Impact of Teen Science Cafés on Scientists

Results of Phase 2 Quantitative Study

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Executive Summary: Scientist Impact in Teen Science Cafés

A Teen Science Café is an out-of-school program in which teens and STEM experts engage in conversation and activities to explore a topic related to the STEM professional's expertise. Teen Science Cafés are independently run and organized at more than 100 sites nationwide – from museums to libraries to aquariums. Prior evaluation of the Teen Science Café model has demonstrated a range of impacts achieved with youth participants, but relatively little research has focused on the experience of the scientist-presenters.

In the present study, a sequential mixed-methods was conducted to explore the nature of the motivations and impacts experienced by scientist-presenters and to explore the value of preparation activities provided by Café organizers (which vary between sites). Following a Phase 1 qualitative study, using in-depth interviews with past presenters (Sickler & Cherry, 2017), a quantitative online questionnaire was administered to scientists from 14 mature Café sites; 132 responses were obtained (65% response rate). The questionnaire was developed based on the themes that emerged in Phase 1, using scales and items adapted from other relevant studies, as well as developed specifically for this project.

Motivations & Goal Fulfillment

Scientists are motivated by a mix of two factors – their desire to contribute to the collective good (impacting the teen audience) and intrinsic personal enjoyment. Extrinsic factors and potential benefits were weak or irrelevant motivators for scientists' participation. Moreover, a comparative analysis of scientists' motivations for doing the Teen Science Café with their motivations for doing outreach with adult audiences showed that, while the collective good motivation is paramount for both audiences, it is significantly stronger for working with teens. A motivating attribute of Teen Science Cafés, in particular, is the opportunity to engage with and possibly impact an audience that is at an influential life-stage.

The strongest outcomes found in this study showed overwhelming, strong agreement among scientists that the Teen Science Cafés provided great personal enjoyment and a feeling that they had positively impacted the teens. While these outcomes do not represent a change in scientists' views, they demonstrate the capacity of Café programs to create fulfilling and rewarding experiences that align with incoming motivations and goals.

Implications:

- Include opportunities for informal interactions between scientists and teens at Cafés, in addition to planned conversation and activities. Reports suggest that informal interactions provided some of the strongest experiences that made scientists feel they had directly impacted individual youth.
- Consider sharing summaries of evaluation results or anecdotal reports of teen impact with presenters to affirm their sense of impact.

New Approaches to Communication

Study results showed that Teen Science Cafés had mixed success at achieving aspects of mutual learning, or ways that scientists learn from the publics with whom they interact. The most prevalent shift related to communication approach; scientists reported thinking differently about how to communicate about their work to resonate with a teen audience. Indicators that scientists had gained new insights from their teen audiences – whether about their science or about the lives of the teens – showed more inconsistent evidence. While a small number of scientists (in survey and interview data) reported strong impacts on their thinking about their work or improving understanding of how teens view their field, this was something experienced only weakly, if at all, for most presenters.

Data from a public engagement outcome scale, which has been tested with other scientists who do public engagement, suggested that Café presenters' outcomes in these areas were not substantially different than others' experiences.

Implications:

- New approaches to structuring or preparing scientists for Teen Science Cafés could be explored to aid the creation of opportunities for mutual learning impacts. For instance, scientists could be encouraged to include more opportunities in conversation or activity for students to voice their views, concerns, or insights about a topic, providing more opportunities for a scientist to take in these perspectives. Continued preparation and support during Cafés for encouraging two-way interaction is important.

Well-Prepared Scientist-Presenters

Although the nature and mix of preparation activities varies widely across the Network of Café sites, nearly all scientists report feeling that they were completely or mostly prepared for their Café sessions. This seems partially attributable to the utility of the preparation activities provided by the Café, as most of the activities that presenters experienced were rated as highly useful. However, with very high feelings of preparedness among scientist-presenters, there was no evident relationship between the level of intensity of preparation activity and their self-assessed feeling of preparedness for their Café. In other words, those who engaged in extensive preparation (such as a practice-run) and those who had not felt equally well-prepared for their Café.

The high level of feeling prepared also seemed attributable to the high degree of prior experience with outreach and confidence in communication abilities brought by these scientists to their Teen Science Café experiences. Nearly all scientist-presenters are actively involved in other forms of outreach (the Teen Science Café was not their first or only activity), and many are actively involved in three or more forms of outreach. In addition to practical experience, nearly half reported they had received formal science communication or outreach training in their careers.

As a result, the data showed that scientists tended to moderately or weakly report skill-gain as a result of the Café. Skill areas that were moderately impacted included finding new ways to talk about research or broadening the range of audiences they were able to communicate with. Similarly, impacts on outreach behaviors were primarily in engaging in a new form of outreach and interest in doing more outreach with teens. The program did not seem to substantially impact broader communication skills (e.g., understanding the nature of informal learning) or outreach behaviors (e.g., doing more outreach), possibly because so many presenters were already at a high level at the outset.

Implications:

- If skill development is a priority, it is important to identify a target skill or tool that the program intends to build, and select an ability that is relevant to Teen Science Cafés, but less commonly applied in other common outreach settings, in order to build on experience.

Value of Practice Runs & Collaboration

Scientist-presenters found the preparation initiated by the Café sites to be helpful in preparing for their Café. Beyond basic background and "what to expect" information, the majority of scientists found the activities they did to be very or extremely helpful. The exception to the positive feedback was the activity of turning in materials in advance; this was generally seen as slightly less helpful overall. The most helpful preparation support was receiving information about the Café goals for teens. In addition, scientists who did a practice run (including teens giving feedback) or collaborated with site organizers (teen or adult) on their activity found the experience to be very or extremely helpful –describing the experiences as essential to improving their Café session.

Because each Café site uses different preparation techniques, not all scientists experienced the more time-intensive activities. When they considered the potential helpfulness of activities that they did not actually experience, few scientists felt these opportunities would have been very helpful. In particular, there was little sense that a practice run, collaboration, or turning in materials would have been helpful. While some of this response may reflect prior confidence, qualitative data indicated that some scientists did not have a clear vision of what activities like a practice run might entail. Some scientists doubted the effectiveness of such a practice session if it was done with adult organizers, not imagining that teens would or could be involved beyond the Café session itself.

Implications:

- Involve Teen Leaders in preparation activities, particularly opportunities to give feedback.
- When including more time-intensive activities, such as a practice run, be sure to communicate clearly what it entails and the role played by teens, as this may not be assumed by presenters.
- Consider sharing specific examples or ways that past presenters have found practice runs or collaboration to be helpful in improving and refining their Café sessions to encourage doubtful presenters to give it a try.
- Consider presenter's openness to feedback when encouraging a practice run. Disappointment was rare, but it was expressed, it typically reflected a feeling that they had spent time, but changed nothing as a result of the experience.

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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 fall 2017, the TSCN represented more than 100 sites in 40 states, established by a wide range of institutions – from museums, to libraries, to out-of-school programs, and beyond.

The Teen Science Café model incorporates Teen 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 (Peterman & 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 leveraged the large 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. **What are scientists' motivations for engaging with teens, and are they different from engagement with other audiences?**
2. **In what ways, if any, does mutual learning take place? To what extent is this an outcome across scientists?**
3. **To what extent do scientists experience other types of impacts?**
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. To answer these research questions fully, the study used a two-phase, sequential mixed-methods approach. In Phase 1, in-depth interviews with a purposeful sample of participating scientists were conducted to explore the full range of areas of impact and experience for scientists in this context. The present Phase 2 study was built upon what was learned in Phase 1, with a survey instrument constructed and administered to the full population of TSCN scientists, in order to understand the prevalence of experiences and outcomes – how common or uncommon they are.

A full report of the Phase 1 study is available (Sickler & Cherry, 2017), and a summary of key findings is presented on the next page. In this report, several quotations from the Phase 1 study are also included to help illustrate and explain the findings of Phase 2.

About Mutual Learning: 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.

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.

Phase 1 Study: Key Findings

Motivations: There was a wide range of motivations for doing Teen Science Cafés, and most scientists got involved for multiple reasons. The most common theme was a collective motivation, or because they believe in the importance of this type of outreach. The teen audience factored into this view. Interviews also revealed intrinsic motivations, where they received personal benefit (having fun or the chance to build skills with a new audience). A few mentioned norm-oriented motivations, or external requirements for outreach; but in interviews, this motivation was always paired with a more personal or collective value.

Impacts: Upon probing into this area in interviews, the majority of interviewees revealed some type of mutual learning gains. Most of these addressed thinking differently about how to explain one's work to the public, but a few expressed deeper elements of learning: thinking differently about some aspect of their work or how they do it and/or realizing something new about how publics view or think about their work. A majority also talked about new realizations about the teens with whom they interacted, including the depth of their knowledge. Because interviews were not a random sample, the survey was designed to explore this in more depth.

Other impacts included the intention to use the communication tools they developed for their Café in other communication venues, improvement in communication skills, intentions to do more or different outreach, and leveraging new connections or partners built through their Café experience. A number also expressed the benefit of personal enjoyment or feeling that they had achieved their goals to positively impact teens.

Preparation: Scientist preparation activities seemed to vary quite substantially from site-to-site, with an emphasis across-the-board on providing the scientist with "what to expect" information and tips on presenting. In a subset of cases, scientists did a "dry run" for the teens or received feedback from teens on their materials in another form. While what-to-expect information is essential, other types of feedback were also seen as valuable. The dry run, of particular interest to Network organizers, tended to be seen as extremely valuable by those who experienced it, but those who had not done one tended to feel ambivalent about its potential value. This was a question we hoped to explore further in the survey.

Methods

Phase 2 Methods

The study of TSCN scientists used a sequential, mixed-methods approach. A first-phase qualitative study, using in-depth interviews with TSCN scientists, explored the full range of experiences and outcomes among scientists, capturing how they interpreted their experience in their own words (see Sickler & Cherry, 2017). These results were the foundation for Phase 2, in which we developed a questionnaire for a network-wide survey of past scientist-presenters in the TSCN. This study sought to document the prevalence of motivations, impacts, and experiences across all scientists.

Study Population & Recruitment

The study focused on scientists from mature Café settings (i.e., operating for at least two years). These sites, many of which have existed far more than two years, had the opportunity to establish and refine their approaches for working with scientists, providing a reasonably stable setting for examining experience. From this set of Café sites, the study recruited any scientist who had participated in a Café program since Fall 2014.

Adult organizers from the Cafés assisted with assembling the list of eligible scientist-presenters. **In total, 204 scientists from 14 Café sites comprised the study population.** Recruitment used a series of email invitations (up to four) to take an online survey. When we received notification of "bounced" messages, we made efforts to correct email addresses and re-send invitations. The survey was open for one month.

132 scientists took the survey, a 65% response rate, with responses obtained from all 14 Café sites in the study. Response rates by site were generally even, with 12 sites achieving over 50% response rates. This response rate is reasonably strong for a survey of this nature, which relies on voluntary participation, but is still, to some degree, a convenience sample. Based upon a few personal responses to the survey request, some non-responses were due to issues unrelated to the TSCN program, such as being on sabbatical or away doing field research.

Questionnaire Instrument

The first step in questionnaire development was identifying constructs from Phase 1 that should be further explored in Phase 2. A review of literature followed, seeking existing and/or validated survey questions/items that addressed the constructs of interest. For most of the constructs, we found few scales or questions that were precisely tailored to our population or questions of interest. There were several sources with somewhat relevant questions or items (e.g., Anderson, et al., 2017; Royal Society, 2006; Sickler & Ong, 2015), but they needed to be adapted or modified to be appropriate to the nature of the Teen Science Café program model.

A key exception was a scale recently developed and validated to measure public engagement outcomes, with an emphasis on mutual learning (Peterman, et al., 2017). With minor adaptations (i.e., identifying the Teen Science Café in item wording), the scale was well-suited to impacts that were of interest in this study. In addition, we applied the six-point, agree/disagree scaling from these items across all impact questions in the survey. This was due to the researchers' findings during item testing that the six-point scale (without a neutral mid-point) more validly represented scientists' views than a five-point scale (K. Peterman, personal communication, August 30, 2017). Its use throughout our survey also provided consistency for respondents.

The questionnaire used closed-ended questions, with some opportunities for open comments (Appendix B). The survey typically took less than 20 minutes to complete, and had four major areas:

- **Motivations**: reasons for wanting to participate in Teen Science Cafés, and reasons for doing other types of outreach.
- **Impacts**: areas of impact, including mutual learning, outreach behaviors, personal enjoyment, and skill development.
- **Preparation:** scientists' experience with and perception of value from preparation activities received from Café organizers and teens
- **Basic Background:** other outreach activities, prior training, and professional demographic characteristics (i.e., experience, professional field, type of institution, etc.)

