Teen Science Research, Communication & Education Program (TSRCP)

Cohort I Evaluation Report

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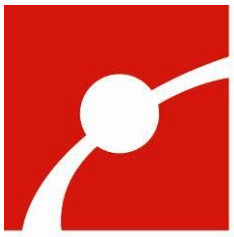

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EXECUTIVE SUMMARY

The Teen Science Research, Communication & Education Program (TSRCP), funded by the National Science Foundation (*Developing A Program Model for High School Science Research, Communication and Education Experiences in Living Laboratory*; DRL-1811276), aims to refine and test a model for having young people participate in and communicate about experimental psychology research. Led through a collaboration between the Museum of Science, Boston (MOS) and Boston University (BU), TSRCP involves a year-long employment program during which teens: 1) engage in research practices, 2) engage in science communication practices, 3) engage in science education practices, 4) experience mentorship from STEM professionals, and 5) become members of scientific communities. The Cohort 1 experience was designed to include a summer intensive (June – August), followed by continued involvement one day per week during the subsequent school year (September – June).

To assess and inform the effectiveness of the program model, the Research and Evaluation Department at MOS conducted a developmental evaluation of Cohort 1. The evaluation was tasked with describing the extent to which teens engaged in core program elements, how teens' science identities changed over time, and which program elements contributed to these changes. Data collection involved surveys, interviews, observations, focus groups, and artifact reviews. The evaluation questions and key findings for each question are:

- *How do teens' science identities change over the course of the program?* Teens entered the program with high interest in and positive affinity for science. These positive interests and affinities continued during the program, with the data suggesting increased differentiation about specific aspects of science that were more and less interesting. In particular, interest in science communication tended to rise over time. When considering science research, communication, and education skills that were part of the TSRCP program, teens tended to report relatively consistent levels of confidence across the program, although they reported a decrease in confidence for writing up a study for a scientific audience at the end of the program. In thinking about the broader ability to contribute to science, teens indicated a decrease in confidence over the summer that then increased over the course of the school year. Teens valued the sense of community they experienced as part of the program, which tended to increase towards a peak at the end of the summer when the program was most intensive. Over the course of the program, teens' sense of self in relation to science became more internalized and less focused on other peoples' opinions.
- *To what extent do teens engage in the core program elements?* Despite some challenges in logistics and communication, the program was highly effective at engaging teens in research practices. Science communication practices were integrated into the TSRCP research activities, although not all teens recognized them as being science communication practices. Although teens enjoyed the science education they did in TSRCP, less program time was dedicated to science education than other program elements. Teens found the program's mentorship to be strong, especially during the summer when the teens had the most contact hours with the program. In terms of community-building, the participants felt well-connected to their immediate peers and mentors, although they sometimes felt disconnected from the broader Museum and Boston University communities.
- *How do the core program elements contribute to changes in teens' science identities?* The program focus on psychology, ability to plan a research study, talking to visitors on the Museum floor, and mentorship were most often associated with interest in science. Teens

indicated that increases in their skills and confidence went hand in hand with what they thought they spent the most time doing: research and science communication. Teens felt that being a member of the MOS community, doing science education, and engaging in research practices contributed to positive science identities.

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I. INTRODUCTION

PROJECT OVERVIEW AND GOALS

The Teen Science Research, Communication & Education Program (TSRCP) is a pilot and feasibility program, funded by the National Science Foundation (Developing A Program Model for High School Science Research, Communication and Education Experiences in Living Laboratory; Award #DRL-1811276), that aims to refine and test a model for having young people conduct and communicate about experimental psychology research. This effort is a collaboration between the Museum of Science, Boston (MOS) and Boston University (BU).

TSRCP draws on the successful Living Laboratory® model that educates museum visitors about developmental science by involving them in authentic developmental research experiments and public outreach activities in museums. Living Laboratory® creates these educational experiences through a structure of partnership and mutual professional development between researchers and museum professionals. Researchers gather data in museums and share their research with museum staff and visitors, while museum staff share their expertise in science communication with the researchers. Museum staff also directly engage visitors in educational activities that share developmental research processes and outcomes in engaging, hands-on ways. This model began in 2005 at the Museum of Science, Boston and has now expanded to more than 30 sites around the country.

