Impact of Teen Science Cafés on Scientists

Results of Phase 1 Qualitative Study

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Introduction

The Teen Science Café Network (TSCN) is a community of practice that provides high quality resources and support to organizations that implement a Teen Science Café. The network was formed in 2012, with support from NSF, to create and support a national network to support the start-up of Cafés at new sites and create a community of practice. As of early 2017, the TSCN represented 66 sites in 33 states, established by a wide range of institutions – from museums, to libraries, to schools, to after-school programs, and beyond.

The Teen Science Café model incorporates Youth Leaders who guide program design, speaker selection and vetting, and highly interactive programs that incorporate activities to engage teens. Past evaluation of this model has provided robust evidence to demonstrate the significant impacts of the program on teen participants' attitudes toward science, scientists, and careers, as well as a sense of belonging and connection with the Café (Hall, et al., 2013).

These evaluations focused on the impact of the program to teens and on preliminary understanding of the strengths and challenges of the essential components of the Teen Science Café model. To this end, scientists were incorporated as informants in focus groups, reflecting on the benefits and challenges of being part of a Café. However, the study did not focus primarily on the impact and experience of scientist-presenters. Few published studies have directly addressed questions of impact on scientists within adult Science Cafés, much less within Teen Science Cafés. A report commissioned by AAAS analyzed the foci of evaluation instruments in Public Engagement with Science (PES) programs and found that scientists were less often studied, and when they were, measures were mainly satisfaction and the type of experiences, rather than impact (Peterson & Robertson, 2015).

The present study was designed to address this gap in evaluation and research literature and improve understanding of experiences and motivations of scientists participating in Teen Science Cafés, and the impacts they experience within this distinctive type of PES. It will take advantage of the Network of sites to understand the impacts on scientists based on a broad and diverse set of institutions, scientists, and geographic locations nationwide.

Research Questions

What is the impact of Teen Science Cafés on the scientists who participate?

1. **In what ways, if any, does mutual learning take place? To what extent is this an outcome across scientists?**
2. **To what extent do scientists experience other types of impacts?**
3. **How are scientists' experiences with teens different from engagement with other types of audiences?**
4. **What is the perceived value of preparation received in advance of Teen Science Cafés? Is there evidence of a relationship between value and the nature of preparation activities?**

The guiding research questions for the full, two-phase study, are presented in the box, above. The study takes particular interest in the ways in which "mutual learning" occurs within Teen Science Cafés. This term is common in definitions of PES (AAAS, 2016; McCallie, et al., 2009), and it highlights a contrast between PES and other communication models, focusing not on one-way transmission of information to publics, but on ways that scientists learn from the knowledge, perspectives, and expertise of the publics with whom they interact. Conceptually, this impact includes influences on how scientists approach their work, what questions they choose to focus on, how they understand their work and its relevance to public views, and/or how they view or trust publics.

About Mutual Learning: Mutual learning is a critical part of the definition of PES, and yet, the nature of these types of impacts and how often they occur has not been well studied. Anecdotal reports among PES practitioners suggests that this view of impact from public engagement is not always resonant with scientists (many of whom subscribe to a model of one-way transmission of information). Recent studies have shown resistance among scientists to the concept of framing as a communication objective or technique that takes audience views into consideration when thinking about how to talk about science (Besley, et al., 2015; Dudo & Besley, 2016). It is in this landscape, and with anecdotal reports by Teen Science Café organizers, that we sought to complete a systematic study of whether such impacts occur in this setting; and, if they do, what types of mutual learning occur and (later) to what extent is this an outcome experience recognized by scientists across the national network of Teen Science Cafés.

A Note on Language: Throughout this report we will use the term "scientist" to refer to all of the science professionals who participated as presenters in Teen Science Cafés. It is important to clarify, however, that not all presenters would identify or characterize themselves as "scientists," as the term may connote a research scientist. While many are researchers or professors, some represent other types of STEM professionals (e.g., physicians) or professionals for whom STEM is critical to their work (e.g., first responders in a rural community). We use the term "scientist" for convenience, but the diversity of these professionals should be kept in mind.

Methods

To answer these research questions fully, the study will use a two-phase, sequential mixed-methods approach. Phase 1 (this report) uses in-depth interviews with a purposeful sample of participating scientists from a range of TSCN sites. Because the constructs of impact on scientists, particularly mutual learning, have had relatively little study, this phase was critical to establish a rich portrait of the full range of experiences and outcomes of scientists directly from their own words.

The analysis and results of Phase 1, including the trends, language, and breadth of scientists' descriptions will be the foundation for the quantitative research phase. In Phase 2 (planned for Fall 2017), a survey instrument will be constructed, based upon these results, and administered to the full population of TSCN scientists. This broad, structured survey will allow us to understand the prevalence of the experiences and outcomes – how common or uncommon they are – across the full population of scientists.

Phase 1 Methods

We used telephone interviews with 18 scientists from seven sites across the TSCN. Interviews were semi-structured, with a set of guiding questions and core topics, but conducted with the freedom for conversation to flow naturally with the scientist's description of his/her experience.

The interview guide (Appendix A) had four major areas of focus:

- **Impacts**: personal impact/benefit experienced by the scientist, with a targeted exploration of mutual learning and what felt unique about a teen audience
- **Motivations**: reasons for wanting to participate, with particular interest in influence of teen audience
- **The Experience:** scientists' view on the overall experience, from preparation to in-Café; emphasis on the value of preparatory activities and areas for improvement
- **Basic Background:** especially other outreach activities, prior communication training

Recruitment & Interview Procedure

Seven TSCN sites volunteered to identify a few scientists with recent Café involvement (i.e., the current or prior year) as candidates for interviews. Site leaders made initial contact with scientists to invite them to participate and introduce the research team. From the invitation, scientists used an online calendar to directly schedule a time for a one-on-one telephone interview.

Each interview lasted about 30 minutes and were audio recorded (with permission from the scientist) and transcribed. If/when recording was not possible, manual notes were taken instead, capturing verbatim quotes as much as was possible.

Analysis

Researchers used an inductive process to develop a coding system to analyze transcripts. The code book was a system of categories and sub-categories that reflected common themes and patterns that emerged across the qualitative dataset. At the highest level, the structure aligned with the four areas of focus (Impacts, Motivations, Experience, Background); sub-code structures were developed as themes emerged from the scientists' responses.

Transcripts were carefully read and excerpts were identified and coded into the appropriate code expressed by the scientist. After developing an initial code book, the researchers independently coded a single interview, and then reviewed areas of discrepancy and revised the codebook to address these areas. This process was repeated with codes and definitions that needed to be refined until consensus codes and definitions were established and agreed upon by both researchers.

From this analysis, results present the full breadth of themes that were present across the interviews. While we will discuss themes being more or less common, these statements should be considered cautiously. These interviewees were not conducted to be generalizable to the full TSCN population (neither a census nor a random sample), but were purposefully selected from several research-interested sites. Phase 2's survey, including the full network will provide a more robust answer about which of these themes are more and less common across all TSCN scientists.

Study Participants

Eight sites from the TSCN were contacted to provide names of scientists for study recruitment, all of whom had indicated prior interest in participating in network-wide research. From those, 18 scientists from seven sites participated in interviews. Table 1 shows the sites, locations, and number of scientists per site who ultimately contributed to the study.

A total of 24 scientists received invitations to participate in the study, with a response rate of 75% who completed interviews. Of 18 interviewees, ten were female, and eight were male. Most of the participants were researchers either in academic, government, or private settings. A couple had applied STEM careers in the field of medical science and GIS technology. Of the researchers, their fields of study ranged widely, including space science, neuroscience, biology, geology, computer science, epidemiology, and nuclear engineering.