Phase 2 Analysis

Analysis of survey data included descriptive statistics (i.e., frequency distributions and central tendency) of the full sample to address questions of prevalence or the extent of impacts or experiences. Because most of the survey items were constructed specifically for this study, rather than using previously tested and validated items, analysis focused on examination of descriptive statistics at the item level. There were two exceptions to the use of item-level analysis, each described in greater detail in this section.

For research questions that required comparisons between sub-groups of the sample, we used inferential statistics as appropriate to the data and nature of the question. In the remainder of this section, we detail specific analyses performed, relative to specific research questions.

Public Engagement Outcomes Scale

As noted earlier, this survey used a recently-published scale that examines scientists' experience of public engagement outcomes, with an emphasis on characteristics of mutual learning (Peterman, et al., 2017). With this prior development and validation work, we were able to score and measure responses to these six items as a single scale, as documented by the developing researchers. We confirmed that our application of the scale had maintained reliability (Chronbach's α=0.85), which enabled us to analyze responses to these items as a single, summated scale to measure perception of mutual learning impacts. In the presentation of results, we include descriptive statistics for the summated scale, as well as providing item-level frequency distributions. For examination of differences between sub-groups, the summated scale score was used.

Motivational Factors

Fourteen motivation items asked scientists to rate how strongly each drove their decision to participate in the Teen Science Café. The items were written for this survey and informed by the language of scientists in the Phase 1 interviews, but they also drew on research-based constructs for motivations in volunteerism (e.g., Eveleigh, et al., 2014; Nov, et al., 2014). Each item was written to reflect one of the four underlying themes revealed in Phase 1 data.

With responses to these 14 items collected, we performed exploratory factor analysis to determine if patterns in scientists' rating reflected an underlying thematic structure. This analysis revealed four factors (see Appendix A for detail), which generally corresponded to the initial framework and provided further clarification about what comprised the themes:

- **Collective motivations**: participate in order to contribute to important work, to benefit of the public, society, or this specific audience
- **Intrinsic motivations**: participate for personal enjoyment from the experience
- **Extrinsic motivations**: participate in response to external expectations, norms, or benefits (e.g., a boss, institution, or funder)
- **Benefit motivations:** view participation as an opportunity to benefit from the experience (e.g., improve skills, resume enhancement)

With the factor structure identified, we analyzed responses within each factor for reliability to determine if it was reasonable to analyze each factor as a single, summated scale. The Collective, Intrinsic, and Extrinsic motivation factors each showed reliability of Chronbach's α>0.70, which is reasonably good reliability to allow for use as a scale. The Benefit motivation had lower reliability at α=0.61; this factor was comprised of only two items, and had been the theme least expressed in Phase 1 interviews. Based on this, we show results of both individual items and summated scales, in order to highlight the strength of motivations for doing Teen Science Cafés. However, in this presentation, the Benefit motivation results should be considered cautiously. (See Appendix A for detail on analysis.)

Motivational Comparisons

To address part two of RQ1 (*Are scientists' motivations for doing Teen Science Cafés different from motivations for engagement with other audiences?*), we asked scientist-presenters to respond to the same 14 motivation items, but in connection with one other form of outreach that they commonly do. The target outreach format was identified based on a question in which scientists indicated which other audiences/formats they had participated in within the past year.

Using the four motivational factors identified above, we used a paired t-test to compare scientists' ratings of the strength of each motivational factor to determine if there was a significant difference in the strength of each factor based on the form/audience of a type of outreach. Analysis focused on comparing motivations for doing Teen Science Cafés with motivations for doing adult-focused outreach (including lectures, talks, and Science Cafés), which was the format with the greatest sample of respondents.

Comparisons of Perceived Usefulness

To address part one of RQ4 (*What is the perceived value of preparation received in advance of Teen Science Cafés?*), scientists were asked to rate how useful they found each of the preparation activities they had actually experienced with their Café site. We were also interested in how scientists perceived the types of preparation activities that they *had not* actually experienced, but which a Café might consider using. In particular, we were interested in whether actually experiencing time-intensive preparation activities (such as the Practice Run) increased the sense of its value, as compared to expectations of how useful it might be prior to having experienced it. As a result, each scientist also rated how helpful they thought a method would have been, if they had not actually experienced it.

These ratings of usefulness were combined into a single variable for each preparation activity, with each respondent coded as having responded based on actual experience or a hypothetical sense. For each preparation activity, an independent samples t-test was used to determine whether the average ratings of usefulness differed depending on whether the scientist was responding from actual experience or a hypothetical perception.

Preparation Level Comparisons

To address part two of RQ4 (*Is there evidence of a relationship between value and the nature of preparation activities?*), it was necessary to find an approach to classify the level of preparation experienced by each scientist, despite the wide variation in the types and mix of preparation activities across the network. This was done with a review of the frequency distribution of each type of preparation and of the total number of activities reported by each scientist, as well as examining patterns of co-occurrence of types of preparation. The main pattern was that the more time-intensive an activity, the less commonly it was done. This resulted in a hierarchy of four types of preparation that corresponded to the most time-intensive method experienced by a given respondent.

- **Receipt of Basic Information and/or Goals**: Scientists who received information (logistics, goals, etc.) with no other active preparation that involved Café organizers. Other session preparation was done independently.
- **Turn in Materials**: Scientists who prepared for their session independently, but were asked to turn in materials for feedback (e.g., slides, a biographical statement, activity plans).
- **Collaboration with Café**: Scientists who collaborated with organizers (adults and/or teens) on the development of their activity, presentation, or both.
- **Practice Run:** Scientists who completed a practice run, or dry run, of their session or part of their session with Café organizers (adults and/or teens).

These four categories became the basis for any statistical comparisons of differences, based on the level of preparation activities, with the primary focus being whether scientists who experienced more intensive preparation felt more prepared for their Teen Science Café presentation.

Comparisons by Other Characteristics

Finally, we conducted a series of exploratory analyses to investigate if there were any strong relationships between scientists' characteristics and their experience of impacts. The primary interest at the outset of the study was whether there was any relationship between a feeling of preparedness or skill-based outcomes and the level of pre-Café preparation activities. We also wanted to explore, based on prior research (e.g., Royal Society 2006; Dudo & Besley, 2016) whether there was a relationship with perceptions or outcomes based on the career stage of the scientist. Finally, some qualitative data within the survey responses suggested we might look for relationships in the data based on measures of prior experience with outreach or science communication training.

Depending on the independent variable in question, we compared means using either an ANOVA or independent t-test. Post-hoc corrections (Holm-Bonferroni) were applied when interpreting results in order to correct for potential errors introduced by conducting repeated comparisons. Independent variables explored included:

- Gender identity
- Career Stage
- Type of Preparation Activities for the Teen Science Café
- High/Low Experience with Teen Science Cafés
- High/Low Experience with Other Outreach
- Prior Formal Communication Training

Study Participants

The study participants were relatively evenly split between men and women, and tended to be either early- (30%) or mid-career (35%) professionals. However, graduate students and senior professionals were also involved. See Table 1 (right) for a complete demographic profile. Participants self-identified their career stage at these levels. A follow-up verification questions indicated that early-career professionals had been working in the field for an average of 6 years, mid-career professionals for an average of 14 years, and senior professionals for an average of 29 years.

Half of scientist-presenters work in academia (colleges or universities), with nearly all coming from research universities. The next most common professional affiliations were non-profit organizations or government-related institutions (including national laboratories), followed by private industry.

Many STEM fields were represented in the scientist-presenters, but the greatest number came from the biological sciences (40%). This was followed by professionals who work in earth and environmental science (17%) and the physical sciences (12%). Other fields were represented by 6% or fewer of the sample.

Table 1. Demographic profile of TSCN scientists responding to survey

	Percent
Gender (n=127)	
Woman	55%
Man	45%
Career Stage (n=130)	
Graduate Student	13%
Early Career Professional	30%
Mid-Career Professional	35%
Senior Professional	19%
Retired	3%
Professional Affiliation (n=129)	
University or College	50%
Non-Profit / NGO	19%
Government	18%
Private Industry / Business	10%
Other	3%
Professional Field (n=129)	
Biological Sciences	40%
Earth and Environmental Sciences	17%
Physical Sciences	12%
Social Sciences	6%
Engineering and Nanotechnology	5%
Medical and Health Sciences	4%
Computer and Information Sciences	3%
Chemical Sciences	3%
Agricultural Sciences	2%
Mathematics	2%
Other Natural Sciences	2%
Other	3%

The majority of respondents (53%) had no prior *formal* training in communicating science to non-specialists, although many of these respondents – 44% of the total sample - indicated that they had trained through years of experience and practice doing outreach and communication. Just under half (47%) of respondents, indicated they had at least one opportunity to receive formal training on science communication. (See Table 2, right.) These opportunities included a range of training sources, from those sponsored by employers or universities to outreach programs (such as PoP or Teen Science Café) to other sources. The question wording specified that teaching training should not be considered in response to this question, however a handful of respondents who selected "other" indicated training or certification as a secondary science teacher.

Nearly all scientists who participate in Teen Science Cafés are also active in other forms of outreach and public engagement. 97% of scientists reported they had done at least one other form of public engagement work in the past three years. The most common types of engagement were outreach for K-12 schools and outreach for the general public (such as science festivals, museum programs, and lab open houses) – each were mentioned by almost 75% of responding scientists. About two-thirds of the sample have talked with or been interviewed by journalists or the media, while just over half have done an adult Science Café or used social media for outreach purposes.

Table 2. Previous science communication training and outreach experience of scientists who responded to the survey

	Percent
Formal Training Science Communication (n=130)	
No Formal Training	53%
Workshop by Employer/University	25%
Training from another Outreach Program (e.g., PoP)	22%
Training by Teen Science Café Organizers	8%
Another Formal Training Source	27%
Other Outreach Experience (last 3 years) (n=131)	
Outreach in K-12 schools	73%
General public activities (festivals, museums, open houses)	72%
Talking with journalists	67%
Adult-focused Science Café	57%
Social media for outreach	52%
Engaging with policy- or decision-makers	38%
Other forms of outreach	10%
No other outreach in past 3 years	3%

Results

Scientist Motivations

As described in more detail in the Analysis section of this report, we asked scientists to respond about how strongly they were motivated by a list of 14 items. These items were drawn from the language and themes from scientist interviews, and fell into four motivational categories:

- **Collective motivations**: participate in order to contribute to important work, to benefit of the public, society, or this specific audience
- **Intrinsic motivations**: participate for personal enjoyment from the experience
- **Extrinsic motivations**: participate in response to external expectations, norms, or benefits (e.g., a boss, institution, or funder)
- **Benefit motivations:** view participation as an opportunity to benefit from the experience (e.g., improve skills, resume enhancement)

Driving Motivations for Teen Cafés

Survey results confirmed and clarified patterns seen in Phase 1 interviews. **Scientists' strongest reasons for participating in a Teen Science Café were Collective (for the good of the public) and Intrinsic (for personal enjoyment).** Extrinsic and Benefit-oriented motivations were very weak motivators among these scientists. These findings reflected patterns in interview data, where scientists tended to express multiple reasons for doing Teen Science Cafés and the dominant themes were Collective and Intrinsic motivations.

Figure 2 (next page) displays the average rating of how strongly each statement was a motivator for scientists. Statements reflecting **the Collective and Intrinsic motivational factors rose to the top, with each of these statements having an average rating over 4.75 (on a six-point scale).** Average ratings for statements that reflected Extrinsic or Benefit-oriented motivations ranged from 2.18 to 3.61, which fell far closer to the "not a motivation" end-point.

Scientists also identified which one of the 14 items best reflected their main motivation. Figure 1 (below) shows the distribution of these selections. **75% of scientists selected one of the Collective motivations as their main reason for participating; 22% selected an Intrinsic motivation statement**.