While the original Living Lab model focuses on professional outcomes for adult researchers and museum staff, TSRCP invites teens to the program with the aim of exploring the outcomes of their participation in science research, communication, and education as well as the development of their identities as related to science. Overall, the goals of the current project are to:

1. Pilot a program in which high school students conduct both scientific research and engage the public in learning about science;
2. Explore strategies for museums and universities to collaboratively engage, support, and mentor high school students in science research, communication, and education activities;
3. Document curricular, other programmatic, and evaluation materials; and
4. Convene professional participants to provide feedback on pilot materials, and assess the viability of implementing similar programs in the future.

The centerpiece of the project is the program for high school students. As part of this program, teens are hired employees of the Museum and also maintain affiliation with Boston University for a year-long co-appointment. The program is structured around five core program elements, stating that teens will:

1. Engage in research practices: Teens replicate published research, conduct novel research, and analyze data.
2. Engage in science communication practices: Teens develop communication products such as academic posters, social media, and more.
3. Engage in science education practices: Teens facilitate research toys and work on the Museum floor as science educators.

4. Experience mentorship from STEM professionals: Teens have mentors both from the Museum of Science and from Boston University.
5. Become a member of a science community: Teens are integrated into scientific communities as Museum staff and contributors to Boston University's Social Development and Learning Lab.

COHORT 1 DESCRIPTION

Six teens participated in the first TSRCP cohort, which began with an intensive summer involvement in 2019 and then extended through the spring of 2020. During the summer, teens worked three days per week. In the school-year, they worked one day per week. A summary of the curriculum and associated contact hours is printed in Table 1.

Table 1: Curriculum summary table for Cohort 1

	Summer 2019	Fall 2019	Spring 2020
Summer Intensive Curriculum	7 hours/week		
Summer Practical Experience	14 hours/week		
Fall Practical Experience		7 hours/week	
Spring Practical Experience			7 hours/week
STEM Community Participation	On-going		

The intensive summer curriculum involved replicating and extending a previously published research study about children's behavior (Blake et al., 2016), including data collection, analysis, and giving a poster presentation at the end of the summer. Teens also conducted post-hoc analysis on data from a prior research study of Living Laboratory® professional outcomes that focused on researchers' communication strategies; led educational activities called "research toys" (which simulate the process of participating in a research study and involve conversations with children and families) on the Museum floor; and participated in community events.

During the 2019-2020 school year, teens worked in pairs to design and conduct their own research studies. They developed research questions, reviewed existing literature, selected and piloted data collection instruments, secured IRB approval, and began data collection. Originally, the plan had been for the teens to conduct data analysis and develop science communication products to share their results. However, the onset of COVID-19 caused the Museum to close its doors for several months and forced the project team to adapt its plans. In-person data collection was no longer possible, and the teens had not yet gathered enough data to move forward with analysis and reporting. Instead, mentors involved them in online research activities including contributing to a systematic literature review exploring the role of imagination in informal science education. In April 2020, the Museum experienced furloughs and layoffs due to COVID-19, and the teens were furloughed. Unfortunately, these furloughs extended beyond the teens' scheduled end date of June 30, effectively ending the program for the first cohort. However, in July the project team invited these students to participate in some end-of-program reflection and evaluation activities, through which the evaluators documented the remainder of students' experiences and their insights on improving the program for the future.

SCIENCE IDENTITIES

The TSRCP program model is designed to influence the formation of teens' science identities. Science identities have been shown to predict long-term commitment to STEM (Chang et al., 2011; Chemers et al., 2011; Estrada et al., 2011; Stets et al., 2017). TSRCP draws on the theoretical perspective that identity formation is fluid and ongoing (Calabrese Barton et al., 2013; Carlone et al., 2015; Farland-Smith, 2012; Rahm & Gonsalves, 2012). Thus, TSRCP aims to immerse teens in science identity work through which teens explore their identification with science.

