
Fair (18%)	Interactive components seemed good for kids, but content written at adult level. Lots of text. Presenters were just helping direct traffic rather than helping understand info
Good (34%)	The activity was building "bugs" from pipe cleaners with batteries to make their "eyes" light up. It was very interactive and all the kids near me were so excited. So although it was not informative, it was engaging
Very good (26%)	Knowledgeable, kid friendly, multiple activities, the skittles activity was great to explain radioactive decay
Excellent (14%)	Great job asking my knowledge about red and white blood cells and plasma and then filling any gaps in my knowledge. Great jobs using objects (beads) to represent blood cells and platelets using color and proportional sizes

> *textbook, it's a lot of interaction and touching and moving and things like that too.*

One exhibitor described "a *glow*" they felt after participating, elaborating that the event made them feel like an active *"part of [their] city."* Commonly, exhibitors shared that the opportunity to informally learn about science from different perspectives had a positive impact on the community, with one celebrating that "*there's three weeks where Atlanta is thinking about science.*" Themes around professional impacts mirror survey data, indicating that the Expo offered opportunities to develop new partnerships with schools, non-profits, and other companies through participation in the Expo. One interview participant shared, *"I can tell you that I've had some consistent relationships that are born out of the festival.… [The Expo] allows us to expand our network and our outreach in those places where we have developed relationships."*

4 Discussion

This mixed-methods case study offers insight on science communication at a large science festival event. Using Peterman and Young's mystery shopper protocol (2015) for observing festival interactions, we were able to document instances of science communication *in situ*, triangulating observations, surveys, and interviews. Findings shed light on the effectiveness of science communication at the 2024 ASF Expo and the impact of participation on exhibitors. Before sharing implications of the findings, we note limitations of the study. Purposive sampling of Expo booths for observations was conducted. While this approach generated a sample that likely was not representative of the full population of Expo booths, it ensured data were collected from a range exhibitor types, including educational institutions, non-profit or other organizations, and large corporate sponsors. Similarly, survey participants were asked to indicate their interest in participating in an interview. Because interview participants were self-selected, qualitative data are not representative of all exhibitor experiences. Another limitation is that we were not able to observe individual booths multiple times, providing the opportunity to assess inter-rater reliability. To address this limitation, efforts were made to standardize observational data collection by training data collectors in the use of the observation protocol. Protocol terminology was operationalized and discussed with data collectors to promote a shared understanding and consistent usage of the tool.

4.1 Effectiveness of science communication

Observation data indicated that most exhibitors engaged attendees through hands-on activities and demonstrations, similar to strategies used in other science festivals (Illingworth et al., 2015; van Beynen and Burress, 2018). This approach aligns with a public participation paradigm of science communication, promoting interaction between scientists and the general public (Kappel and Holmen, 2019). In providing overall ratings of Expo booth quality, data collectors identified aspects of effective communication that enhanced their interactions, including clear messaging, passionate exhibitors, and engaging activities. Some practices for effective science communication were more common than others. At most booths, exhibitors connected content to a real-world example and avoided jargon, but the use of questioning to promote dialogue or interest was limited. Both qualitative and quantitative data indicated that exhibitors generally felt confident in their preparation and ability to communicate scientific topics at the Expo, though this could be due to a self-selection bias, in which scientists with higher self-efficacy for science communication are more likely to participate in science outreach events (Bao et al., 2024).

Past research has emphasized the inclusion of scientists outside academia to help connect science content to real-world applications (Illingworth et al., 2015). At the 2024 Expo, booths hosted by corporate sponsors and organizations offered opportunities to hear about science from those who are not part of the academic community. In this study, exhibitors at these booths used effective science communication practices less frequently compared to exhibitors at educational institution booths or organization booths. This is reinforced by survey data, which showed that exhibitors from large corporations reported feeling less confident and prepared in their science communication abilities. Thus, while training is recommended for anyone attempting to engage in effective science communication (Peterman and Young, 2015), our data suggest it may be especially crucial for non-academics participating in science festivals.

4.2 Impact on exhibitors

While much of the literature cited above considers the impact on attendees, our study explored the impact on exhibitors themselves. Survey and interview data suggest that exhibitors generally felt

10.3389/fcomm.2025.1622230

TABLE 3 Exhibitors' perceptions of science communication ability.

Item	*M* (*SD*)			
	All exhibitors (*n* = 97)	Educational institution (*n* = 54)	Organization (*n* = 19)	Large corporation (*n* = 24)
I felt prepared to effectively communicate booth content with Expo attendees.	4.28 (1.06)	4.37 (0.88)	4.32 (1.11)	4.04 (1.37)
I feel confident in my ability to give a science talk to a lay audience.	4.02 (1.03)[a]	4.11 (1.02)	4.11 (0.99)	3.74 (1.05)[b]
In my day-to-day life or work, I regularly communicate science topics to the general public.	3.60 (1.20)	3.65 (1.15)	3.95 (1.31)	3.21 (1.41)

Participants rated their agreement on a 5-point scale, from 1 (strongly disagree) to 5 (strongly agree).
[a]*n* = 96.
[b]*n* = 23.