Fig 1. Percentage of scientists selecting each motivation item as his/her MAIN motivation for participating in the Teen Science Café (n=132)

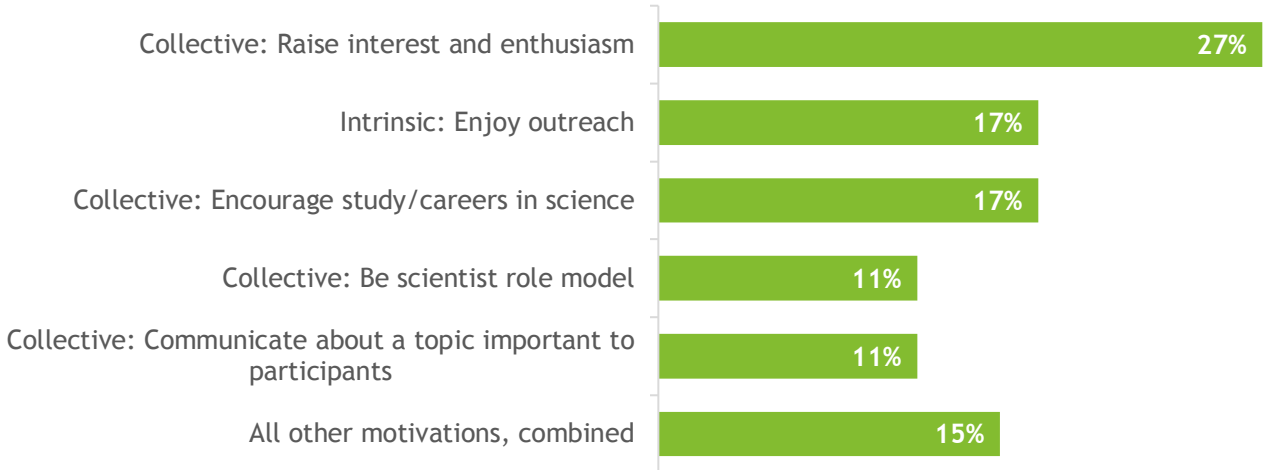


Fig 2. Average rating among scientists of how strongly each statement was a motivator for participating in the Teen Science Café (n=132)

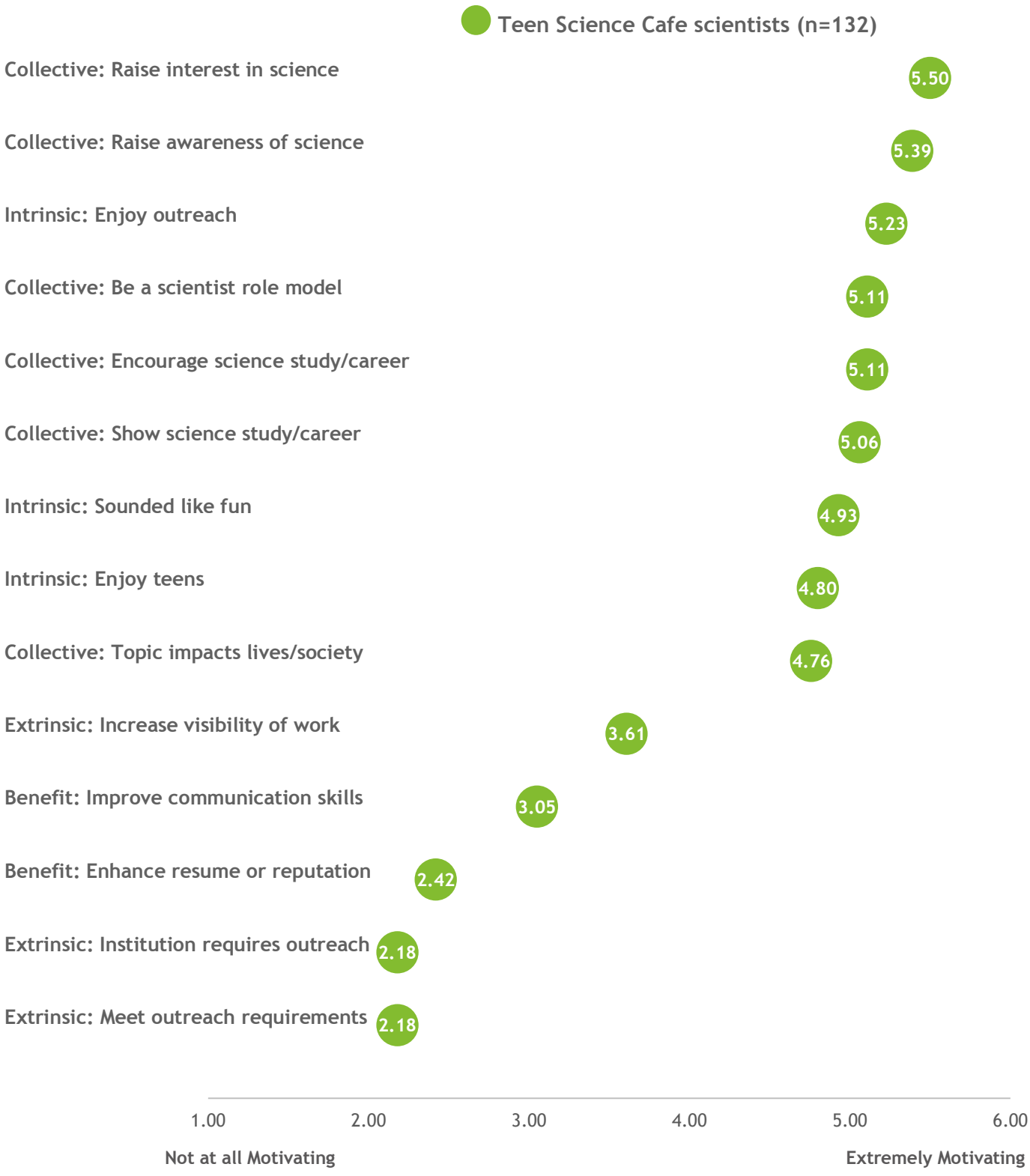
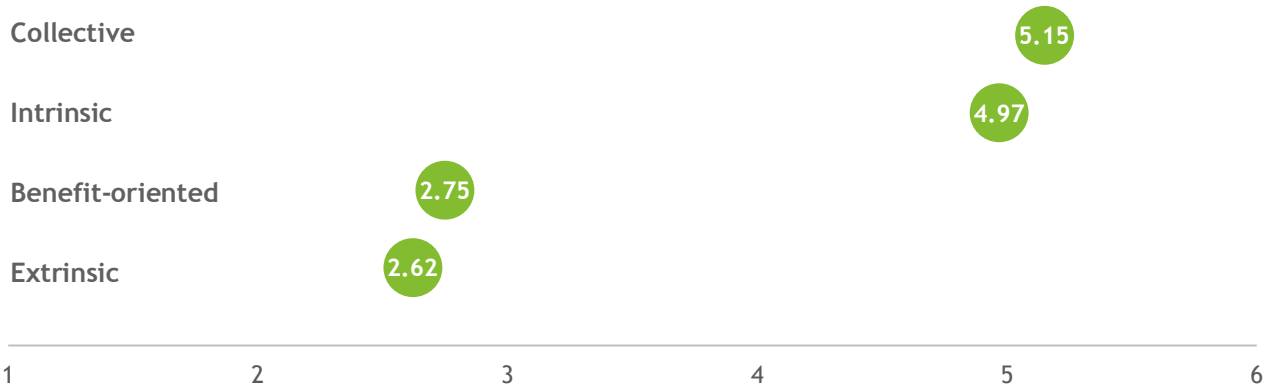


Fig 3. Average rating among scientists of how strongly each motivational factor drove them to participate in the Teen Science Café (n=132)



The summed scale ratings for the four motivational categories (aggregating the individual statements) highlight the strength of Collective and Intrinsic motivations, each of which had means of around 5 (out of 6). The Extrinsic and Benefit-oriented motivations, in contrast, both fell to the negative side of the scale (at or under 2.75), indicating that these two factors had little, if any, effect on scientists' reasons to participate. (See Figure 3, above.)

The open-ended comments left by some of the scientists (n=39) almost entirely reiterated the sentiments expressed in the rating items. Only one idea (mentioned by two people) was not represented in the statements; these individuals were motivated to participate by a prior relationship with the Café organizer. The rest of the sentiments reiterated the blend of Collective and Intrinsic motivations, and noted specific personal experiences that sometimes fueled a Collective motivation – such as the desire to be a role model for underrepresented groups or tying motivations to significant life experience in the scientists' youth. The survey comments mirrored very closely the sentiments expressed in the Phase 1 interviews. Quotations, right, demonstrate the sentiments behind these motivational ratings.

"I think that it is very important to expose teens to science and scientific careers at the time when they are making decisions determining their lives. I view interactions with high school students as the most important and the most rewarding outreach activity." (Survey, 65)

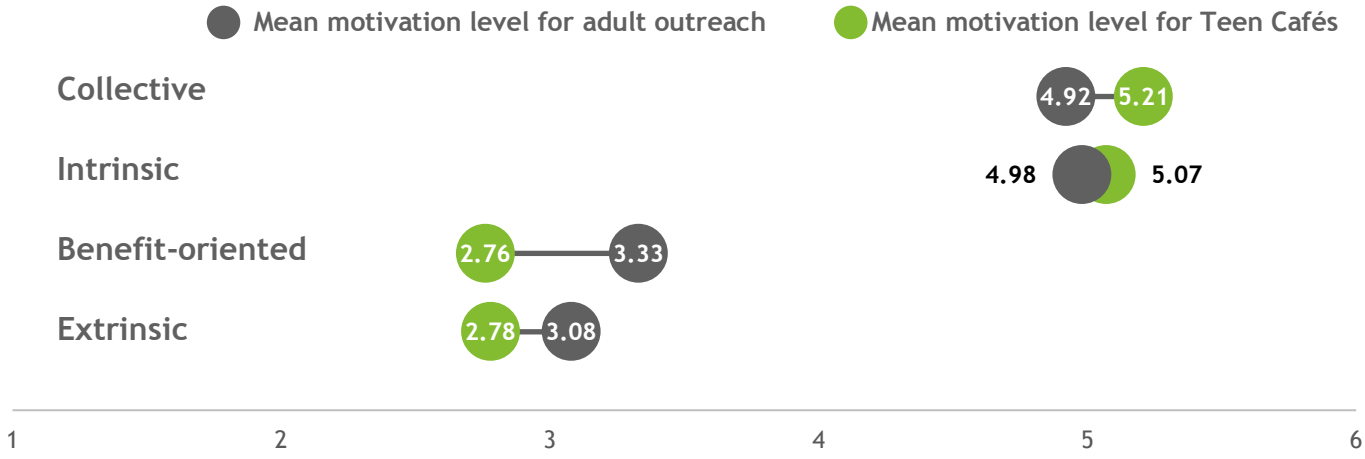
"As a woman, one very important aspect of doing outreach for science is being an example of a successful woman in science, in order to make it easier for young women to see themselves as scientists in the future." (Survey, 25)

"When I was a teenager, I participated in many science camps, fairs, and symposia. It really shaped my career path. I wanted to "pay it forward" and encourage high school students to start thinking NOW about what they might want to do - and how to get there." (Survey, 155)

"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).

"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).

Fig 4. Comparison of scientists' average levels of each motivational factor for doing adult-focused outreach and for doing a Teen Science Café (n=69)



Motivations Specific to Teen Outreach

As described in detail in the Analysis section, responding scientists were asked to report on their motivations for doing outreach with a non-teen audience (depending on what types of audiences they had worked with previously), using the same motivation measures. The most robust sample came from scientists who did adult-focused outreach, such as lectures, tours, or Science Café presentations. Using a final set of 69 scientists who reported their motivations for both types of outreach – Teen Science Cafés and adult-focused talks and Cafés – we compared their reported motivational levels.

Scientists' motivations for adult outreach mirrored the profile seen with teen outreach. Collective and Intrinsic motivations were the main drivers, while Extrinsic and Benefit motivations were weak motivators. However, there were differences in the strength of motivations for each audience. Figure 4 (above) shows the difference in average motivation levels within each category. This highlights the similarity of the overall profile and the relative degree of difference for each motivation.

A paired t-test confirmed that the differences for three of the factors, while small, were statistically significant, depending on whether it was a reason for doing a Teen Science Café or adult-focused outreach. **Collective motivations were stronger for doing a Teen Science Café than for adult-focused outreach; while Benefit and Extrinsic motivations were stronger for adult-focused outreach.** There was no significant difference in Intrinsic motivation levels, suggesting that personal enjoyment may be less dependent on type of audience. (See Table 3 for statistical test results.)

Table 3. Results of paired t-test comparing ratings of strength of each motivational category as reasons for doing a Teen Science Café, compared with reasons for doing adult-focused outreach

	Mean difference	Std. Dev.	t	df	p-value	adj. p*
Collective Motivations**	0.29	0.62	3.91	68	<.001	<.001
Benefit Motivations**	-0.57	0.98	-4.79	68	<.001	<.001
Extrinsic Motivations**	-0.30	0.90	-2.78	68	0.007	0.014
Intrinsic Motivations	0.10	0.64	1.26	68	0.214	0.214

**Holm-Bonferoni sequential correction for multiple comparisons applied.* ***significant at p<.05 level*

Impacts on Scientists

Personal Enjoyment & Goal Fulfillment

Across all of the outcome areas, **scientists most strongly and consistently experienced personal enjoyment and fulfillment due to participating in Teen Science Cafés.** As seen in Figure 5 (below), more than 85% of responding scientists moderately or strongly agreed with all five of statements in this category. From feeling strongly that it was worth the time and effort to feeling strongly that they had positively impacted the youth. Virtually no scientists disagreed with any of these statements (represented by the very small gray-colored bars to the left in Figure 5).

Although these outcomes did not represent a change in scientists' prior attitudes or skills, they are important because **they demonstrate that the Teen Science Café experience fulfilled the core motivations and goals for choosing to participate in this programming.** As discussed earlier, scientists were strongly driven by the desire to positively impact teens (Collective motivations) and by experiencing personal enjoyment (Intrinsic motivation). These data show that Teen Science Cafés fulfill scientists' motivations and provide an enjoyable experience where they can feel they impacted youth in their community. Quotations from interview respondents (right) illustrate the reactions and feelings expressed in these results.