There is a wide research base about science identity. This project's theoretical approach adapts Hazari et al.'s (2010) model for the informal learning context of TSRCP. The TSRCP model of science identity involves three aspects, as shown in Figure 1, below. The first aspect is interest and affinity, which has been shown to influence both career pursuit and the integration of science into one's life beyond traditional science employment (Hazari et al., 2010; Johnson, 2017). Second, we consider aspects of skill development and self-efficacy, an important element of science identities and something that the Living Laboratory® model and other authentic research opportunities are effective at providing (Beaumont et al., 2016; Hazari et al., 2010; Johnson, 2017). Third, we look at elements of belonging within the social contexts of science. This work draws on research showing the importance of mentorship and community (Adams et al., 2014; Aschbacher et al., 2010; Chemers et al., 2011; Farland-Smith, 2012; Hazari et al., 2010).

Figure 1: TSRCP Model of Science Identity

II. METHODS

OVERALL APPROACH AND EVALUATION QUESTIONS

To assess and inform the effectiveness of the program model, the Museum of Science, Boston's Research and Evaluation Department is conducting a developmental evaluation of TSRCP. The developmental evaluation approach encourages innovation by recognizing that data collection can continuously describe progress and promote improvement (vs. applying strictly to formative or summative efforts). This approach "supports the development of innovations and adaptation of interventions in dynamic environments" (Patton, 2011, p. 23), and is especially appropriate for projects in the early stages of innovation (Gamble, 2008).

As mentioned above, the key outcome for this project is science identity among teen participants, and the evaluation focuses on knowledge generation around science identity formation as it relates to the variety of science identity work offered by the pilot program. Evaluation activities were structured around the three aspects of the theoretical model displayed in Figure 1, above (interest and affinity; skills and self-efficacy; and belonging and community).

The evaluation is tasked with describing the extent to which teens engage in core program elements (engaging in science research, education, and communication; receiving mentorship; and participation in scientific communities), how teens' science identities change over time, which program elements contribute to these changes, and how the core elements of the program can be adjusted to better foster the development of science identity. The evaluation questions are:

1. How do teens' science identities change over the course of the program?
2. To what extent do teens engage in core program elements?
3. How do the program elements contribute to changes in teens' science identity?

PARTICIPANTS

The participants for this evaluation were the six teens employed by the Museum to engage in the TSRCP program during the first cohort. This cohort ran from June, 2019 through May, 2020 (see Table 1, above, for a summary of the program curriculum). Cohort members were selected through a typical Museum hiring process for teens that involved submitting a written application and participating in an interview. As part of the Museum's career ladder model, teen employment required prior volunteer experience with the Museum. Thus, to be eligible to apply for the program, teens needed to have volunteered with the Museum for at least 40 hours. The members of Cohort 1 had volunteered in different areas of the Museum, including the *Discovery Center*, an early learning exhibition, and the *Hall of Human Life*, an exhibition about human health and biology. Both of these exhibitions host Living Laboratory® researchers and thus the teens were familiar with the Living Laboratory® model prior to entering the program.

DATA COLLECTION

This evaluation used multiple data sources to investigate the development of science identities within the TSRCP program. Data collection approaches are described in further detail below and instruments are provided at the end of this document as appendices.

Surveys

Participants completed surveys at the beginning of the program (June 2019), the end of the summer (September 2019), in the winter (February 2020), and following the completion of the program (July 2020). Each survey was identical except for some slight differences on the pre- and post-surveys (i.e., the pre-survey asked what the participants were most interested in about the program vs. the post-survey, which asked what the most interesting part of the program had been). The surveys included three sections that followed the TSRCP model of science identity (see Figure 1, above): interest and affinity; skills and self-efficacy; and community and belonging. The interest and affinity section asked about participants' interest in general science topics and activities as well as their interest in specific aspects of the TSRCP program. Questions about general interest drew on Hidi and Renninger's (2006) four-phase model of interest and NISE Net's approach to measuring interest in informal science contexts (e.g., Todd et al., 2018). The questions about skills and self-efficacy were co-developed with the project team. These questions asked participants to rate their confidence in the different elements of the program. For instance, teens indicated how confident they were in considering the ethics of a research study, tailoring their science communication for different audiences, and talking about scientific methods with museum visitors. The section about community and belonging included Vincent-Ruz and Schunn's (2019) science identity scale as well as several other items developed by the team that asked about specific aspects of the program, such as teens' sense of community with the Museum and Boston University.