Table 1. Participation in interviews, by site

Site	intvws
Cafe Scientifique (New Mexico)	3
Explora Science Center (New Mexico)	3
Teen Science Café for ME! (Maine)	1
Morehead Planetarium & Science Center (North Carolina)	3
North Carolina Museum of Natural Sciences	3
St. Louis Science Center	2
Texas State Aquarium	3
TOTAL	18

Prior Outreach Experience

The interviewed scientists were largely experienced at doing outreach. Nearly all interviewees (16, 89%) had participated in some sort of field-related outreach prior to participating in the Teen Science Café. The types of outreach varied, but **the most common type involved school-based settings, working with K-12 audiences** (12, 67%). Examples of this included: teaching science at a middle school, creating science kits or workshops for teachers, developing curriculum, giving presentations at schools.

A little over one-third of interviewees mentioned prior experience with family-focused outreach, such as tabling activities at local museums, science festivals, or informal learning venues. A few indicated they do face-to-face outreach with adult audiences, which included lectures, tours, or talking with community leaders. A couple had participated in broader media outreach, such as appearing on radio or television programs.

Only three indicated previous focus on outreach for teens, but for most of the interviewed scientists, teens had not previously been an audience of focus for their outreach. Those who had talked about leading mentored research opportunities for high schoolers and doing issue-related outreach (e.g., the dangers of binge drinking).

Prior Communication Training

Due to this experience, most scientists felt fairly skilled at outreach before their Teen Science Café, yet only a third (6, 33%) indicated having formal communication training. This included formal teacher preparation, work-sponsored workshops, and involvement in other outreach (such as Portal to the Public). Of the other two-thirds, six said they had no prior training and six reported they felt that they had been "trained" through the experience of doing outreach, such as this scientist:

> *"No, nothing formal. Just having to teach for a handful of years, trial by fire, getting up in front of people and figuring out what gets the point across effectively" (Interview 2).*

Results

Scientist Motivations

As we reviewed the patterns in the qualitative data, scientists' descriptions of their reasons for getting involved with their Teen Science Café shared characteristics with existing conceptual frameworks for understanding volunteer motivations in other settings (for example, citizen scientists). We used these frameworks as a grounding to create our coding, which included:

- Intrinsic motivations: enjoying outreach generally, liking teens, and wanting to improve skills
- Norm-oriented motivations: extrinsic motivators, such as a requirement by a job, boss, or funder
- Collective motivations: the feeling that this is important work, for the benefit of the public, society, or the teens
- Personal history motivation: that this kind of opportunity was either unavailable or deeply impactful to the scientist when he/she was a child *(note: this concept is not drawn from other volunteer literature)*

Most scientists expressed multiple motivations for participating in the Teen Science Café, with most mentioning two or three different categories.

Collective Motivation: Importance

The most commonly mentioned theme was a collective motivation – participating because they believe in the importance of doing this type of outreach; 14 scientists (78%) indicated this was one or their only motivation. In their responses, they typically talked specifically about the importance of this work in relation to the teen audience, rather than about the general value of outreach. They viewed teens as being at a critical life-stage, where they might have a positive impact.

Within this, three sub-themes emerged to describe the ways scientists articulated their view of the why participation was important (and motivating): building the STEM pipeline, being a role model, and the relevance of their field to societal change.

The importance of building the STEM pipeline and encouraging youth to enter the field was the most common framing of a collective motivation; ten scientists (56%) stated this motivation. Descriptions related to the opportunities at this life-stage, how informal experiences can provide new opportunities to students, and the excitement in the scientist of thinking about inspiring the next generation.

> *"I just think it's a little bit easier to connect sometimes with students who have a lot of options open to them. They don't have a college major yet. They're thinking about the future, and so I want to help them add science to a possible future" (Interview 10).*

> *"You go in and you get to share with them and encourage them to be that next cadre of scientists. So that's fun. That's part of my mission in what I do…" (Interview 15).*

> *"I really think there's great value in informal science education especially for people who are potentially receptive to going into science as a profession…I feel very strongly that the opportunity to connect some of this scientific understanding with young people who are interested in it in a way that they can touch it and get up close with it and think about it on their own terms is very important, and I think that's what the Teen Science Cafe aims to do" (Interview 8).*

Another sub-theme were scientists who saw the opportunity to act as a role model to help more (and more diverse) identify with a scientist. Five scientists (28%) expressed this sub-theme of the collective motivation. It included female scientists wanting to illustrate the possibility of who can be a scientist, and others who described wanting to help shift perceptions of what a scientist and scientific fields are.

> *"As a female engineer, I am always interested in being out there and being a face for hard science and engineering, particularly to show diversity. I'm the only female in the front office [at my institution], and I'm the only female within about 40 members of our tech advisory council. There's just not enough females going into some of these hard sciences still, and so I find it personally important to make time and be out there as much as I can when asked" (Interview 9).*

> *"It's an informal but interesting way to talk about what I do and show that all science isn't just white lab coats and iPads. I think it's interesting to show some of the other faces of science and get people interested in geology" (Interview 11).*

> *"I really liked the idea of kind of demystifying what a scientist is and making myself available to secondary school-age students to ask anything really" (Interview 10).*

Finally, a few scientists (3, 16%) talked about the importance of their outreach to motivate change or have societal benefit via communicating about their specific field. This could include environmental issues or social issues (such as binge drinking), but the tone of responses was not a motivation to communicate information as much as the possibility of prompting action and societal benefit.

> *"So I feel like our area of research is fairly interesting to the general public, and part of the way we can start to address the issue of marine debris and plastics in the ocean is to actually get out in the community and talk with folks that have an ability to reduce the amount of debris that we put in the environment. A lot of time it starts with teens or schoolchildren" (Interview 4).*

Personal History Motivation

This category emerged entirely from an interesting pattern in these interviews, and is not a common motivational category in the frameworks we considered in this analysis. Four scientists (22%) expressed that they were motivated to participate in hopes of replicating a personal science experience they'd had as a child or because there had been an absence of such experiences available to them. This category may be closely related with the collective motivations (giving back), but they were distinctive in the fact that multiple interviews framed their thinking relative to a personal experience had in their own youth.

> *"…that's why I'm a scientist. My parents took me to an outreach event when I was seven years old and it was for Haley's Comet and that's why I do space science. Somebody let me look through their telescope. So I know that one person can really change the course of someone's life if you do it right" (Interview 10).*

> *"I grew up in a small town and we didn't get a lot of opportunities to do things like what we did with the teen café. We didn't have a university within an hour of us. It was really hard to get exposure to research and other ideas. So being able to go out in the community is something I want to give back and do as a faculty member" (Interview 4).*

Intrinsic Motivation: Personal Benefits

Several different sub-themes comprised the intrinsic motivations of scientists. These motivations are all things that focus on a benefit experienced by the individual scientist, which included enjoying/liking outreach or working with teens (i.e., it's fun) and the opportunity to improve their skills.

Of these most were motivated because of personal enjoyment (9, 50%) either of outreach in general or of working with teens. Seven scientists' comments reflected a sense of generally enjoying outreach – that teaching and interacting with the public is simply something they want to do. While five scientists described wanting to interact with teenagers specifically, as a motivation to do the Teen Science Café.

> *"I like the research side of it all, but the education side is more fun." (Interview 15)*

> *"I'm kind of looking for a way to - even if it's a one-off thing - get in front of people and do a little more outreach and explanation of what we're doing." (Interview 2)*

> *"I really like teenagers. I think that they're awkward but they're hilarious" (Interview 6).*

> *"I was much more interested in doing the Teen Science Café than I guess the general Science Café." (Interview 3)*

The other area of intrinsic benefits was the desire to improve their skills, which was mentioned by four interviewees (22%). All four framed the skill-development in terms of facing the "challenge" of preparing for a teen audience as a motivating reason to participate.

> *"It makes me think out of the box. They haven't had as much science as someone that's been through college or has four years life experience. So it makes me take a step back as a scientist and go back to the basics and remember that I have to explain, well, why do we tag this species and not that species…that's a little bit of a selfish reason!" (Interview 1)*

> *"I thought it would be challenging. I felt like crafting a talk that makes sense to such a young and broad audience would really challenge me in many, many ways." (Interview 17)*

Norm-Oriented Motivation: Required

This category encompassed **motivations that were extrinsic, driven by norms or expectations of the scientists or his/her job. Only three interviewees brought up this area** of motivation (17%), and all of them focused on requirements with in grants or encouragement by the institution to do outreach as part of their work. For none of these was the extrinsic motivation their only reason for participating; they tended to describe that the requirement dovetailed nicely with their other interests and motivations for participating.