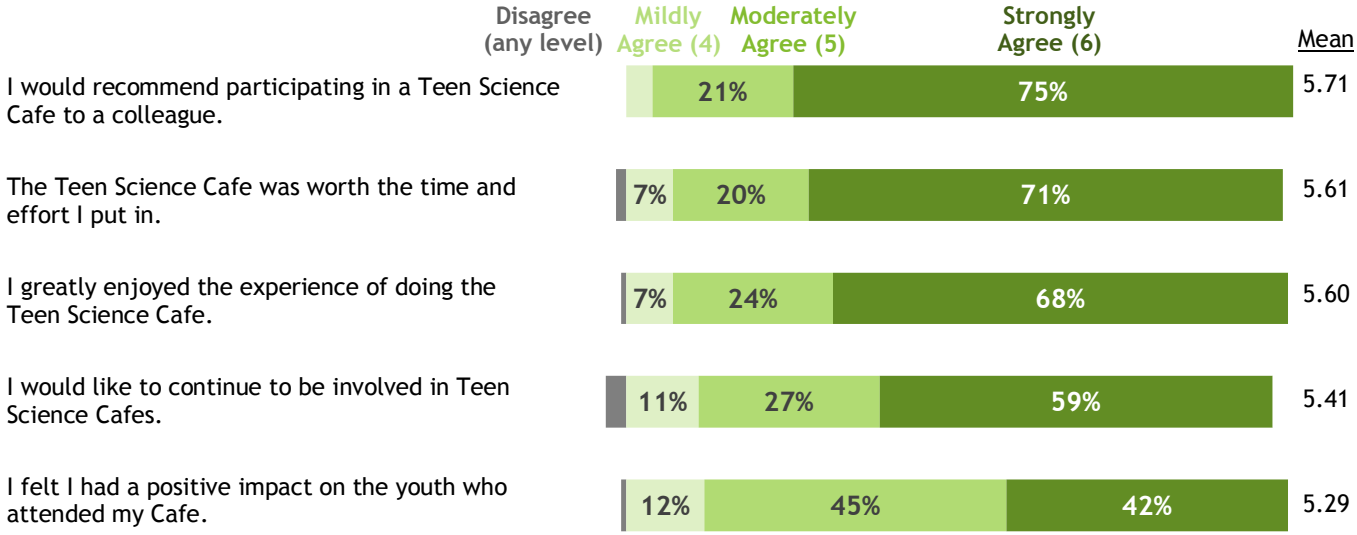
"And then I just love interacting with students and trying to get them excited about science, so I just had fun doing it." (Interview 3)

"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)

"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)

Fig 5. Distribution of agreement ratings by scientists with statements about personal enjoyment and goal fulfillment from the Teen Science Café.

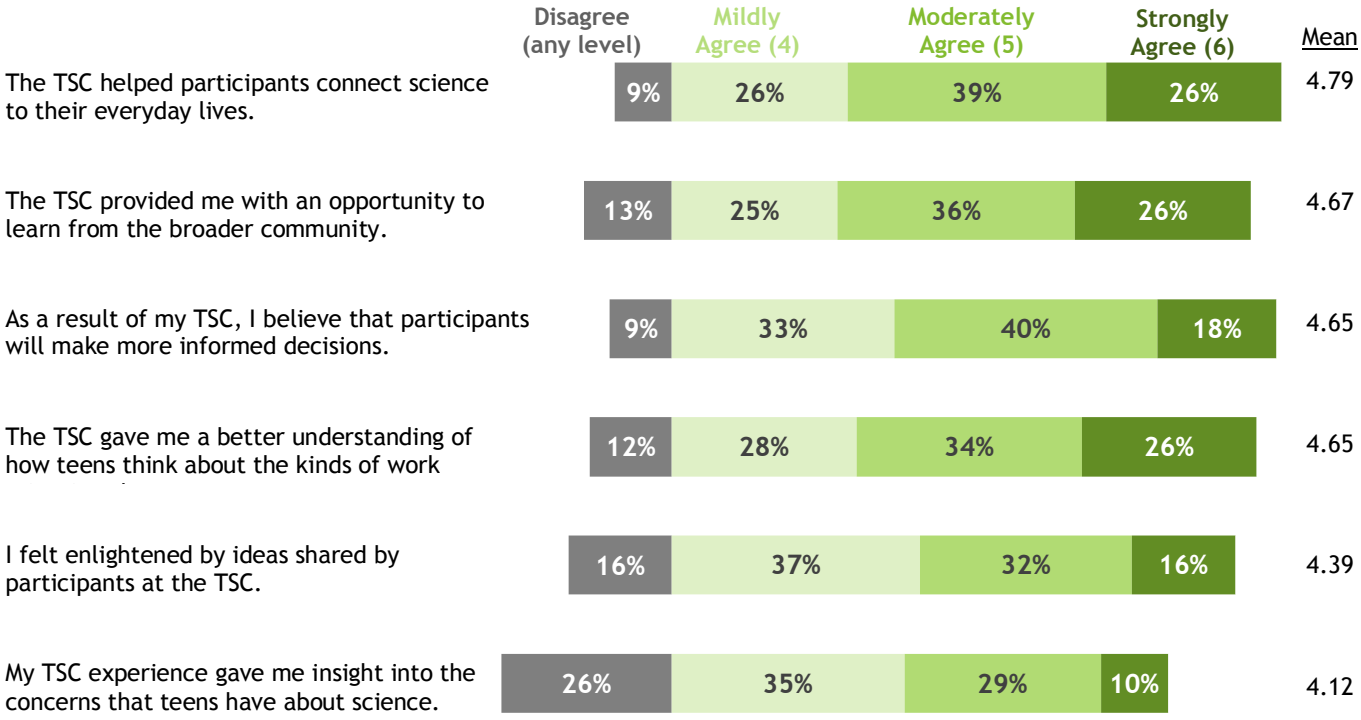


Mutual Learning: Professional View

Several measures were used to examine indicators of mutual learning experienced by scientists from their Teen Science Café experience. A main aspect of mutual learning is how a scientist might come to think differently about his or her work, due to engagement. One measure of this is a recently developed scale designed to measure perceptions of public engagement outcomes, with an emphasis on mutual learning (Peterman, et al., 2017). Using this measure, **TSCN scientist-presenters reported an average level of impact of 4.54 (out of 6), which indicates a mild-to-moderate sense of achieving public engagement outcomes.**

This level was similar to, but slightly lower than, results from initial testing of the scale, which found an average rating of 4.63 from a broad sample of scientists who do public engagement activities (Peterman, et al., 2017). From the TSCN population, the distribution of agreement ratings to the individual items is presented in Figure 6 (below); between 39% and 65% moderately or strongly agreed with each item in the scale.

Fig 5. Distribution of agreement ratings by scientists with individual statements from the public engagement outcomes measurement scale (Peterman, et al., 2017).



Phase 1 interviews suggested that there was a continuum of the types of professional impact experienced from Teen Science Cafés. At the highest level was thinking differently about their own work, a mid-level reflected improving understanding of how publics think about their work, and the least direct impact was changing how they communicate about their work with publics.

To explore the extent of these dimensions, we also asked scientists to respond to a set of four items constructed for this survey. **The responses to these items confirmed the patterns seen in interview data; Teen Science Cafés most often impacted scientists' thinking about how they communicate about their work. About one-third of the sample strongly agreed this had occurred** (Figure 7, below). There was a slightly weaker, but still moderately strong, sense that the Café experience provided new insights about how teens think about their work, which was also illustrated by an open-ended response:

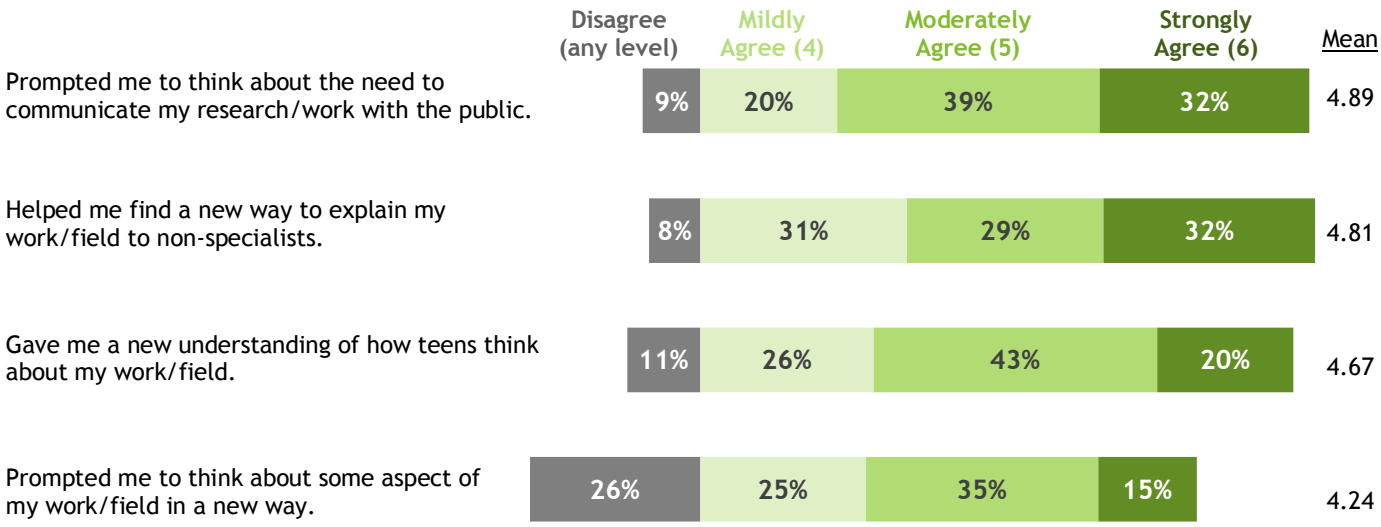
"I work with teenagers while on science expeditions (e.g., Iceland with National Geographic). Participating in Teen Science Cafe gave me insights to how teenagers feel about doing science - and how they engage with hands-on activities." (Survey 155)

Data about the deepest type of mutual learning impact – thinking differently about an aspect of their work – indicated that it had occurred (strongly, for 15% of respondents), but was not prevalent across-the-board. More than one-quarter of respondents disagreed that this occurred. This suggests that such impacts may have been a more infrequent or isolated, but reflects the Phase 1 interview data which presented a few reports of changes in perspective in response to a Café interaction, such as:

"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 [my subject] is really good for me." (Interview 6)

"The main benefit was getting the chance to talk to these kids and hear what they're thinking… Hearing how they think about some of the questions … 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)

Fig 7. Distribution of agreement ratings by scientists with statements about the range of professional impacts from doing a Teen Science Café



Within the survey responses, no scientist-presenters left comments indicating specific anecdotes of ways in which their work had been impacted. However, several scientists who reported disagreement or only mild agreement with the statements within these impact areas provided comments that they felt this was because they were already experienced with outreach or education. These comments suggest a point-of-view that more experienced communicators may feel they already understand public attitudes or thinking about their topic, and perhaps do not expect to experience learning from their audience as a result of each public engagement activity they complete.

"My whole job is basically science outreach, so I can't really claim the Teen Sci Cafe INCREASED my thinking about things (e.g., "gave me a better understanding..." or "find a new way..."). I was already there. …those who do a lot of outreach won't necessarily gain much "new understanding" into how teens think based on yet one more presentation--they've already got it." (Survey 56)

"If I had never done outreach before, maybe it would have impacted my thinking, but having done outreach it wasn't particularly groundbreaking." (Survey 133)

A handful of open-ended responses from scientists who expressed a lack of mutual learning impact discussed difficulties while engaging with the teens during their session. These responses stated or suggested that they were not able to learn about how the teens felt about their work or about how to communicate with the teens, because of the underlying communication difficulties. This points to a relationship between how well a scientist is able to engage an audience and the potential for experiencing change in how they understand the perspectives of that audience.

"Teens are very hard to communicate with, as you do not know if you are getting through to them." (Survey 97)

"The students didn't really engage with me, so it was difficult to gauge their understanding of the topic, what they liked or didn't like, what they would like to know more about -- perhaps the students could submit questions to the scientist before the cafe so that the scientist can work in answers to their questions throughout the presentation." (Survey 143)

Perception of Teenagers at Café

Another quality related to mutual learning explored the perceptions of teenagers based on interactions during the Cafés. From Phase 1 interviews, we did not find evidence that Cafés changed scientists' general perceptions of teenagers as a group. But the interviews indicated that some scientists saw positive qualities in the teens who attended the Café, such as depth of knowledge, critical insights, or high levels of engagement. A few interviews indicated gaining a new perspective about the lives and experiences of teens, but this did not seem to be pervasive.