Interviews

Participants were interviewed at the beginning of the program (June 2019), the end of the summer (September 2019), in the winter (February 2020), and following the completion of the program (July 2020). Each interview was administered in conjunction with a survey. The interviews varied slightly on each occasion, but contained sections on interest and affinity; skills and self-efficacy; and community and belonging, to match the sections of the survey. In each of these interview sections, interviewers probed about quantitative responses from the corresponding sections of the survey. For example, if an interviewee said they strongly agreed that they were a scientist, the interviewer would ask the teen to explain why they felt that way. These interviews also contained formative evaluation questions so participants could give feedback on the program and describe the progress on their research projects. For the final interview, participants were shown a PowerPoint presentation with data visualizations of their quantitative responses to survey questions over the course of the year, photographs of their meaning maps, and summaries of their qualitative data and quotations from their prior interviews. Participants were asked to react to this data, provide additional context, interpret the findings, and reflect on the extent to which the data matched their perceptions of their science identities over time.

Meaning-maps

The interview protocols began with a meaning mapping activity. Unlike the identity measures on the survey protocol that use traditional multiple-choice measures to generate quantitative measures, this meaning mapping approach provided rich, open-ended descriptions that embraced participants' own ways of describing themselves and science through words, pictures, diagrams, or other means. The meaning mapping approach drew from a number of prior studies. Falk, Moussouri, and Coulson (1998) introduced personal meaning mapping to the informal science field as a way to investigate museum learning in a way that embraces individual differences in a relativist-constructivist theoretical frame. They wrote, "Each individual brings varied prior experiences and knowledge into a learning situation and that these shape how that individual perceives and processes what he or she experiences" (Falk, Moussouri, & Coulson, 1998, p. 109). During the TSRCP program, teens produced two maps at their interviews. On the first, they described themselves and on the second, they described their conception of science. The meaning mapping activity concluded with several interview questions through which participants explained their maps, the decision-making that went into their creation, and any relationships the teens saw between their two maps. This approach is based on McCreedy and Dierking's method of meaning-mapping (2013), with one adjustment: rather than focusing on the name of the program we were evaluating, our second map focused broadly on science. Although McCreedy and Dierking (2013) found it helpful to have a narrower focus, our goal of understanding the formation of identity with regards to science, rather than just the TSRCP program, meant it made more sense for us to take a broader view.

Journal entries

To supplement the survey data and more closely track changes in science identity over time, the evaluators initially created a journaling activity for the teens to complete at the end of every program day. This consisted of a set of mini-surveys that had one or two multiple-choice questions taken from the main evaluation survey and a single open-ended prompt that centered around a particular theme (interest and affinity, skills and confidence, belonging and community). Although we had been optimistic that this approach to repeated samples data collection would produce valuable data, the teens soon reported that journalling felt burdensome and repetitive and the response rate was low, so we ultimately decided to discontinue gathering this data.

Artifacts

Program staff provided the evaluation team with products that the teens made as part of the program, and we analyzed these products for science identity factors and evidence of skill development. The products included worksheets, written materials, and meaning maps that the teens made during the program orientation about how they thought about science education and science communication.

Observations

Evaluators observed the participants as they did program-related activities on the museum floor, such as facilitating research toys and conducting research. The evaluation team took open-ended field notes about the conversations the teens had and the actions they took, documented evidence of the core program elements, and tracked any behaviors that could be related to science identities.

Focus groups with mentors
At the conclusion of the summer intensive portion of the program, the evaluation team conducted a focus group with mentors and other program staff to review how things were going. The focus group questions asked for general reflections on the program as well as brainstorming about how the program could change to support the participants' engagement with the core program elements and development of science identities.