> *"…it's a grant-funded activity, is to do some outreach for our center. … As part of my job, I do a variety of outreach to children, to families, to parents, and so that's something that I'm interested in doing. Because it's grant-funded, every time I do speak with a group, I write it down and report it on a progress report for the grant. So I'm looking for [opportunities]." (Interview 7)*

Other Motivations

No other categories emerged from the responses, although there were two other scientists who had isolated comments about reasons for participating that didn't fit into one of the above themes. These included being attracted to elements of the structure of the Teen Science Café. One mentioned that the Café provided "a captive audience… that was voluntarily showing up to hear about that topic" as an enticement, while another liked the inclusion of an activity, rather than just a presentation.

These types of structural motivations may be worth considering for inclusion in the final survey, in case they are more prevalent in the larger population. These motivations suggest that the structure the Café provides – managing an interested audience or facilitating activities – could be part of what draws some scientists to these opportunities.

Impacts on Scientists

A major focus of this study was to understand the impacts experienced by scientists, which were explored by asking them to discuss any benefits they felt they received as a result of participating in the program. Within that the interview probed into specific areas that were of interest to the study, such as mutual learning, communication skills, and interest in future outreach, to see if and how scientists described these impacts.

Mutual Learning: Professional View

As described earlier, one aspect of mutual learning impacts is that a scientist comes to think differently about his or her work. It is a goal of many PES activities, but one that is not well understood. Upon probing into this area in interviews, we found that 13 (72%) of the scientists articulated an experience of mutual learning related to their professional view. Within this, the comments were grouped into three sub-themes, which represent a continuum from the most to least impact on the scientist's work:

- Think differently about my own work
- Understand how publics think about my work
- Think differently about how to talk about my work to publics

Five of the scientists fell into the first group, reporting that participation prompted them to actually think differently about some aspect of their work. These comments included seeing a bigger picture perspective on their work, seeing new ways of approaching questions, seeing how tools they created work with publics, and creating new research opportunities to involve teens in their lab. One comment even described these experiences helping to find errors or problems, including a very concrete example (although the example was from a different public engagement program, not the Teen Science Café).

"Well, sometimes the really obvious stuff is so obvious, and you sit around asking specific in-depth questions. And you, it's like common sense gets set to the side. And so when you have to zoom all the way out to the big picture, then you start realizing the similarities or the glaring obvious things that you lose in the lab because nobody's talking about the big picture. And everyone's just talking about a tiny protein that's misfolded or something. So it just gives you a perspective. And just the process of making the slides or trying to explain the origin and our understanding of epigenetics is really good for me." (Interview 6)

"And you know honestly having the kids mess around with this data, I just gave a talk yesterday and was able to give an actual number, a rough estimate of how many minutes, which was seven minutes, on average would add to the ambulance ride to go around the flooded areas. So that actually allowed me to get—you know I hadn't done a systematic test but it allowed me to get a sort of general estimate, which is kind of cool too" (Interview 14).

"Seeing how these teenagers were approaching some of these hard questions, and how they were applying some critical thinking, you know, made me question some of my colleagues when they failed to do the same thing. The adult brain works differently than the teenage brain." (Interview 5)

"It forces us to go back to the basics. And many times we've gone back and had to explain something that, again, somebody who's been through college or has 40 years life experience would already know. Having to go back and re-explain that to somebody forces to us to re-evaluate our experiments sometimes, and we've caught many flaw that way as well. …Someone asks you a question and you're like, 'Maybe we should go back and check that.' (Interview 1)

Six scientists fell into the second group, reporting that the experience gave them a new perspective – in particular, a teen's perspective – into how the public thinks about their work. This is also a critical element of mutual learning and developing mutual respect between scientists and publics, as scientists come to have new insights about how their work and its relevance is perceived.

> *"The main benefit was getting the chance to talk to these kids and hear what they're thinking, hear how they're consuming a lot of the news that's coming down about these missions and about [space] exploration in general. Hearing how they think about some of the questions that the adults ask and give very, very different answers about; and the question in particular I'm thinking of is, 'Why do we bother? Why do we invest, why do we spend money and time in space exploration?' Adults view that very, very differently than particularly teenagers do." (Interview 5).*

> *"…Getting out of our little academic world and understanding what people who are not scientists are thinking and the questions they want to know and the confusion they have. Like where are we doing a bad job with explaining? …So I feel like it helps me understand a lot more like what the questions and the interests of people who are outside of my community have, which becomes really important when you try to explain why we should spend our tax dollars on my research." (Interview 10)*

> *"I think in general, I've been thinking more about how does work really matter to the general public? And how can I get them interested in? Then Teen Science Café was one way for me to sort of see, well, do people here in [our state] that doesn't have mangroves, are they still interested in wanting to know about these ecosystems? Do they really care? So it was a good way to sort of get my feet wet in testing that out a little bit." (Interview 3)*

Nine scientists' comments fell into the third category of mutual learning in the professional realm. **These scientists described that the Teen Science Café experience prompted them to think differently about how to talk about their work.** These comments reflect a significant overlap of two types of impact – mutual learning and communication skills – as the scientists are describing how they improved their ability to communicate with non-specialist audiences. However, these comments did not reference general communication skills, but specifically articulated an improvement in the ability to talk about or describe their research or work in ways that were meaningful to public audiences.

> *"It just made me take a step back and really think about the easiest and clearest way to explain my research so that really anyone could understand it. Because tailoring it for a high school student really tries make it intelligible for anybody at that point" (Interview 3).*

> *"I think it's a really good exercise to try to express science and the scientific process and the ideas behind scientific research in a way that is understandable or at all interesting to specific audiences. So I think it's a good challenge and it's a worthwhile one, as a scientist, to try to stretch yourself to really be able to use the vocabulary and the interest of a specific group and to be able to frame your research and its importance in a way that is specific towards the audience." (Interview 11)*

> *"So when I get questions – so when people are confused by something I say, I'm like, oh, that's when I'm slipping back into like nerd talk or something. [I ask myself] how can I come up with a better way to explain this?" (Interview 10)*

> *"But I am, I think, almost constantly now thinking about how to frame and how to communicate all of the different things that goes on in my lab to broad audiences." (Interview 17)*

Mutual Learning: Views of Teenagers

Another aspect of mutual learning that was explored related to the importance of building mutual respect between scientist and public audiences. In the case of Teen Science Cafés, we examined whether the experience had any impact on scientists' views about teenagers, after this opportunity to interact with them so closely. As with professional mutual learning, the responses that fell into this theme fell into three sub-themes of the nature of the impact:

- The depth of teens' knowledge and thinking;
- Aspects of teens' lives, experiences, and worldviews;
- Surprise at how engaged teens were in the Café or science content.

Thirteen of the 18 scientists interviewed (72%) described a realization or awareness of at least one of these themes during interviews about the Teen Science Café.

Six of the scientists specifically noted that the teens at the Café showed greater depth of knowledge, critical thinking skills, or topical insights than the scientist might have expected. In many cases, the scientist seemed aware that the Café attendees were a self-selected group, and may not broadly represent all teens; however, the interaction did influence their perception and understanding of the knowledge and intellectual abilities of this sub-group of teens.