The response to survey items seemed to support these trends (Figure 8, below). **The majority of responding scientists indicated they strongly agreed that teens had asked very good questions during the Café.** More than one-third strongly agreed that the teens had shown great interest in their topic, with another 47% moderately agreeing with this sentiment. Similarly, scientists surveyed tended to disagree that teens seemed reluctant to participate or easily distracted during the session.

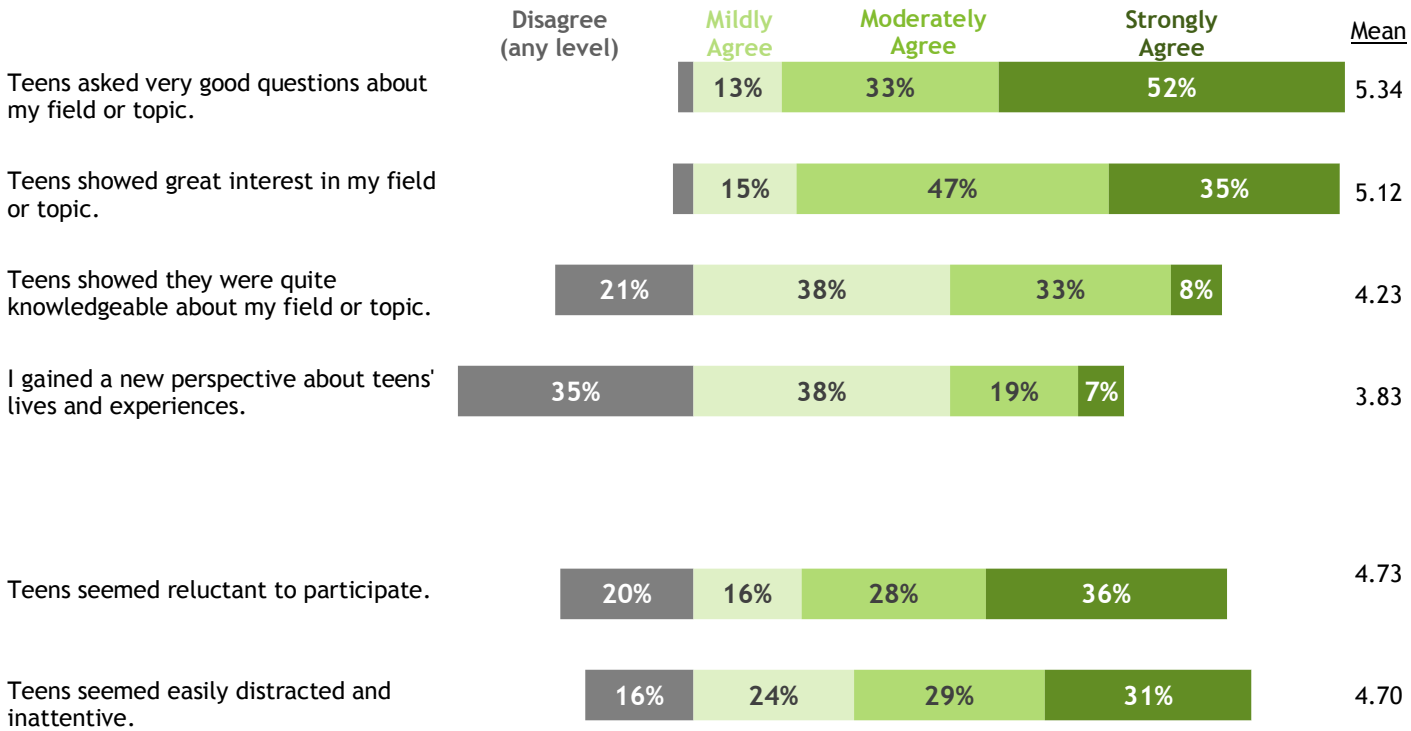
"[It] seemed like participants all wanted to be there and had an interest, although weren't quite sure of themselves enough to ask questions - at first." (Survey 62)

"Having been to previous Teen Sci Cafes and hearing the stories from others, I already knew this was a stellar bunch of folks who'd be interested." (Survey 56)

"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)

Fig 8. Distribution of agreement ratings by scientists with statements about perception of teens' engagement and knowledge levels



Open-ended comments in the survey tended to reflect that some scientists experienced a mix of student engagement levels at Cafés – with some students being highly engaged and asking good questions, and some seeming distracted or disinterested in the experience. In other cases, presenters who went to two different sites noted differences in student engagement and enthusiasm across the sites.

"[It] varied tremendously depending on location." (Survey 110)

"There was a whole spectrum of enthusiasm, from people who already knew a lot and had a lot of good questions to the very disinterested." (Survey 66)

"There were teens who were completely focused and interested and others who were disinterested and disengaged. Overall, even some mildly disinterested teens chose to participate as the topic was applicable to their health and life in general." (Survey 118)

On the whole, however, these data confirm that **the Cafés were not strong at helping scientists gain new perspectives about teens' lives**; 35% disagreed that this was an outcome for them, and only 26% either moderately or strongly agreed. This was a present, but infrequently expressed, experience in the Phase 1 interviews (as illustrated in the quotation below). The survey confirms that while this outcome may happen occasionally, it is not a common impact.

"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)

Communication Skill Improvement

Phase 1 interviews indicated that some scientists felt the Teen Science Café had helped them focus their message and/or build communication skills specific to teens. In order to explore the extent of this impact due to Teen Science Cafés, we asked about improvement in five areas, using items originally used in Portal to the Public evaluations.

The strongest impacts confirmed the themes heard in interviews; **around 65% of scientists moderately or strongly agreed that they had improved their abilities to adjust communication to different age-levels and to explain their work to non-experts** (Figure 9, below). There was slightly weaker sense of improving understanding of the nature of informal learning, and a much weaker sense of having learned about how people learn or how to use inquiry strategies. These latter concepts are less frequently the focus of Café preparations. Examples of impacts described in qualitative data:

"Practice explaining my work to a large group with varied levels of knowledge." (Survey 66)

"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).

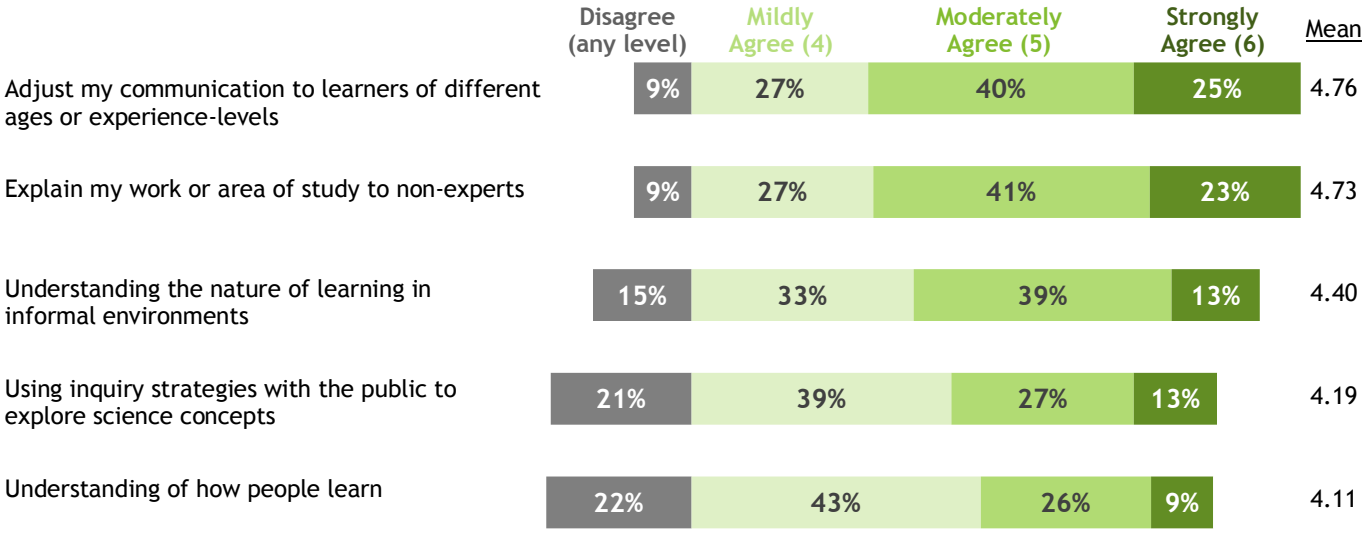
In some of the open-ended survey comments and in the Phase 1 interviews, some scientists felt there was a limit to how much they could gain in skills because they had so much prior experience with outreach or education. Teen Science Café organizers tend to select presenters who have demonstrated prior experience or communication skills. These comments suggest that some of the lower rating levels to this impact area may reflect this "ceiling effect," as illustrated in quotations from respondents:

"I've done many outreach activities like this with ALL ages, so I was already pretty well prepared." (Survey 74)

"…I already understand the nature of learning in informal environments. It's what I do for a living. A single 45-minute presentation, on top of the hundreds I've already done for all different types of audiences, isn't likely to improve my understanding much further. But if I'd never done it before, heck yeah, I'd be putting "strongly agree" all over this survey." (Survey 56)

"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…" (Interview 12)

Fig 9. Distribution of agreement ratings by scientists with statements about science communication skills gained through the Teen Science Café



Impact on Outreach Activities

The survey also explored ways the experience may have impacted outreach activities generally. **More than 58% of respondents moderately or strongly agreed that the Teen Science Café had increased their interest in outreach with teens, allowed them to try a new form of outreach, and improved the quality of their outreach** (Figure 10, below). Anecdotally confirming this finding, a handful of scientists replied by email to the survey invitation message to reiterate that they were interested in doing another Café.

"I guess I would be more willing to do things with that particular age. … it would make me more willing to, at least definitely more comfortable, in doing outreach with teenagers." (Interview 13)

Results were more mixed regarding whether the experience impacted outreach external to the Café. Around 50% strongly or moderately felt they had gained transferrable outreach tools, more than one-quarter disagreed that it had at all. Similarly, more than one-third felt it had not increased level of involvement in outreach generally, and the majority reported it had not led to new connections or partnerships.

These findings again reflect the patterns seen in the Phase 1 interviews, where a few scientists noted these deeper changes in outreach practice or opportunities had resulted from the Café, but it did not seem to be the norm across scientist-presenters. Moreover, because some scientist-presenters are already heavily involved in outreach, there is a "ceiling effect" for how much any new experience might further increase their activities. Comments and interview data reflect the range of sentiments:

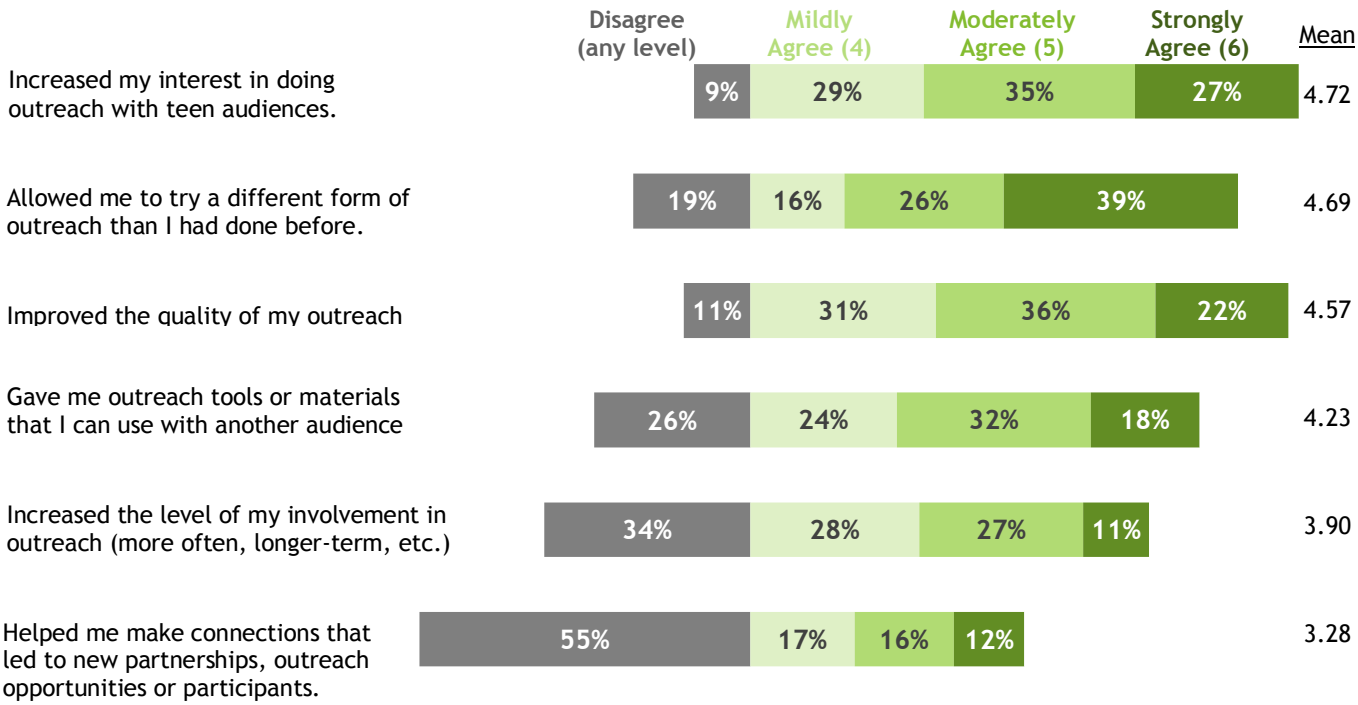
"I may have recruited teens to work with us in the husbandry department." (Survey 47)

"I'm [now] actually trying to start a citizen science project where part of it is tailored to working with high school students." (Interview 3)

"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)

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

Fig 10. Distribution of agreement ratings by scientists with statements about impact on other outreach activities, due to Teen Science Café involvement.