DATA ANALYSIS

The evaluators used a multiple case study approach to analyze the data, managing an ongoing balance between looking closely at the findings from each individual case and reviewing findings from the whole group of cases (Stake, 2006, p. 46). In this structure, each teen served as a single case. The first step of analysis began at the level of the individual case. Evaluators read and re-read all the data from one case at a time and created a memo for each case. Quantitative data were reviewed descriptively, looking at the central tendencies (mean and median) and spread (minimum and maximum values) over time. For qualitative data, evaluators developed a deductive coding rubric for the core program elements and the three parts of the TSRCP model of science identity (see above). Then, the evaluators used an inductive process to develop additional codes for each core program element as well as emergent codes that were present in the data but were not contained within the core program elements. Individual evaluators coded the data in the Dedoose qualitative analysis software. Then, a second evaluator coded 10% of the data. There was an 84% agreement rate among the two coders, and the evaluators discussed all disagreements and came to consensus.

Through the individual memos, evaluators reflected upon the data and the interactions between program activities and science identities using rich qualitative description. Looking at the single cases shed light on the development of science identities within the complex web of individual factors, including differences in starting identities, various levels of engagement with the program, and changing relationships with mentors, other project staff, and other youth. Following the generation of memos for each individual case, data were reviewed at an aggregate level. At this stage, qualitative codes had been quantified, and evaluators assessed the co-occurrence of the core program element codes and the science identity codes, identifying areas of notable overlap and then returning to further code the excerpts that had co-occurrence to illuminate the nature of the relationship. For example, in identifying that the code for "statistics" often overlapped with the "skills and self-efficacy" identity code, we then inductively coded the excerpts with both codes to better understand that youth often had lower self-efficacy in statistics than other areas, and numerous respondents found the program's approach to teaching statistics to leave room for improvement. Overall, the aggregate data helped assess the extent of evidence backing each finding. Evaluators looked for similarities in the development of science identities across the cases and investigated what elements of the program most likely contributed to that growth in identity. This analysis across cases provided a comprehensive look at program elements and the way those contexts contributed to individuals' science identities.

III. RESULTS AND DISCUSSION

3.1 HOW DO TEENS' SCIENCE IDENTITIES CHANGE OVER THE COURSE OF THE PROGRAM?

The following findings sections look across the participants to describe the changes in science identities along the three dimensions of the TSRCP model of science identity: 1) interest and affinity, 2) skills and self-efficacy, and 3) community and belonging. In addition to the data about each dimension, this section concludes with case studies that describe each teen's experience in the program and how their identities changed over time. These case studies tell rich, primarily qualitative descriptions of the individual experience whereas the next several pages look for trends and share quantitative findings from the surveys.

The findings for this section include:

3.1.1 Teens entered the program with high interest and positive affinity for science. These positive interests and affinities continued during the program, with the data suggesting increased differentiation about specific aspects of science that were more and less interesting. In particular, interest in science communication tended to rise over time.

3.1.2 When considering science research, communication, and education skills that were part of the TSRCP program, teens tended to report relatively consistent levels of confidence across the program, although they reported a decrease in confidence for writing up a study for a scientific audience at the end of the program. In thinking about the broader ability to contribute to science, teens indicated a decrease in confidence over the summer that then increased over the course of the school year.