"That's one of the things that really impressed me about them, is they weren't taking a lot of what they had read or heard on TV at face value. So, one of them point blank asked me, do you think what Elon Musk is saying about SpaceX going to Mars, do you see that as possible? And you know, they were already starting to question; [there was] some critical thinking going on there that was a little bit surprising." (Interview 5)

"I guess it reinforced that these teens, especially this group, I think, had more poignant, insightful questions than many adults that I talk with on a daily basis. It reinforced that if you're motivated, it doesn't really matter what your age is. You can kinda figure out some complex issues." (Interview 2)

"But these teens, it was just you know lots of hands and lots of questions and all the questions were good. But some of them were at a level that I would expect to come from colleagues at a conference." (Interview 15)

"Some of the questions [teens raised] were related to the idea of antibiotics resistance, so that the more antibiotics that we administer, the greater the chance that microbes will evolve resistance to them. And, of course, the research that I was describing, the goal of this is to identify new and more potent antibiotics. And so, some of the students recognized that there are some societal and regulatory issues that are to be considered when we develop antibiotics. I thought that was really incredible." (Interview 17)

Gaining an even broader perspective, **a few scientists described that the Teen Science Café raised their thinking about aspects of teens' lives and experiences.** A couple of these comments focused on gaining perspective on teens' academic lives – impacts from testing or fear of failure. One scientist noted a difference in teens from adults related to open-mindedness.

"I guess I think it was really interesting to see which students were the most willing to jump in and talk and which ones weren't and why. [At one setting] I noticed that the kids were a lot more hesitant to ask - I'm gonna put quotations around this -"crazy" questions, because those kids know that they should know things, and if they don't, they're afraid to ask because [they are from] a very affluent school system. But [at a less affluent site], those kids were not embarrassed to say anything. They were like "What's an isotope?" I'm like that's a great question because if you don't know what an isotope is, then the rest of this isn't gonna make any sense. …they don't know that they're supposed to know what an isotope is, and who cares, right? Like they don't feel embarrassed." (Interview 10)

"I'm a little out of touch with what modern teenagers are looking at media-wise, what they're thinking about, what's on their minds, what's in their sort of cultural wheelhouse. The dry runs for this and the actual event really exposed me to more of sort of their cultural affinities. I also learned about what their exposure to some of the sciences and school. …they spend so much time on test prep and worrying about things like college entrance and exams…. I'm sorry to see most of the changes that I think are happening, but nonetheless it's important to realize their experience is different from my own. (Interview 8)

"There's a lot of preconceived ideas that are based more on political ideology than anything else. But these students, they didn't have that. So that would lead me to believe that the next generation would be more informed on these topics. I hope so anyway." (Interview 15)

Finally, the most common sentiment expressed in this category represented a less fundamental shift in how scientists viewed teenagers. **Seven reported being at least somewhat surprised at the teens' level of engagement, interest, or enthusiasm within the Café activities.** Again, it was often noted that the Café attendees are a self-selected group, but each response indicated some level of surprise at the teens' level of their engagement or their behavior in comparison with other audiences they have worked with. This included how enjoyable that could be for the scientist, as well.

"[I learned] that boy, if you really hook 'em and they really engage, it's really super fun" (Interview 12).

"I was really happy with how they wanted to talk with us and interact, and they weren't scared to communicate with us. I feel like sometimes high schoolers are a little shy around college students or grad students and faculty…but they were very good, and it was enjoyable to interact with them. And it wasn't a struggle like it could have been" (Interview 4).

"These are probably some of the more interested teens in some of the outreach events I've given. So obviously, that helps increase my point of view or my perception of their motivation, when I have teens that are more highly involved or have questions. Versus you give a 20-minute talk, and everybody just sits there and stares at you." (Interview 1)

"I didn't expect that they would provide so much feedback. I didn't think it would be as interactive as it was. I guess what I'm used to is lecturing to you know like stuffy old academics and professors or even PhD students sometimes are falling asleep. And I just didn't expect it to be so much fun actually. It was really great." (Interview 15)

Communication Skill Improvement

Whether scientists felt participation improved their communication skills was another area of interest, which the interview guide asked scientists to consider. As noted in the results for mutual learning, some responses to these questions expressed both improvement in communication skills and an audience-specific perspective on communication. Other scientists talked about impacts on their skills without the overt focus on teen audiences. **Together, 13 scientists (72%) described these types of impacts on their communication skills.**

As presented earlier, nine discussed learning new ways to talk about their professional work/field. Eight scientists discussed other ways their communication skills improved from the Teen Science Café. Most of these comments referred either to the skills of honing and focusing a message or to building skills specific to working with a teen audience.

> *"Well there's nothing that really gets you to focus on the true information value of something like the process of putting together a program for the general public and you know a program for younger people whose backgrounds are widely different and who aren't on a career trajectory necessarily into science but might be interested. You know something like this really makes you focus on you know what elements do you want to include? What essential communication that has to go into this program and what could be left out? What should be left out? How to not overwhelm it?" (Interview 8).*

> *"I think it probably enabled me to talk better with teenagers than I did before. I have very good communication skills already, so I don't know that it helped me so much on that. I present a lot at lots of different venues. But I think kind of talking to the teens and listening to their feedback, it kind of gave me different ideas on how I could potentially address that population more effectively." (Interview 12)*

> *"it was good to talk with teens as opposed to younger kids or parents because that keeps me kind of flexible." (Interview 7)*

Another three scientists responded positively to the question about communication skills, but did not provide any tangible explanation of how their skills had improved. These responses included focusing on the benefit to others, rather than themselves or generalities about the importance of practicing.

Intention to Use Communication Tools

Related to impact on skills, was a theme seen in six of the interviews, in which **scientists expressed that they were walking away with high quality communication tools, approaches, and activities that they intended to use again** in other outreach or communication events (5, 28%). These comments suggested the Teen Science Café had provided some scientists with a "model" for future activities and that the process of developing, testing, and finalizing messages, activities, and ideas that was very useful in future activities.

> *"I'm supposed to go talk to a public audience on [an upcoming date] and I look back on this experience as sort of a model for how to prepare even though I won't have the same resources available to me [at that event]." (Interview 8)*

> *"I actually have tangible products that I can use in the future—so I have this 20-minute slide deck that I've actually already reused for the outreach activities, so I think that's been really fantastic as well" (Interview 17)*

> *"What's useful is setting up and getting another nice high school-level public release briefing that's very science-y but with lots of interaction and films, because we have that material [from the Café]. …When I got back and was turning in the equipment, the outreach program [at my organization] of course wanted a copy of my briefing. They actually want a write-up, too. So they're trying to use the data from this also and find all the other programs that they can to coordinate with [to use these materials]." (Interview 9)*

Intentions of Doing Future Outreach

Another area the interviews explored specifically was whether scientists felt that the Teen Science Café had impacted their intentions around doing outreach. **Nearly all of the scientists (16, 89%) indicated that they felt they would be willing to do more or different types of outreach experiences following this experience.** Most of the more specific comments focused on the interest in doing further outreach work with teens and/or with the Teen Science Café, having had such a positive experience.

Most of the scientists already participate in various types of outreach, and many of these articulated this impact as reemphasizing their commitment to outreach and adding an interest in focusing on teen audiences.

> *"I guess I would be more willing to do things with that particular age. You know the medical field is very kind of defined. After you get into medical school, you know the medical people have their own community and they have their own outreach things to med students. But you know I think there is a lot to be said for either outreach to folks that are even younger and earlier than that, in college age and even in high school age students. So yeah, it would make me more willing to, at least definitely more comfortable, in doing outreach with teenagers." (Interview 13)*

> *"I already do quite a bit of it…but it certainly made me want to go back to that particular venue and that particular group" (Interview 5).*

> *"Yes, definitely. I'm actually trying to start a citizen science project where part of it is tailored to working with high school students." (Interview 3)*

New Connections and Partners

In a related theme, a few scientists noted specific instances of how connections made through the Teen Science Café – whether with the site/organizers or the teen audiences – that had already led to new or expanded public engagement opportunities. In one case, a scientist was partnering with a site for an art-science showcase involving one of his undergraduate classes, while another was recruiting teens from the Café to participate in lab experiences at their institution.