Café Preparation Experience

Beyond basic information about Café format and "what to expect," which is common to working with any Teen Science Café presenter, there was a range in the forms of preparation activities that scientists experienced. Figure 11 (below) shows that **the most common preparation activities were 1) for sites to share information about the Café goals and 2) to ask scientists to turn in materials (e.g., slides, a bio) in advance for feedback.**

More in-depth preparation activities, including collaboration with a Teen Science Café site on the activity, talk, or to do a full practice run of the session, were far less common – each was reported by fewer than one-third of survey respondents.

Teens are most frequently involved in giving feedback via the Dry Run; 86% of those who did a dry run indicated that teens were involved in giving them feedback. (See Figure 12, right.) Collaborative preparation – whether to develop the talk or the activity – tended to vary, with around half of the scientists reporting that teens had been collaborators and half reporting that only adults from the Café worked with them to develop materials.

"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).

Fig 12. Percentage of cases in which teens provided feedback during specific preparation activities

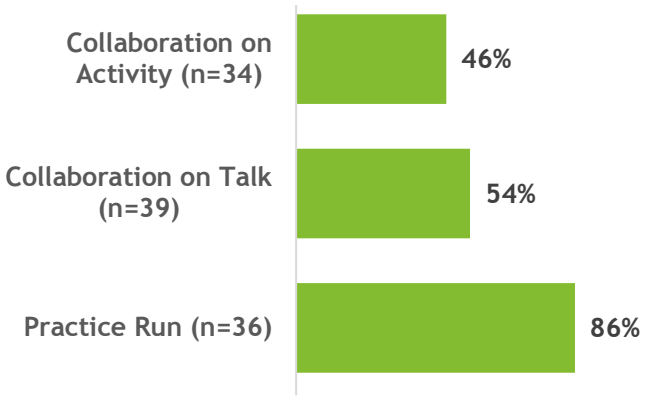
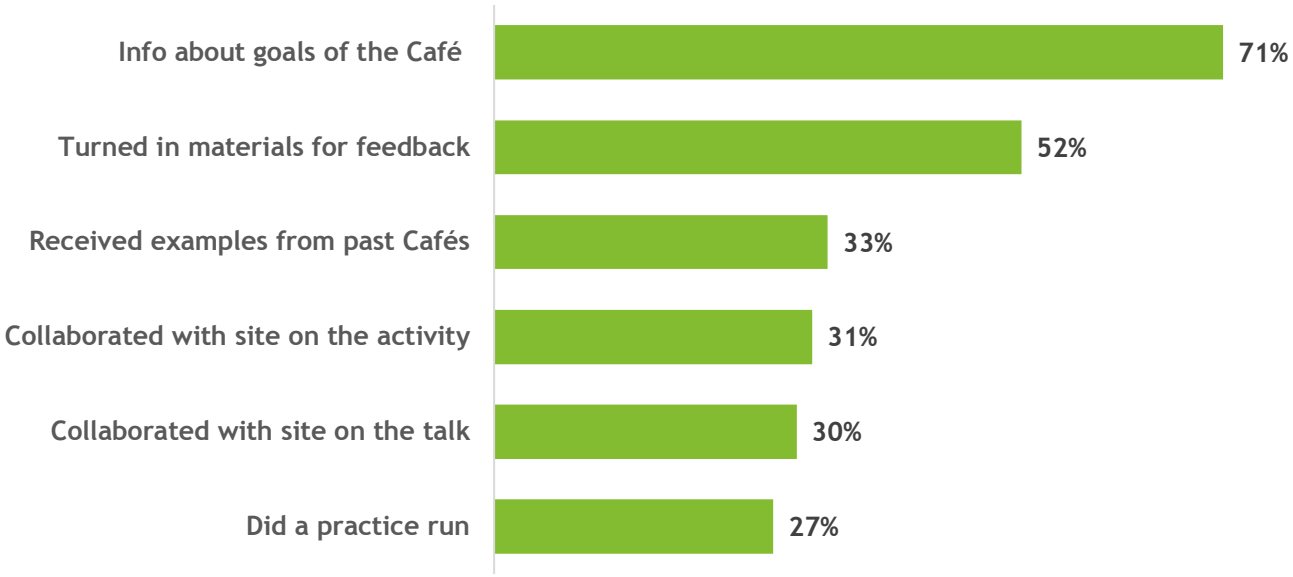


Fig 11. Percentage of scientists who received each of the following forms of preparation activity (n=132)



Feeling of Preparedness

Scientists overwhelmingly felt very prepared to engage with Teens based upon their preparation - 94% reported they felt mostly or completely prepared (Figure 13, below), and no scientists reported feeling unprepared.

As detailed in the Analysis section, scientists were grouped into four levels of preparation activities, based on time-intensity of work with the Teen Science Café organizers. These categories were the basis for statistical comparison of whether the form of preparation activities impacted the feeling of preparedness:

- Level 1: Receipt of Basic Information and/or Goals (31% of sample)
- Level 2: Turn in Materials in Advance (18%)
- Level 3: Collaboration with Café (23%)
- Level 4: Practice Run (27%)

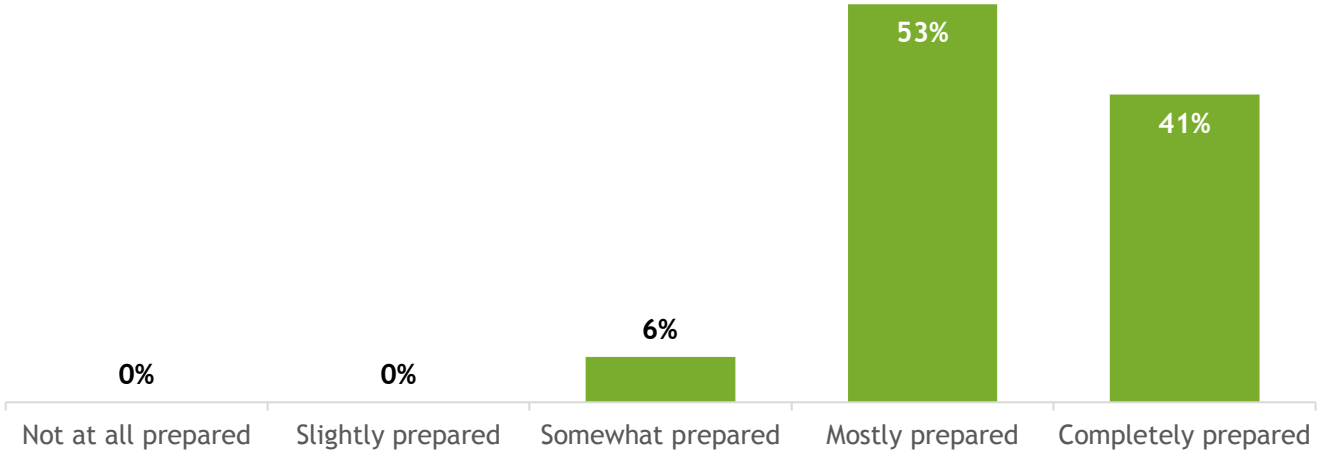
A one-way ANOVA showed there was not a significant effect of the intensity of preparation activities on the scientist's reported feeling of preparedness ($F(3,127) = 1.35$, $p=.260$). Each group's mean preparedness was fairly similar, ranging from 4.2 to 4.5 (see Table 4, below). In fact, Table 4 shows that there was not a clear relationship between greater preparation activities and greater feeling of preparedness.

Although somewhat counter-intuitive, there are several possible reasons for the lack of difference. Primarily, there was very little variation in scientists' feelings of preparedness – all scientists felt quite prepared, regardless of which group they fell into, which made it difficult to detect any difference. Additionally, as has been noted, some scientists entered the program extremely confident and experienced in outreach, which led them to feel very prepared for their Café – whether or not they received additional support from the organizers.

Table 4. Scientists' average ratings of how prepared they felt, based on the level of preparation activities with the Café site

Prep Activity Level	Mean Rating of How Prepared	N	Std. Dev.
1: Basic Info	4.39	41	0.59
2: Materials	4.50	24	0.51
3: Collaborate	4.32	31	0.65
4: Dry Run	4.20	35	0.58

Fig 13. Distribution of how prepared scientist-presenters felt for their most recent Teen Science Café (n=131)



Perceived Value of Preparation

On the whole, scientists found the preparation activities that they experienced to be helpful. **The two most helpful activities - rated extremely or very helpful by 80% or more of scientists - were receiving information about the Café goals and doing a full practice run.** In fact, 40% or more said these two activities were "extremely helpful" (Figure 14, below). Fewer, but still a majority, felt that collaboration and receiving examples from past Cafés had been either very or extremely helpful. The only activity that seemed to be somewhat less helpful was turning in written materials in advance.

This confirmed findings from Phase 1 interviews, in which scientist-presenters tended to describe most of the activities as critically helpful to preparing for this venue and audience. One difference was that few interviewed scientists described learning specifically about the Café goals, but survey results this may have been an oversight, as it was quite common – and quite valuable – for presenters. While most ratings indicated utility of activities, one open-ended comment reflected views of the few who felt practice runs weren't useful, expressing that it increased the time commitment but had not resulted in changes to their plans, talk, or activity.

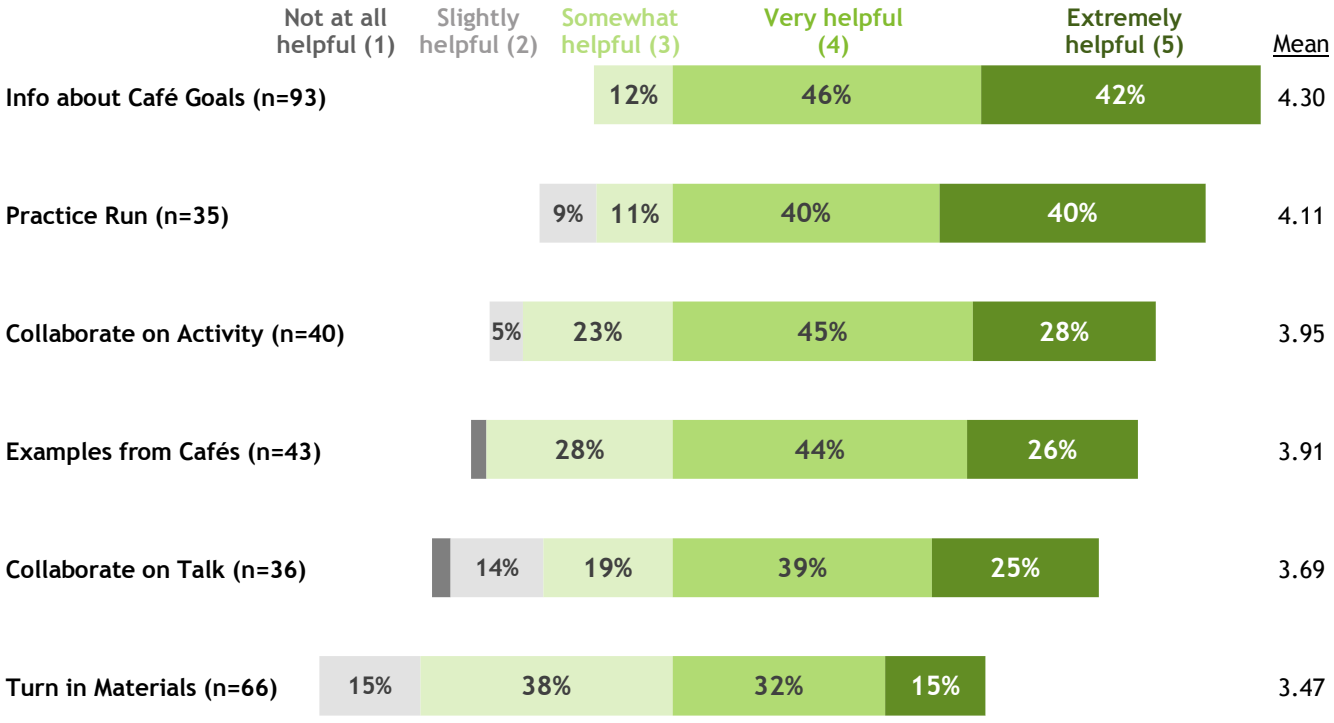
"I am usually pretty prepared, but it was extremely helpful to have a test run with the teen leaders. Their feedback provided very necessary insight, and allowed me time to alter my presentation slightly, making it more interesting the teen audiences later." (Survey 110)