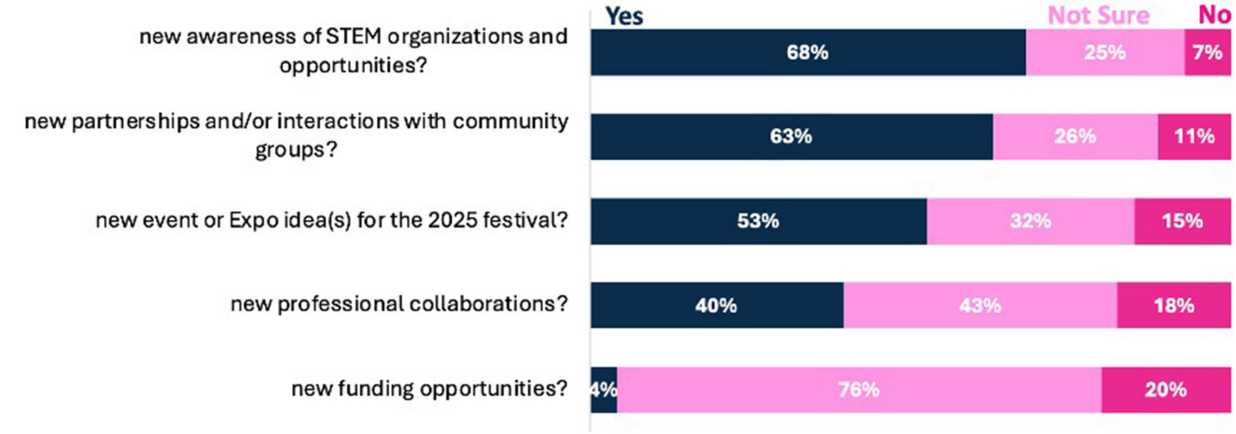

FIGURE 1
Impact of expo on exhibitors.

well-prepared and confident in their science communication abilities, with lower perceptions of confidence and preparedness among exhibitors at corporate sponsor booths. Many exhibitors reported that their participation in the Expo reinforced their STEM knowledge and provided a unique opportunity to share their passion for science with the public. Science festivals can have a positive impact on the broader community (Frew and Makua, 2023), which Expo exhibitors noted was a valuable aspect of their own participation in the festival. Witnessing the positive benefits for students and communities had an altruistic impact on exhibitors, allowing them to give back to the community and inspire the next generation of scientists. The formation of new networks and partnerships as a result of the Expo further highlights the benefits for exhibitors in building collaborative relationships within the scientific community, as discussed by Peterman et al. (2020).

4.3 Implications

Interactions with scientists at science festivals have been shown to positively influence attendees' learning and enjoyment (Boyette and Ramsey, 2019), underscoring the importance of supporting festival exhibitors in their science communication efforts. The 2024 ASF Expo offered a valuable case study for examining science communication through a mixed-methods approach. The findings of this study have several implications for those involved in planning science outreach events. First, individuals at universities or non-profits may be well positioned to participate in science communication at outreach events like science festivals, due to the experience they have with science communication in their day-to-day work or lives. Recruitment efforts could focus on educational institutions and organizations (non-profit or otherwise) when looking for exhibitors. Second, providing comprehensive training on effective science communication techniques is crucial. This training should emphasize the importance of clearly conveying the "big idea" of their exhibits and using interactive questioning to engage attendees, as recommended by Peterman and Young (2015). This may be especially helpful for volunteers who are less practiced in communicating science, such as scientists outside academia. Third, our study highlights the use of a public participation approach to science communication, leveraging hands-on activities and demonstrations. Future festivals should continue to prioritize these

interactive methods while exploring new ways to enhance attendee engagement, in line with the recommendations of Illingworth et al. (2015) and van Beynen and Burress (2018). Finally, the positive impact of the Expo on exhibitors underscores the importance of creating opportunities for scientists to engage with the public, especially communities often underrepresented in science. Future researchers may consider using a critical lens when exploring effective science communication. Science festivals not only benefit attendees but also provide valuable professional development for exhibitors, reinforcing their communication skills and fostering a sense of community.

Data availability statement

The datasets used in this study are not readily available because they are part of a larger evaluation agreement between the Georgia Institute of Technology and Science ATL, which includes confidentiality protections for participating exhibitors and staff. As such, the data are not publicly posted, but they can be shared with qualified researchers upon request, pending IRB and funder approval. Requests to access these datasets should be directed to katie.king@ceismc.gatech.edu.

Ethics statement

The studies involving humans were approved by Georgia Institute of Technology Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

KK: Writing – review & editing, Formal analysis, Resources, Writing – original draft, Data curation, Methodology, Investigation, Conceptualization, Supervision, Visualization. TK: Writing – review & editing, Formal analysis, Resources, Writing – original draft, Data curation, Methodology, Investigation, Conceptualization. KN: Resources, Data curation, Formal analysis, Writing – review & editing, Investigation, Writing – original draft. MA: Project administration, Methodology, Conceptualization, Funding acquisition, Supervision, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This work was funded by Science ATL. While the funders collaborated with the authors on the development of the initial Exhibitor Survey used as part of a larger evaluation, they had no role in the design of the secondary analysis presented here, nor in the interpretation of results or the decision to submit this manuscript. The authors acknowledge their proximity to ASF as an evaluation partner and have taken measures to ensure the independence and rigor of the analysis. The funders reviewed the manuscript only to confirm the factual accuracy of program descriptions.

Acknowledgments

We would like to acknowledge the Atlanta Science Festival Leadership team, including Meisa Salaita and Jordan Rose, and 2024 evaluation data collectors for supporting the evaluation effort.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

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