> *"And meet people at I guess institutions like the aquarium that have an interest in your research and develop collaborations and connections that way too" (Interview 4).*

> *"There are a couple students that I think are actually at the beginning parts of some of the programs here because of some of that Teen Café work that we did. That's very rewarding, even if it's only a couple students out of however many we – I don't remember what the total attendance was. But that makes me very happy that we gave a beacon to somebody or a handful of students that now are going to pursue science for their career" (Interview 12).*

Personal Enjoyment

Another outcome of participation in the Teen Science Café, expressed by six scientists, was simply having fun in the experience. These scientists reported a benefit of enjoying the experience and interaction with the teens. In this way, this shows the potential of Teen Science Cafés to fulfill the scientists' motivations for participating because it's fun, and perhaps, further building a group of scientists who participate in outreach because of previous enjoyable experiences.

> *And then I just love interacting with students and trying to get them excited about science, so I just had fun doing it. (Interview 3)*

> *As far as the experience, I had a great time, so that in my mind was a big positive. I enjoyed the process, and actually giving the talk, and doing something a little bit different than the norm. (Interview 2)*

Benefit of Impacting Teens

Finally, several of the scientists' responses about the benefit of participating focused not on ways that the experience impacted or changed them. Rather, **they framed the benefit of participating in terms of the opportunity they had to impact others – specifically, to impact the teens – as being rewarding for them** (7)**.** For many, they actually described this desire to impact publics as intrinsically tied with their career responsibilities or professional objectives. This expression of benefit related very much with the driving motivation of most of the scientists, discussed earlier, which was seeking to do this experience because of the importance of outreach to impact public audiences, and particularly teens.

> *"The main reason and the main benefit was creating a forum where we have another opportunity to talk to kids and get them excited about things they would do in college and talk to them about aspirations, and not just interested in, but capable of pursuing higher education. That's the main benefit, and you know I see that as part of my duty and my job as well." (Interview 14)*

> *"And if I could just provide some encouragement to even one teenager, I think that that's a good thing. I found a couple of people that were interested in STEM but were actually really thinking very specifically about going in the medical field. And I was able to sort of help clarify their understanding about what that was like or just kind of give them a better idea of what they were to expect and encourage them. So if I encouraged that one person, that would be a benefit for me." (Interview 13)*

> *"I think being able to interact with the kids afterwards so you know I hung around and got to chat with them and talk to their parents and just encourage as many of them as I could to become scientists themselves. I think that was very rewarding." (Interview 17)*

Teens as an Audience

Beyond directly reporting how their views of teens may have been impacted by this experience, scientists who had other types of outreach experience were asked to reflect on what they felt were the main differences between teens and other audiences – whether adult or younger children. A few key themes emerged.

Ten scientists described cognitive differences between teens and other audiences they worked with. Compared to children, scientists noted teens' increased ability to conceptualize challenging or more abstract concepts than when they work with younger audiences. When comparing teens with adults, some scientists noted that, although adults may be even better able to handle and understand complex scientific concepts, they found that teens are often more curious and open to hearing new ideas than adults.

> *"They do have more knowledge base than younger kids, and they are more autonomous than younger kids." (Interview 7)*

> *"And then [with] younger kids, maybe you have to explain or dig into the details a little more at their level. Whereas the teenagers are, to some extent, more knowledgeable about a lot of science than adults, because they're still being educated and their minds are kind of open to ideas. Or they're just learning about certain things, so they're more interested in them. Whereas adults are kind of stuck in their worlds." (Interview 4)*

> *"Compared with adults, they're much more uninhibited and they're still asking some very good questions and applying their scientific background but…they're interested in more flashy questions or more kind of sudden impact or huge impact kind of events. And so, they're very excited about cataclysmic things whereas adults maybe are more slightly refined in their process thinking. And young children are so fun but, of course, they don't quite have the scientific understanding to really begin to make the connections between scientific disciplines or research datasets or things like that, which teens are just beginning to really make really big connections…" (Interview 11)*

Nine of the scientists reflected on using different strategies to engage teens. In general, they focused on the need for more active and visual experiences with teens than adults, while needing to consider things like group dynamics and social interactions more for teens than for younger audiences.

> *"I like to do active learning exercises where the students actually get up and do things. And my college students, they kind of do it grudgingly. And at professional meetings, you know, you just can't get people to do it. They just want to sit there and drink their coffee." (Interview 15)*

> *"The challenge with [teens] is to deal with their cynicism and their attention span. [Laughs] And I'm not saying the younger children don't have attention-span issues as well, but it's a different thing. And you have to read past their external mask because some of them present to the world this cynical cool facade, and that may or may not be what's going on inside…And so I think managing the social situation is way a bigger deal than for younger kids, because I think for younger kids you can just kind of throw them together in random groups, and I'm not saying it's not going to have an effect but it's less important than if you break the teenagers up in different group size and kind of manipulate the social infrastructure." (Interview 13)*

> *"And what I've found, talking particularly with teenagers, middle schoolers and teenagers, is they respond well to video. And they respond well to a lot of images. Where adults don't necessarily need that in their presentations." (Interview 5)*

A few scientists discussed that their own feeling about doing outreach was different with teens than with other audiences, such as a scientist who expressed feeling far more comfortable with teens.

> *"…I feel much more comfortable with teens. I think it's okay if you mess something up. It's not as scary if it's in front of teens versus adults. It seems like it's easier to get excited about your research and good response from teens versus adults. …I haven't done too much with little kids, but it's nice to be able to talk a little more specifically about the research. You can do that with the teens, but not necessarily with younger kids." (Interview 3)*

Café Recruitment Experience

Evidence of Pre-Vetting

A general principle of the TSCN is that sites are encouraged to do some advance vetting of scientists, to find those with some communication skills to draw upon within the Café. Nearly all scientists provided information that indicated that the Café organizer was already familiar with them, their work, and/or their communication abilities prior to the invitation to participate. Most often, scientists mentioned that someone from the site contacted them after attending a program or an event where they had spoken, such as another outreach activity, science café, or community program.

> *"I took part in a Science Friday event and someone in the audience contacted me and thought I'd be a good speaker" (Interview 18).*

> *"I have done a lot of activities for kids in the region. I'm one of the scientists that they call when they want to have STEM activities for the robotics competition that the 4H folks do and that sort of thing. So I'm sort of known to the circle of people, and they contacted me" (Interview 14).*

Advance Communication

All of the scientists communicated with the adult leaders ahead of time, which generally consisted of emails, phone calls, and (in some cases) in-person meetings. The focus tended to be about what to expect and tips for their presentation. In a few cases, scientists also reviewed their materials with the adult (without teens present) and received feedback directly from the adult leaders.

Advance communication with teen leaders was variable; just over half of the scientists (11, 61%) had some sort of communication with teens. The level of communication varied from teen comments on materials (transmitted via the adult leader), to collaborating with teens from the beginning on planning, to doing a dry-run rehearsal with teens and getting their feedback ahead of time.

Those who received teen feedback – particularly in the dry run – tended to appreciate the feedback they received and felt that their presentation and/or activities improved as a result of this trial.

> *"They gave me feedback about what could be better, like having a different card be different colors. Just getting their honest feedback about the activity made it better" (Interview 18).*

> *"I had everything ready to go, and I basically gave them what the plan was for the other three sessions of the Teen Café. They went through all the activities, and they listened to the presentation, and then they gave me feedback on what they thought" (Interview 12).*

In a few cases, teen feedback came via a virtual meeting with teens, but not a full dry-run. This type of meeting was also reported as being helpful to get a sense of students' knowledge and interests.

> *"…a week or two before the Teen Science Café, we sat down [virtually] for about an hour and just talked about what they were interested in and what their backgrounds were. That also gave me a pretty good idea of what prior knowledge looked like, which I always try to assess prior knowledge in a new group of students." (Interview 15)*

In one case, the scientist did not directly interact with teens, but they described a process where the adult did first reviews of materials and then passed it on to the teen committee for final review.

Café Preparation Experience

Format & Content of Café Session

Most scientists reported they prepared to do a typical Teen Science Café format, which tended to have three parts – a brief talk, a hands-on activity, and Q&A with the teens, with each taking about 20 minutes. However, there were a few cases that differed. In two cases, scientists didn't do a "hands-on" activity and focused on a discussion-based talk. In two other cases, scientists created an integrated program, where the "presentation" and activity were interwoven throughout the session.