"It was really great having the cafe team help prepare the hands-on activity." (Survey 74)

"While the request for a dry run was understandable, it was also irritating. It required more of my time in coordinating the dry run, more emails, and felt somewhat micromanaging. I didn't end up changing my presentation at all, so it felt more like an interview than anything else when I was already volunteering my time." (Survey 133)

"It was definitely useful 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 14. Distribution of how helpful scientists felt each preparation activity was for their Café



Difference in Perception of Usefulness

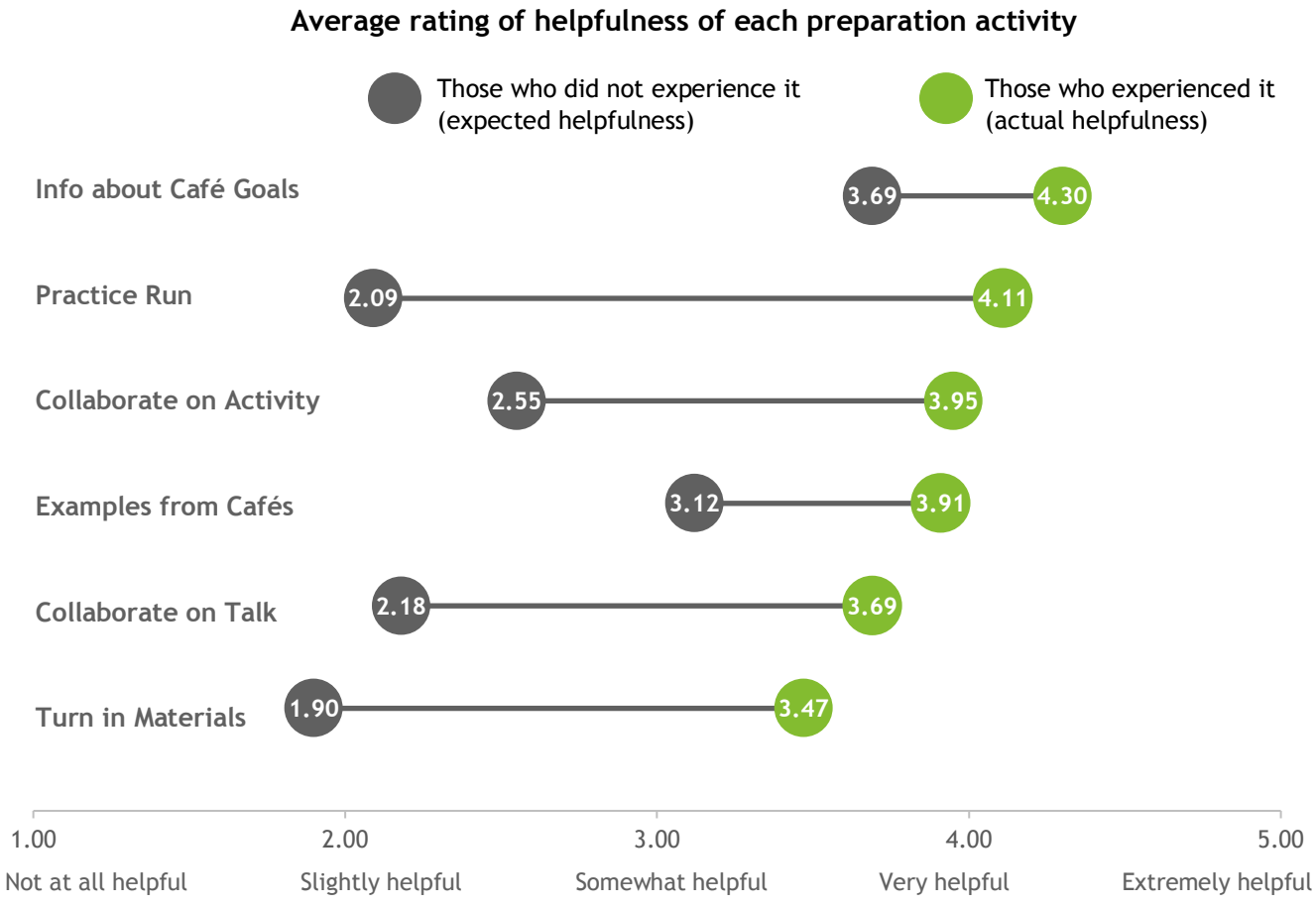
Scientists were also asked to consider the areas of preparation they had not actually experienced, and then rate how helpful they thought such a preparation activity might have been for them. This line of questioning responded to a pattern seen in Phase 1, where most scientists who had done a practice run felt it was extremely helpful, while those who had not done one seemed ambivalent about its potential utility.

In the survey results, scientists' ratings of the likely helpfulness of activities they had not experienced were generally quite low, with average helpfulness ratings ranging from only 1.90 to 3.69. Presenters tended to think that information about the goals of the Café would have been most useful, followed by examples from past Cafés. Open-ended comments cited concerns about time commitment and of being already experienced at outreach, feeling that some of these activities weren't necessary.

By comparing ratings of helpfulness based on actual or hypothetical experience, we see that **scientists who experienced a given preparation activity rated it as much more helpful than those whose rating reflected an anticipated level of helpfulness** (Figure 15, below). All differences were statistically significant (at the $p<.001$ level) in an independent samples t-test (see Appendix A for details). The most dramatic differences were on the four most time-intensive strategies for a scientist:

- Doing a practice run
- Collaborating on the talk
- Collaborating on the activity
- Turning in materials in advance for feedback

Fig 15. Comparison of average ratings of helpfulness for each preparation activity, depending on whether it was based on actual or hypothetical experience



As described earlier, those who did a practice run or collaborated with sites to develop their hands-on activity found the experience very or extremely helpful in preparing for the audience. Comments in Phase 1 interviews tended to talk about these experiences and receiving feedback directly from teens as being one of the most useful types of support they received. These comments mirror the high ratings of helpfulness that was revealed in the survey results.

"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)

In the survey results, there were a few scientists who expressed that they would have benefited from receiving greater support from their Café site, including interest in collaboration and/or doing a practice run. These opinions were clearly not dominant across the sample, but they were present.

"I was given a data and time and general topic to discuss, I developed everything else on my own. Some assistance in these areas would have been helpful and would make me more likely to do another cafe, as this was a tremendous burden in terms of time and effort." (Survey 82)

"…It would be nice if more preparation and collaboration would occur, but it was good that something was there to cover me for an activity [provided by the Education department]. As a scientist, we are not always equipped or trained in development of activities, however on the flip side, we have a lot of ideas and data that could be of use if collaborating with someone with an education background." (Survey 62)

It was notable that scientists who did not do a practice run, tended to feel that it would have only been slightly helpful to them. This matched the sentiments expressed in interviews, where scientists either imagined it was either unnecessary or would have only been marginally helpful.

"For the activities that we did, [a dry run] 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)

"[A dry run] probably would have been [helpful]. But I think the benefit would have been marginal." (Interview 15)

Several open-ended comments in the survey similarly expressed scientists' doubts about the value of the practice run. **However, several comments in the survey responses indicated that, in the abstract, some scientists may not be able to envision how a practice run works or the role played by teens in giving feedback.** These comments indicate that scientists do see value in learning from delivering the session to teens, but that they are not envisioning a way to do this other than the event itself.

"A practice run of the activity is not likely to be especially useful unless you actually have a group of students similar to the target audience with whom to conduct it." (Survey 34)

"After doing it once, I am better prepared to deliver a more relevant talk. The only way to fully understand the audience is having done it once before. I usually talk to college students." (Survey 80)

Other comments in the survey again related to a scientist feeling already experienced in outreach or education, or being wary of activities that would require greater time commitment. Taken together, this suggests that scientists have incoming biases about what preparation activities entail and what they might provide, which may not align with a Café organizer's design or intent for the activities.

Influence of Other Characteristics

As described in the Analysis section, we conducted exploratory analyses to look for evidence of relationships between various dependent variables measured in this study (i.e., motivations, impact areas, feeling of preparedness) and known characteristics of the scientists or their program experience:

- Gender identity
- Career Stage
- Type of Preparation Activities for the Teen Science Café
- High/Low Experience with Teen Science Cafés
- High/Low Experience with Other Outreach
- Prior Formal Communication Training

Personal/Career Characteristics

Other than the relationships already discussed in this report, very few significant relationships were uncovered in this analysis. Among individual characteristics, there were no differences found in how scientists responded based on gender identity. There were generally few differences based on career stage, however, there did appear to be a significant effect of career stage on a Benefit-oriented motivation for doing the Teen Science Café ($F(2, 124)=17.64$, $p<.01$); **as scientists were earlier in their career, they rated Benefits higher as a motivational factor** (see Table 5, below). There were not significant differences in the other motivational categories based on career stage, however. Since the Benefit motivation had the weakest reliability as a scale, this result should be interpreted cautiously.

Table 5. Scientists' average ratings for the Benefit-oriented motivation, based on the career stage

Career Stage	Mean Benefit Motivation	N	Std. Dev.
Early-career or Student	3.36	55	1.19
Mid-career	2.62	45	1.29
Senior-career or Retired	1.78	27	0.76

When looking at the impact items individually, results suggest that there may be a relationship between career stage and two outreach-focused variables: the sense that the Café improved the quality of outreach ($F(2, 123)=15.72$, adj. $p<.01$); and that they walked away with transferrable outreach tools or materials ($F(2, 124)=11.87$, adj. $p<.05$). **In these cases, earlier career professionals tended to rate these impacts higher than more experienced science professionals.** This may reflect that they are also newer to outreach and felt they had more room to grow.

There were no significant relationships found between career stage and other variables, including the public engagement impacts scale or individual items in other areas.

Teen Science Café Activities

There was no evidence found of significant relationships between the various motivation or impact scales and the type/level of preparation activity the scientist experienced, nor was there evidence of a significant relationship between motivation or impact scales and whether a scientist had been a first-time or a multi-time Teen Science Café presenter.

Prior Outreach & Training Experience

There was no evidence found of relationships between the various motivation or impact scales and the level of experience with other forms of outreach, nor was there evidence of a significant relationship between motivation or impact scales and whether a scientist had previously experienced formal communication training (versus primarily learning through experience of doing outreach).

Discussion & Conclusions

Teen Science Café presenters are particularly motivated by a desire to contribute to the collective good through their participation – specifically, the opportunity to impact teens.

The survey data showed that scientist-presenters are strongly motivated to participate in Teen Science Cafés by two driving factors – their desire to contribute to the collective good and intrinsic benefits of personal enjoyment from doing outreach. In contrast, extrinsic motivations (e.g., expectations of an employer or funder) and benefit-oriented motivations (e.g., gaining skills or enhancing one's CV) were generally a very weak or irrelevant motivational factor for participation in this type of outreach.

These findings confirmed patterns found in the Phase 1 interviews with scientist-presenters, in which scientists tended to speak about multiple motivations, with the two most common themes representing collective good and intrinsic motivations. While interviews included mentions of added benefits of extrinsic factors, such as dove-tailing with a professional outreach requirement, this was generally stated as a peripheral reason for participating in the Teen Science Café. Likewise, benefit-oriented motivations were very rarely mentioned in interviews at all.

The descriptions given in interviews seemed to indicate a strong link between motivations for the collective good and the teen audience of these Café programs. Interviewees had described a desire to encourage pursuit of STEM careers, serving as a role model, and providing opportunities to spark new interest in STEM within this specific audience. Survey data seemed to confirm this relationship, as we found that scientists reported stronger collective motivations for doing Teen Science Cafés, as compared with motivations for engaging in adult-focused outreach activities. While scientists' desire to contribute to collective good was a very strong motivator for all types of outreach, it was a significantly stronger motivation for Teen Science Cafés. This likely reflects scientists being attuned to the opportunities afforded by teens' life-stage, where they see the Café as an opportunity to encourage and shape future paths in ways that are not as central to working with adult audiences.

Personal enjoyment and goal fulfillment are the most powerful outcomes experienced by scientist-presenters, achieving their main motivations and fueling ongoing participation.