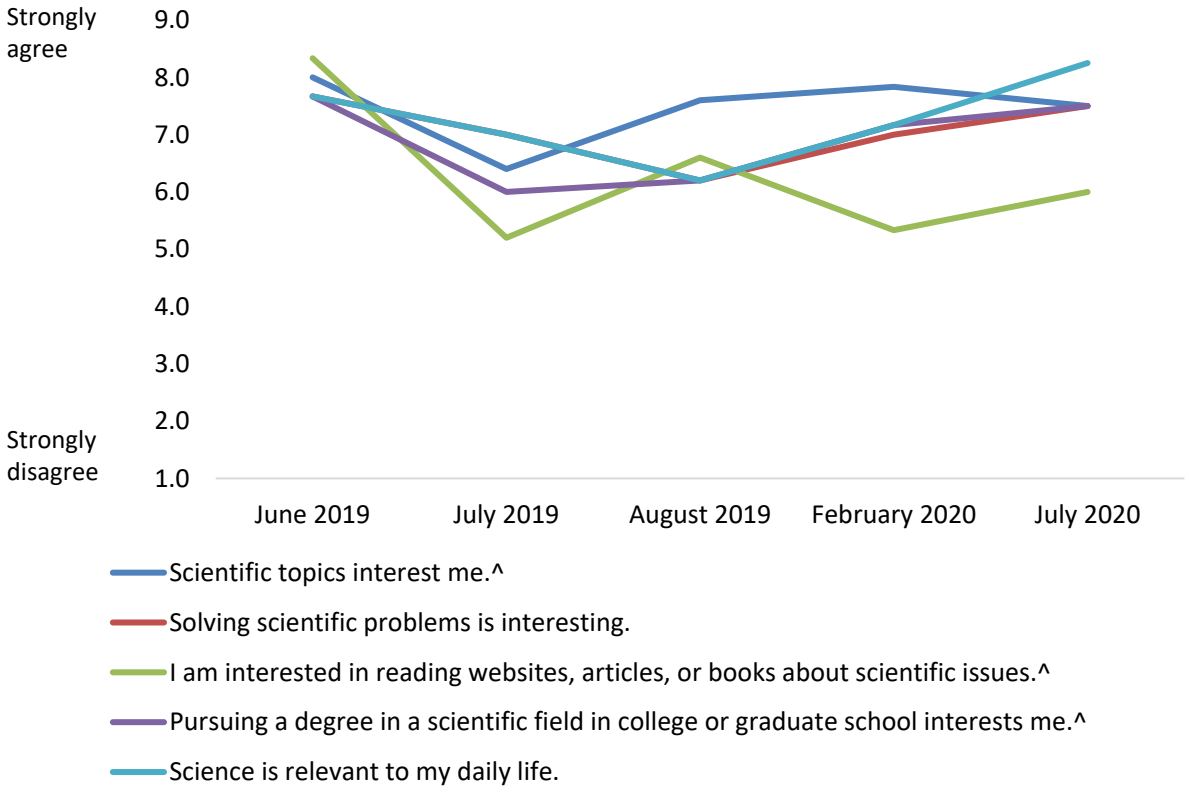
3.1.3 Teens' sense of community and belonging tended to increase towards a peak at the end of the intensive summer followed by a decline during the school year. Over the course of the program, teens' sense of self in relation to science became more internalized and less focused on other peoples' opinions.

3.1.1 Teens entered the program with high interest and positive affinity for science. These positive interests and affinities continued during the program, with the data suggesting increased differentiation about specific aspects of science that were more and less interesting. In particular, interest in science communication tended to rise over time.

Teens found science to be interesting throughout their experience, but over the course of the program they developed increased granularity about what was most and least interesting to them. Figure 2, below, displays survey data about teens' interest in various science topics. The data show that at the start of the TSRCP program, teens averaged around an 8 out of 9 on their interest to all of the items: scientific topics interest me; solving scientific problems is interesting; I am interested in reading websites, articles, or books about scientific issues; pursuing a degree in a scientific field in college or graduate school interests me; and science is relevant to my daily

life. Then, interest in all of these areas declined in July. As the case studies and other findings sections suggest, the summer was highly intensive, which may have dampened teens' initial enthusiasm. By the end of the summer, however, interest in reading and science topics rebounded, with interest in science topics remaining high for the duration of the program. The increase in interest in reading is notable because of the significant amount of reading teens did during the summer program. However, as the teens entered the school year and the reading load declined, their interest in reading subsided as well. The school year involved planning a research study, through which teens engaged in problem-solving around how to develop a research protocol while navigating a number of constraints. Correspondingly, interest in scientific problem-solving increased at this time. Meanwhile, interest in pursuing a scientific degree and the relevance of science in everyday life increased as well. The rise of COVID-19 may have influenced the view of science as relevant, as two teens discussed the virus influencing their perspectives of science being important.