Typical Format:

> *"I did a PowerPoint presentation, and then we did a hands-on experiment kind of thing. It's about a maybe 20-minute PowerPoint presentation with a bunch of videos that shows here's what it looks like in the field when we do this. Here's why we do this. Here's why you should care about it as somebody that may not actually be interested in sharks. And then we did a hands-on tagging experiment for them" (Interview 1).*

Discussion without Activity:

> *"We did go back and forth on sort of whether or not a hands-on thing could be incorporated. And I eventually was like, 'I just think it's going to be too much.' They were like, 'I don't know.' So eventually we didn't do [an activity], and I think it worked out fine. With my presentation style I just thought, 'I think it's going be too much to try to jam it in.'" (Interview 10)*

Integrated Experience:

> *"I think it's very important to… think about the science behind understanding that environment, and it's more interesting if it's something that you can actually see. So I found a bunch of local [geologic] datasets and then the [adults] just pulled out every kind of arts and craft or marker or paint or glue or scissors or magnets and screws and stuff. It was less of a lecture format and more of an interaction in groups in data interpretation. I gave a brief intro into what we were doing and then we just made different datasets using the different medium available and it was really fun." (Interview 11)*

Most scientists had to create a new presentation or materials for the Teen Science Café Experience (12, 67%). Within this, some collaborated with the teens ahead of time to decide on their content and create their presentation, while others worked more or less independently to develop the ideas and materials of their session.

Collaborating with Teens:

> *"We had a planning meeting with the students the director of the program. I prepared a couple of ideas for an activity that the students would do. Then I basically plugged it to them, and they told me what ones they liked" (Interview 3).*

Developing Independently:

> *"I thought that it was definitely an uphill battle to try to figure out. And I have a friend who teaches high school AP bio in the area. So I talked to him about what he teaches them in class with the part of their curriculum, and where I could try to pick up from there" (Interview 6).*

The rest of the scientists adapted materials they had used previously for their Teen Science Café presentation.

> *"Every year I come up with a new activity, but I use it in another venue, at one of the local science museums during an event called Brain Awareness Week. …and then I did this Teen Café in the fall of 2016. So it was on my mind. It was fresh. I had all the props. When I was asked to consider doing the movie - Teen Café, then that's why I thought of the* Concussion *movie and then having the goggles there for students to try" (Interview 7).*

> *"I do give these kind of presentations a fair amount. And fortunately, the Teen Science Cafés have come up at a time when I had previously given the particular presentation… to a more adult audience. So, I didn't have to start from scratch. I was able to, not so much reuse but make use of an existing presentation. And simply update it" (Interview 5).*

Content of Preparation from Sites

Several types of preparation activities were typical across sites and scientists. **Three areas of preparation content were most common, reported by more than half of scientists: information about what to expect, tips for presenting, and feedback on materials or activities.** See distributions in Figure 1.

The most common support was providing scientists with information about what to expect in the Café, which included information about presentation format, audience, or overall logistics, which was described by 16 of 18 scientists. Next most common was that sites provided tips for presenting, which focused on strategies for communicating or advice for connecting with the teen audience (14 scientists). These tips came in various formats – in a written sheet, via conversation, or as part of a dry run presentation. Similarly, eleven scientists mentioned receiving some sort of feedback on their materials—such as their slides or their materials for their activity. As with presentation tips, some of this feedback came through dry runs, while in other cases it came through asynchronous review of materials and sending comments.

Less common forms of preparation mentioned included sites sharing examples – information, handouts, activities, etc. – from past Cafés to help make the ideas more concrete for scientists. And three scientists indicated that sites had shared with them information about the overall goals of the Teen Café program, to help them align with the objectives for the teen experience. Only one interviewee indicated they did not receive any significant preparation support from their Teen Café site.

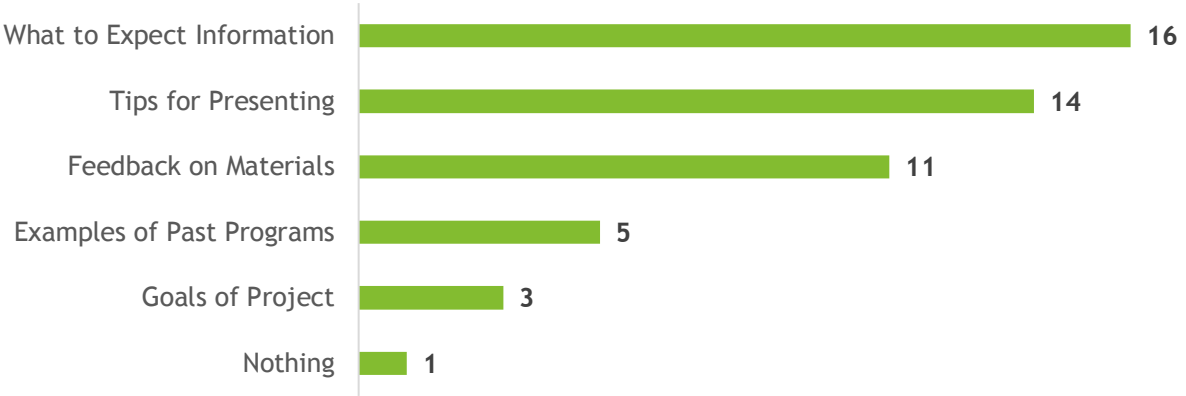

Fig 1. Number of scientists interviewed who reported each type of preparation (n=18)

Usefulness of Preparation Activities

Scientists were also asked to reflect on which of the types of preparation they felt were most useful to them. From this, **three types of support were noted as most useful by more than half of the scientists who experienced them: information about what to expect, tips for presenting, and information about the goals of the project.** Figure 2 shows the proportion who said a type of support was most useful, of those who experienced it.

Ten scientists reported that the "what to expect" information was most useful to them (out of 16 who reported receiving such information). Comments indicated that they benefited from the foundational information about the audiences, logistics, expectations, format, etc. This was the starting point for their preparations.

> *"[It was most helpful] Knowing who you're going to go in and be talking to. And how many of them. And what kind of questions, interactivity, beyond just beyond them sitting there stone-faced. What you might anticipate there" (Interview 5).*

Similarly, scientists responded very positively to receiving tips and advice on presenting and communicating. Eight scientists (of 14) indicated that the feedback, advice, and tips they received – from adults and/or teens – were very helpful. Again, this very often occurred during a dry run, although it was possible they received tips in other forms, such as a tip sheet.

> *"The most helpful thing for me was I was going a little bit fast for them and there were things that my brain automatically spit out that I didn't realize I had to explain, because you know I don't have to explain some of these things on a day-to-day basis to people. So I had to go back and kind of really be careful about explaining the terminology I used" (Interview 13).*

> *"Their handout at the beginning was absolutely complete and fundamental, again, knowing how long you have and some recommendations for how it's been useful in the past to break it up into perhaps three sections so that you don't have this solid hour of just slides, emphasizing using films if you have them" (Interview 9).*

Only three scientists mentioned receiving information about the goals of the Teen Science Café, but of these, two indicated it was very helpful information. These comments indicated that knowing the intention of the Café helped them align their materials toward those goals.