While the responses from scientist-presenters showed positive reactions and outcomes across many of the areas measured, there was overwhelming, strong agreement that the Teen Science Cafés created great personal enjoyment and a feeling of fulfillment among the vast majority of scientists who participate in the program. While these outcomes do not represent a change in scientists' views or skills, they are important because they demonstrate the capacity of the Café programs to create fulfilling and rewarding experiences for the scientists who volunteer their time, where they feel they are making an impact on youth in their community. Phase 1 interviews suggested that personal fulfillment was an important takeaway in the view of scientists, as they cited specific examples of conversations with youth at Cafés that they felt showed their potential for achieving the positive impact that they desired to achieve by doing this type of outreach.

Another area where scientist-presenters reported strongly positive responses to the Café experience related to the youth participants. Phase 1 interviews had revealed that scientists were impressed by the quality of questions, knowledge, and engagement by teens at Cafés, but did not indicate that the experience shifted their perceptions of teens more broadly. The survey data seemed to confirm these patterns, with scientists strongly agreeing that teens had asked good questions and been highly engaged in the Café, but there was far weaker sense that scientists had walked away from the experience with a better understanding of the teens or teens' lives. Another caveat that emerged in the data was that the perceptions of teens' engagement was inconsistent, showing substantial variation between programs or (based on open-ended comments) between individual teens attending a single program. Several presenters noted that they had seen a difference in engagement between youth attending by choice and those attending for a school assignment. This area of outcome experience for scientists seems highly dependent on program-related factors.

Aspects of mutual learning by scientist-presenters occur broadly, but primarily come in the form of thinking about new ways to talk about their expertise to non-experts.

Mutual learning from public engagement with science activities is an oft-stated goal for which there has been limited evidence of achievement. The survey results show that Teen Science Cafés had moderate success at achieving this outcome, but seem to suggest that the most common type of impact was to prompt scientists to think about how they might communicate about their work differently to resonate with a teen audience. This indicates new perspective-taking activities by scientists, in the process of preparing for communication. This was supported by Phase 1 interview data, where this was one of the more common mutual learning outcomes expressed by scientists.

More direct qualities of public engagement or mutual learning outcomes appeared to be moderately present, but were less pervasive as results from the Teen Science Café experience. Using a validated public engagement outcomes scale, Café scientist-presenters rated an average outcome that was similar to, but slightly lower than, an average from a broad sample of outreach-engaged scientists. While some scientist-presenters rated very strong impacts related to mutual learning – such as changing a perspective on their own work or improving understanding of how teens think about their work – for most, this was something experienced only weakly, if at all.

This also seems to confirm patterns in Phase 1 interview data, which showed that these deeper impacts of mutual learning were present among Teen Science Café scientists in some cases, but that they were not broadly experienced outcomes. The data raise further questions about what factors may relate to a scientist's gains in these areas – whether it is influenced by the nature of a particular engagement experience, whether it has more to do with scientist mindset or experience, or whether other factors are involved in creating the conditions for this type of perspective-change. The data collected in this study did not show evidence of a particular characteristic that may have related to higher or lower impact in this area.

Scientist-presenters bring a high level of outreach experience, which seemed to limit potential for the Café to impact their skills and outreach behaviors.

Survey and interview data both clearly indicated that scientist-presenters are well-vetted by Teen Science Café organizers, and that the vast majority come to the program with extensive experience doing outreach. Nearly all presenters are actively engaged in at least one other type of outreach, and most are actively engaged in multiple forms of outreach – from adult lectures to K-12 outreach to science festivals and beyond. This extensive outreach experience leads to a strong sense among presenters of entering the program with a well-developed set of communication skills; and around half of the presenters have had some sort of additional formal science communication training.

This high level of experience and self-confidence as science communicators seemed to temper the extent of potential impact experienced in the areas of communication skill improvement and impact on outreach activities. Survey results showed that reports of skill-gain as a result of the Café was moderate for scientists, with the most direct influence relating to the attributes of the teen audience – how to talk about one's research and how to communicate with a range of audience ages. Similarly, the main impact on outreach activities was to provide an opportunity to engage in a new form of outreach or engage with a new audience. This impact included interest in doing more outreach with teen audiences in the future. These themes were also heard in Phase 1 interviews as the most common impacts on scientist-presenters, with outcomes most centrally tied to the teen audience being most central to their experience.

Changes in broader communication skills or outreach behaviors occurred, but among a much smaller subset of scientist-presenters. The Teen Science Café program does not seem to be primarily suited to shifting scientists' understanding of the nature of learning, for example, nor does it broadly shift mindset and interest in outreach generally. This is due to the fact that these are not central to the Café experience, but also to the fact that the presenters are already highly experienced and active in outreach, with very little room for further gains from this type of experience.

Scientists feel well-prepared for their Cafés, and those who do a Dry Run or collaborate with sites to develop materials find the experience extremely helpful preparation.

Survey data confirmed that preparation activities vary substantially across Café sites and between individual scientists. While virtually all scientists receive necessary background, logistical, and "what to expect" information, the extent of additional preparation support is more varied. Essentially, some scientists' preparation consists mainly of receiving information and preparing independently, while some are expected to turn in materials in advance, while others actually collaborate with Café organizers to develop materials, and some participate in a practice run of their session (usually with teen leaders).

The data show that, regardless of preparation activities, scientists felt well prepared for their Teen Science Café. Because the feeling of preparedness was so strong across-the-board, there was no evidence of a relationship between the form of preparation activities and this confidence. It is quite possible that this finding is influenced by the high incoming experience levels of nearly all Café presenters in this program, which also would have influenced a feeling of preparedness.

However, the data showed a very strong difference in how scientists perceived the value of preparation activities, based on what they had experienced. Survey data confirmed a Phase 1 finding that presenters who did a practice run or collaborated with sites on their session rated those experiences extremely useful, describing them as "essential" in qualitative data. In contrast, those who had not done these activities imagined they would have been minimally helpful, if at all. Qualitative data suggests some scientists lack clarity about what a Café practice run would entail, particularly the role of teens in the process. Some scientists doubted the effectiveness of such practice being done with adult organizers, not imagining that teens would be involved in advance of the Café itself. These data suggest that preparation activities that involve teen feedback are very helpful for scientists, but that it is critical to clearly communicate to scientists the structure, function, and value of these processes in order to get their buy-in. Such processes are not the norm for scientists, and they may not be able to envision the benefit it will provide them.

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Appendix A: Additional Statistical Results

Motivation Items: Factor Analysis Results

As an exploratory effort was conducted to determine if it was feasible to reduce a list of 14 Likert-type motivational statements to a smaller number of scales that reflected underlying motivational constructs. The results of that exploratory effort are below, with the caveat that this was exploratory in nature using just the sample available in this study. Further testing to confirm the reliability of these factors is recommended.

Exploratory factor analysis, using the principal components analysis (PCA), was conducted on the 14 Likert-type items (six-point scale: 1=strongly disagree, 2=moderately disagree, 3=mildly disagree, 4=mildly agree, 5=moderately agree, 6=strongly agree). Data from 128 respondents was included (4 participants with missing data were excluded from analysis). The criterion for inclusion in the model was that a component had an eigenvalue greater than 1, which resulted in four-factor model (Table 6).

Varimax rotation was used to determine the factor-loadings for each item used. In the final solution, each item loaded greater than .5 onto one of the four factors and no items loaded on multiple factors, with one exception. One statement loaded moderately on two factors, a review of this item led to the determination of the factor for that item, based on its conceptual intent. All of the factor-loadings were reviewed by the researcher for the degree to which they reflected an actual underlying conceptual structure; most of the items loaded in ways that reflected coherent underlying themes for the set of items. Table 7 shows the final factor solution for these items, highlighted cells represent the identified dominant factor for each item, factor names were created by the researcher to describe the underlying constructs.

Factor scores for each factor was generated by averaging the responses for each item within a factor. Factor scores were generated for any respondent with completed data for all 14 motivation items (n=128). Reliability analysis was run to verify using the items as a summed scale. Descriptive statistics and reliability testing results are presented in Tables 8-9.

Table 6. Principal Component Analysis: Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.19	29.93	29.93	4.19	29.93	29.93	2.83	20.21	20.21
2	2.11	15.10	45.03	2.11	15.10	45.03	2.17	15.52	35.73
3	1.37	9.82	54.85	1.37	9.82	54.85	2.28	16.29	52.02
4	1.13	8.04	62.89	1.13	8.04	62.89	1.52	10.88	62.89
5	0.93	6.64	69.53						
6	0.75	5.37	74.91						
7	0.72	5.14	80.04						
8	0.65	4.68	84.72						
9	0.50	3.58	88.29						
10	0.46	3.31	91.61						
11	0.38	2.71	94.32						
12	0.30	2.17	96.49						
13	0.27	1.90	98.39						
14	0.23	1.61	100.00						

Table 7. Results of Factor Analysis: Rotated Component Matrix; highlighted cells represent the researcher-identified dominant factor

Item	Factor 1: Collective Motivation[1]	Factor 2: Extrinsic Motivation	Factor 3: Intrinsic Motivation	Factor 4: Benefit Motivation
It was an opportunity to showcase an area of science study or careers	0.74	0.29	-0.02	-0.01
I wanted to encourage the participants to pursue study or careers in science	0.71	-0.05	0.07	0.09
I wanted to be an example of what a scientist is really like for participants	0.55	0.02	0.17	0.04
I wanted to communicate about a topic that impacts the lives or decisions of the participants[2]	0.34	0.20	0.43	-0.23
I wanted to raise awareness of science	0.76	0.01	0.39	0.07
I wanted to raise interest and enthusiasm for science	0.78	0.08	0.23	0.02
I enjoy doing outreach and public engagement work in general	0.14	0.09	0.83	0.01
I enjoy engaging with teens	0.17	-0.07	0.79	0.07
It sounded like it would be fun	0.26	0.18	0.70	0.33
I wanted to increase the visibility of my work or institution	0.21	0.64	0.04	0.13
It would help meet outreach requirements in my work	0.07	0.79	0.08	0.28
My institution expects or requires me to participate in outreach	-0.06	0.86	0.09	-0.09
I wanted to improve my communication skills	0.06	0.03	0.19	0.86
I wanted to enhance my resume or professional reputation	0.06	0.46	-0.06	0.71

[1] Factor motivation labels were given by the researcher to reflect the underlying constructs represented by the items within each factor.

[2] Item moderately loaded on two factors; researcher determined it best aligned with the constructs of Factor 1

Table 8. Reliability statistics for factors

Factor	Chronbach's α	Number of items
Factor 1: Collective Motivation	0.74	6
Factor 2: Extrinsic Motivation	0.71	3
Factor 3: Intrinsic Motivation	0.77	3
Factor 4: Benefit Motivation	0.61	2

Table 9. Descriptive statistics for summed scale scores for each factor

Factor	N	Mean	Std. Dev.	Minimum.	Maximum
Factor 1: Collective Motivation	129	5.15	0.68	3.17	6.00
Factor 2: Extrinsic Motivation	129	2.62	1.27	1.00	6.00
Factor 3: Intrinsic Motivation	129	4.97	0.84	2.67	6.00
Factor 4: Benefit Motivation	129	2.75	1.30	1.00	6.00

Preparation Activities: Independent t-tests of Helpfulness Ratings

Respondents were asked to rate each possible preparation activity on the same five-point Likert-type scale of its helpfulness (1=not at all helpful; 2=slightly helpful; 3=somewhat helpful; 4=very helpful; 5=extremely helpful). The stem of the question was altered depending on whether the scientists had actually experienced the particular form of training. If they *had* experienced it, they were asked "How helpful was each to you in preparing for your Café experience?" If they *had not* experienced it, they were asked "How helpful do you think each would have been for you in preparing for your Café experience, if you'd had it?"

Ratings for each form of preparation were combined in a single variable, with the individual respondent coded as either responding based on experience (actual helpfulness) or responding based on hypothetical experience (expected helpfulness). Each rating was compared using an independent t-test between the two groups (actual and expected); a Holm-Bonferroni correction applied to correct for possible error introduced for repeated comparisons, however the extremely low p-values meant this had little effect. Results of the t-tests are presented in Table 10.

Table 10. Results of independent t-test comparing ratings based on whether or not the scientist had experienced the form of preparation

	Expected			Actual			Mean Difference	t	df	p-value	adj. p*
	N	Mean	Std. Dev	N	Mean	Std. Dev					
Examples from past Cafés **	84	3.12	1.01	43	3.91	0.87	0.79	4.35	125	<.001	<.001
Goals of the Café**	36	3.69	0.79	93	4.30	0.67	0.61	4.38	127	<.001	<.001
Turn in materials in advance**	60	1.90	1.08	66	3.47	0.93	1.57	8.74	124	<.001	<.001
Collaborate on talk**	88	2.18	0.94	36	3.69	1.09	1.51	7.75	122	<.001	<.001
Collaborate on activity**	86	2.55	1.23	40	3.95	0.85	1.40	7.44	106.5	<.001	<.001
Practice Run**	91	2.09	1.10	35	4.11	0.93	2.03	9.63	124	<.001	<.001

**Holm-Bonferoni sequential correction for multiple comparisons applied.* ***significant at p<.01 level*