> *"It was definitely useful you know that they were clear about what the learning objectives were. You know beyond just the content, specifically what they wanted the kids to get out of it." (Interview 14)*

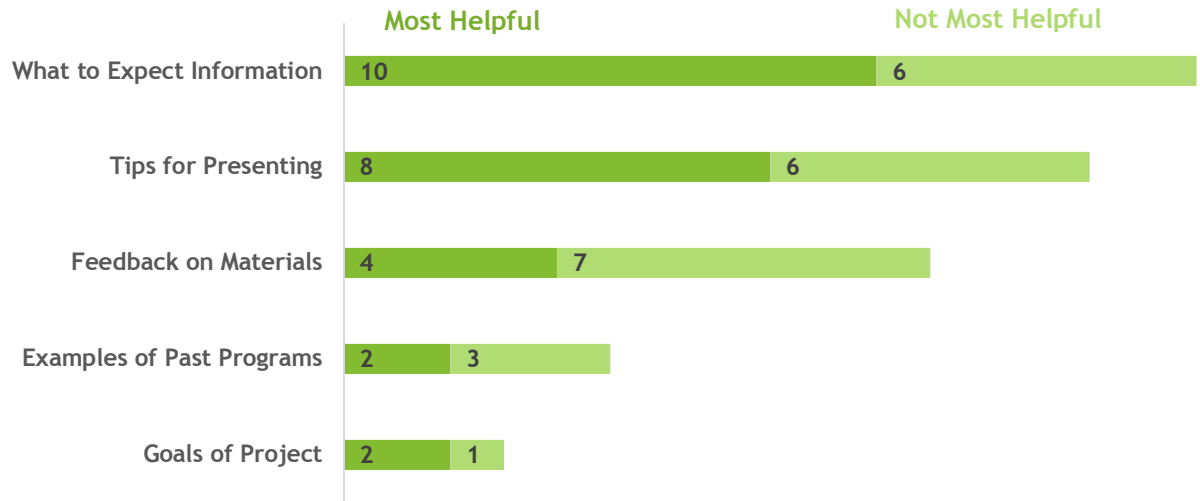

Fig 2. Number of scientists interviewed who reported each type of preparation, and the proportion that indicated that preparation content was most useful to them (n=18)

In addition to these, several scientists reported that receiving feedback specifically on their materials was one of the most useful resources they received. Again, this feedback often came through the dry run experience, although not exclusively.

> *"Then you know the most valuable advice actually was from the rehearsal and the dry run where they actually said very specific things. "Why don't you use colored paper for this purpose" and "Why don't you have the tables setup on that side of the room?" You know just programmatic things were very helpful" (Interview 8)*

And a few scientists also indicated that receiving examples of past programs was one of the most useful resources they received.

> *"Getting some examples, seeing what previous researchers had done, kind of how they modified their talks for that audience was very helpful" (Interview 2).*

In addition to the resources mentioned above, in some cases, the site provided specific materials, such as microscopes or art supplies, which the scientists really appreciated.

From another angle, scientists were asked whether there was anything missing from their preparation that would have been helpful. Seven of the scientists were satisfied with their preparation and had no other needs. Of those who did, a few wanted more information about what to expect, tips for presenting, or specific feedback on materials. However, in many cases, the answers were focused on very specific details that fall within these categories, rather than something they felt was completely absent from their experience. Some of these examples include wanting to have a better sense for what the audience would be, or doing the dry run in the actual room where the presentation would take place. A few presenters requested more feedback on their talk or activity to make sure ahead of time that it would resonate with teens.

The Dry Run: Helpful or Not

As noted above, the dry run was a preparation technique that was used and allowed for sites a mechanism for providing feedback on presentation style or content and on materials or activities. **The interviews showed that half of the scientists did participate in a dry run, and seven (of nine) reported that the experience was helpful to them or that they changed something specific as a result of the practice session.**

> *"The rehearsal is an essential part of [the process], and I got the best advice during those rehearsal events. Anybody who does this sort of program needs to have the benefit of those rehearsals." (Interview 8)*

> *"I think the meeting with the teen committee members was absolutely the most useful aspect." (Interview 17)*

The other two were less enthusiastic about the idea of a dry run, feeling that they'd been reasonably prepared with out it.

> *"A full standup [rehearsal], depending on your scientist, is going to be difficult to schedule and probably unnecessary. I've been doing this 24 years. …I don't need a [dry run]." (Interview 9)*

Among the other half of scientists, who did not have a dry run, responses were split between those who thought it might have been helpful and those who felt it was unnecessary. However, even those who thought it might be helpful were not as enthusiastic about the idea as those who had experienced it.

> *"For the activities that we did, it obviously wouldn't hurt, but it's not something that I felt was lacking necessarily. I mean, any advanced preparation's always good preparation. But I don't feel like anything was hurt by not having one." (Interview 1)*

> *"It probably would have been [helpful]. But I think the benefit would have been marginal." (Interview 15)*

> *"I never do that [rehearsal] anymore. I just do the presentation. I don't have to anymore. I'm embarrassed to say it, but it's the truth." (Interview 5)*

The Café Program Experience

What Made a Program Successful

When describing what went well in their Café programs, the most common attribute mentioned by scientists was that they felt the teens were engaged with the experience (10, 56%).

> *"It seems like they had good time. I don't think it was quite what they expected. Just it required them to be more interactive with people they didn't know the whole time. But I think overall everybody had a pretty good time and it was very relaxed, and people were very comfortable talking to people and asking questions about the other groups." (Interview 11)*

The next most common indicators were a feeling that they, the scientist, did well in their delivery of the session (6, 33%). For others, an indicator of success was that logistics of the evening went well (5, 28%).

> *"There was pretty good interaction because I ask questions. I'm not going to just give information. I'm going to ask questions. So I kind of evoke interaction" (Interview 7).*

> *"Well, we had no technical glitches, so that's good" (Interview 7).*

Other comments, mentioned by one or two scientists, included that the event was well-attended or that their hands-on activity went well.

Challenges Experienced during Cafés

While the challenges were varied for each scientist, a few common themes emerged. **The most common challenge related to the audience; half of the scientists remarked on a challenge involving the audience** – whether it was lower attendance than expected, higher attendance that made personal interaction hard, or that the teens were younger than expected.

> *"I will say the attendance [at one site] was a little disappointing. There were not many kids. I mean, I think the number of people I brought with me to help with the different activities, I think we might've outnumbered the kids that attended. That was a little disappointing." (Interview 12)*

> *"The activity could have been a bit more polished, for such a wide range [of ages] for the event…. Initially, I thought it was going to be majority 8th grade and up, less from the 6th grade. But when people started to fill up for the event, the first session had more of the younger age group, less high school; but the second event had more high schoolers than middle schoolers." (Interview 18)*

The next two most common challenges were each mentioned by five scientists – logistics or set-up issues and the scientist's level of preparation. With logistics problems, in some cases unexpected events caused changes to the Café that scientists found hard to adapt to. In one example, a scientist discussed how the pizza was not ordered when expected, which shifted the schedule around for the evening and he found it hard to concentrate and focus on presenting the material he had planned. Another example referenced the difficulty presented by the venue.

> *"The second one [I did] was [in a venue that was] just too large and people couldn't hear it. And so, for the type of material that I prepared, it really wasn't well-suited because you can't have a conversation when participants can't hear each other very well. So that was probably the worst of the three [I did.]" (Interview 16)*

Some of the scientists talked about how their personal preparation presented challenges—often how, in hindsight, they would have done something differently. One scientist talked about how they would have changed their slides, another how they would have brought more materials, and another how she changed the topic fairly late, and it would have been better had she changed the topic even earlier:

> *"I probably should have changed the topic earlier, but that would've helped me just kind of maybe prepare a little bit more." (Interview 11)*

Another challenge was the time commitment, which was only mentioned by two scientists, but both were from sites where they presented multiple Café programs within about one month. The experience of squeezing in multiple Cafés within a short timeframe created a time commitment that felt a bit onerous for them. In contrast, presenters who had done multiple Cafés but over longer periods of time (e.g., one per year) did not make these comments in interviews.

> *"It was a lot. I wouldn't want to do it every year, but it was definitely workable. I appreciate being told that [commitment] up front. I definitely understand why they want to do it that way" (Interview 12).*

> *"I love this program so I'm mostly willing to do it. This year actually I was like I just cannot. It's like killing me because it has to be during the school year. If it were one talk, that's no problem. If it's two talks, that's easier. Three, four, that starts being rough." (Interview 10).*

Other challenges were mentioned by just one or two scientists, and were often specific to certain situations, such as participating multiple years and having repeat students, watching time, and communication challenges. A couple noted that activities fell flat with students, and that they found the hands-on element very challenging.

> *"I definitely felt like [the activity] didn't really work. I kind of forced it. I think it was useful, but there was definitely one child who raised his hand…, and he was like, 'I'm not getting anything out of this activity.' And I was like 'Thank you, I think that is totally valid…'" (Interview 6)*

Feedback for Sites

In addition to the research questions, interviews revealed that some scientists had specific feedback for the programs, including positive feedback and ideas for improvement. All comments were site-specific, rather than generalized, but some of them point to positive attributes of the Teen Science Café model.

One example of such feedback was a few scientists who expressed very positive impressions of the professionalism and quality of the Teen Science Café they worked with, particularly in its organization, support, and structure. One scientist who expressed how enjoyable it was to work with the Teen Science Café due to their advance planning and staff participation in the process of developing the session, which differed from the outreach experiences they were used to.

> *"It was really fun and I was pleased to see the amount of thought that goes into one of these Teen Science Cafes. That was - you know we do a lot of stuff where people just say, "Hey, can I bring you a group of 20 kids?" And you know, I do stuff like that. So it was nice to have some planning and forethought, because I think it was more effective as a result." (Interview 14)*

Similarly, another scientist talked about how it was enjoyable to be part of a program that was professional and produced great material for the teens.

> *"This is a great program and I think it's run with the sort of rigor that is good for it. Too often you find in these volunteer programs that there's not a real clear scope or you know the rigor to make it good, but I think the Teen Science Cafe really does have that. It takes a serious approach to a subject we all ought to care about more which is bringing the best educational experiences to the next generation. So I'm really - you know I'm grateful to have participated." (Interview 8)*

In terms of critiques that might have more Network-wide significance, at least one scientist expressed struggles with creating the hands-on activity for their program, as discussed earlier. In the feedback for sites, these comments raised a question of whether there were ways that Café sites and organizers might have more flexibility in format or more strategies for helping scientists who feel their fields do not lend themselves to interactivity arrive at compelling and relevant experiences for teens, while staying reasonably within the comfort zone of the scientists.

Discussion & Conclusions

Scientists have multiple motivations for participation, with a desire to create positive impact on teens seeming to lead the way.

Scientists generally spoke about multiple motivations in their interviews, indicating that there can be a mix of reasons and factors that influence potential speakers. Interestingly, the dominant theme in this sample was what we called Collective Motivation, or the feeling that they were contributing to an important mission or end-goal. This motivation seemed linked with the teen audience, as they described motivations related to encouraging pursuit of STEM careers, serving as a role model, and/or providing opportunities for youth at a critical development stage.

However, there was also evidence that intrinsic motivations exist for these scientists, with individuals being motivated, at least partly, because they get personal enjoyment from the experience and/or because they feel it will help them build communication skills. Similarly, there was also evidence of norm-oriented motivations, from outside sources. These were primarily expectations from funders or institutions that scientists engage in outreach. The interviews suggested that these externally-focused motivations never existed in isolation, however. All scientists interviewed who expressed these reasons connected them with either a collective or intrinsic reason.

Phase 2 Survey Implications:

Because scientists hold multiple motivations for participation, the team will need to prioritize the most useful way to understand these motivations. For instance, is the priority to identify presence of any motivation? Or to identify primary/secondary motivations? Or to identify relative strength of each motivational factor? These decisions will guide how questions are structured.

Survey data can provide an opportunity to explore the emergent pattern that external/norm-oriented motivations do not exist in isolation for scientists; in other words, scientists who do Teen Science Cafés tend not to participate solely because of an outside requirement, expectation, or grant requirement.

There is robust evidence that Teen Science Cafés have the potential to impact elements of mutual learning among scientists.

Mutual learning from PES experiences is an oft-stated goal for which there has been limited evidence of achievement. The degree to which public engagement impacts how scientists think about their work is unclear. This first phase, however, provides clear evidence that – in at least some cases – scientists leave the experience with different perspectives or lenses on their work. This does not always mean a change in direction or *how* a scientist proceeds with her/his research; however, multiple interviewees discussed seeing questions or relevance of their work from a new point-of-view. In this vein, the results also indicated that the program has the potential to impact scientists' views and thinking of teens (or at least Café participants) in a new light – their cognitive abilities and their worldviews and life experiences.

In terms of impact on communication skills, the Teen Science Cafés appeared to have the greatest opportunity at the intersection of mutual learning and communication skills. In particular, there was a strong theme of skill-gain in the scientists' view of how to talk about his/her research/work, rather than expressing gains in more general communication skills (although this was not entirely absent).

There also seems to be a broad impact of encouraging future outreach, in particular, the interest to continue to do outreach with teens or with Teen Science Cafés. Most scientists did have extensive experience with outreach coming into the program, however. So, it may be more of a shift in focus on this new audience than greater volume of outreach overall.

Phase 2 Survey Implications:

The interview responses provide useful language and framing that can be used to construct survey items to measure how often or how strongly each type of impact is experienced by scientists in the broader population. In particular, it will be useful to understand how frequently mutual learning impacts are experienced, across the range of professional and interpersonal themes that were found.

The preparation experiences vary between sites, and scientists bring different levels of experience, but opportunities for feedback from teens seem to bring important value.

Interviews suggested that Teen Science Café scientists are well-vetted and experienced with outreach prior to becoming involved with the program. In line with this, most expressed that their "training" in science communication came from years of practice and experience; relatively few of the interviewees reported any formal training experience.

In this context, the first and most critical level of preparation activity (which appeared to be common) was providing scientists with strong information about what to expect within a Teen Science Café. This included information about format, logistics, audience, and expectations. This established a common foundation.

At a next level, the interviews suggested that dry runs (or other mechanisms to give scientists direct feedback from teens) are not something scientists expect to do or would request as a preparation activity. Some come with a mindset that they don't need to practice. However, nearly all who experienced such dry runs or feedback sessions reported that it was very helpful and/or that they made changes as a result of the feedback they received. The data suggest that sites would need to push for these things, as they are not the norm for many scientists; and there is value to be had from encouraging this process.

Another preparation attribute that was rarely experienced or expected, but proved to be helpful to those who received it, was for sites to communicate their goals for the Café and teens. Like a dry run, it may not be expected by a scientist, but it is a piece of information that can help them calibrate their contribution.

Phase 2 Survey Implications:

These data provide a framework of the range of types of preparation activities that scientists might experience – in particular the nature/focus of the preparation (i.e., what to expect, tips, feedback). From this the survey can use this framework to explore the extent of what is experienced by scientists, their perception of its helpfulness, and if it relates to a sense of success with the program.

The feedback heard in interviews suggest that Teen Science Cafés present a positive experience for most scientists, with structure and logistics support that is valued.

Although general feedback about the Teen Science Cafés was not the focus of this interview, the responses occasionally expressed these sentiments. The theme that stands out in this regard was the level of organization and structure that Teen Science Cafés provided scientists, in comparison with other outreach experiences. There was a sense of positive interactions and relationships, for the most part, that emerged from these scientists and their sites. Only a few challenges emerged that seemed like constructive points for the broader Network to consider.

There can be a significant time commitment challenge for scientists who are asked to do multiple Cafés within a relatively short time period (a month or two). While there might seem to be a benefit in the scientist getting to put their preparation to work in multiple sessions right away, some find this time commitment to be burdensome and a barrier to participation. That pattern was not seen among scientists who have done multiple Cafés over a longer period of time.

Scientists greatly appreciate that the staff and teen leaders take care of logistical details and are helpful on-site for the Café. But unexpected events can be challenging for some scientists, who can feel thrown off by logistical shifts that don't match their expectations. A common area related to the audience that shows up at a Café; whether it was fewer students, more students, or that teens were younger than expected, these unexpected details can be a problem. While unexpected events are a norm in these environments, the more that can be done to prepare scientists for these possible situations, the less distracting it might be.

Finally, it was uncommon, but a couple of scientists indicated discomfort with the activity-focused format of the Café. This structure is central to the experience, and it may be that some science professionals need more support to become comfortable with this format and develop an activity that will work for their expertise. It may be that activity examples from other Cafés or scientists with similar experiences may help create that trust in the format.

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