Figure 2. Please indicate how much you disagree or agree with the following statements (n=6)[1]

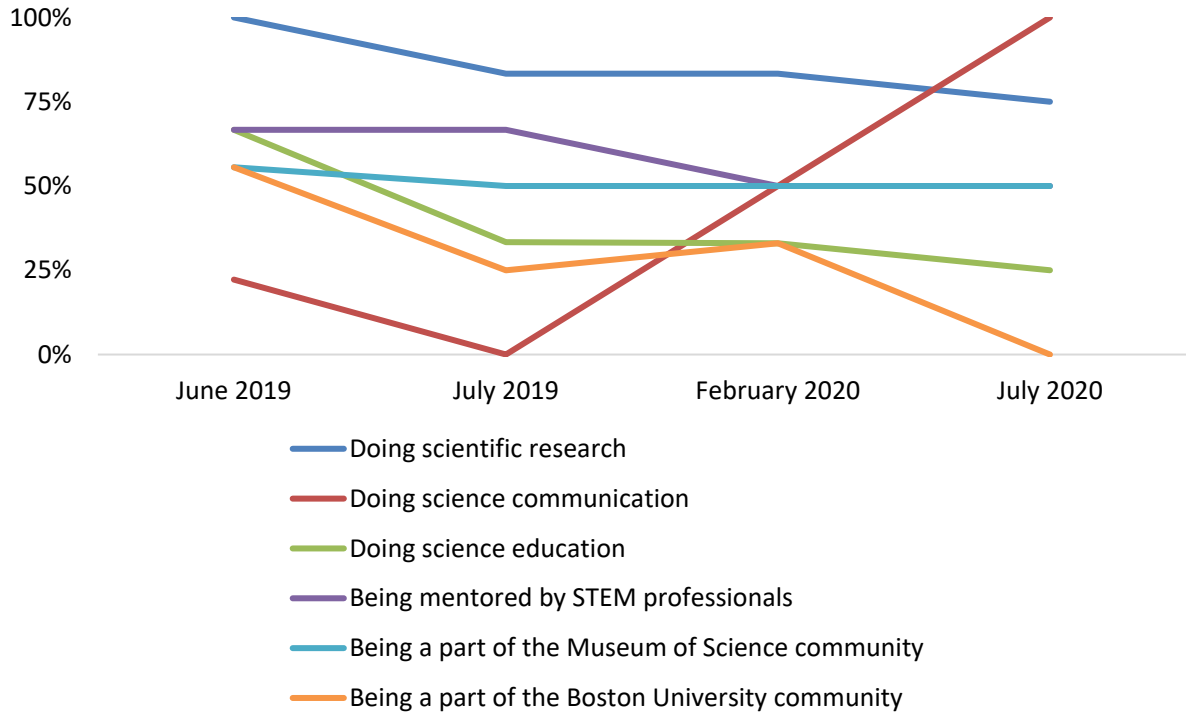


Looking at interest in specific program elements, teens' interest in science research remained strong and interest in science communication rose over time. On the survey, teens were asked to select up to three aspects of the program that were most interesting to them. As shown in Figure 3, interest in research was always high. Teens came in with notably less interest in science

[1] Statements marked with a ^ have been recoded for the sake of comparative data visualization. The actual question items were, "Scientific topics do not interest me," "I am not interested in reading websites, articles, or books about scientific issues," and "Pursuing a degree in a scientific field in college or graduate school does not interest me."

communication but, after having engaged in some science communication practices in August and the school year, their interest in this area rose sharply, eventually overtaking science research as the most interesting aspect of the program. Interest in other aspects of the program remained relatively stable or decreased slightly over time. In particular, a decrease in interest in being a part of the BU community coincided with the graduation of the participants' primary BU mentor; the discontinuation of teens' mentorship relationship with her seems to have contributed to their reported decline in interest in being a part of the BU community.

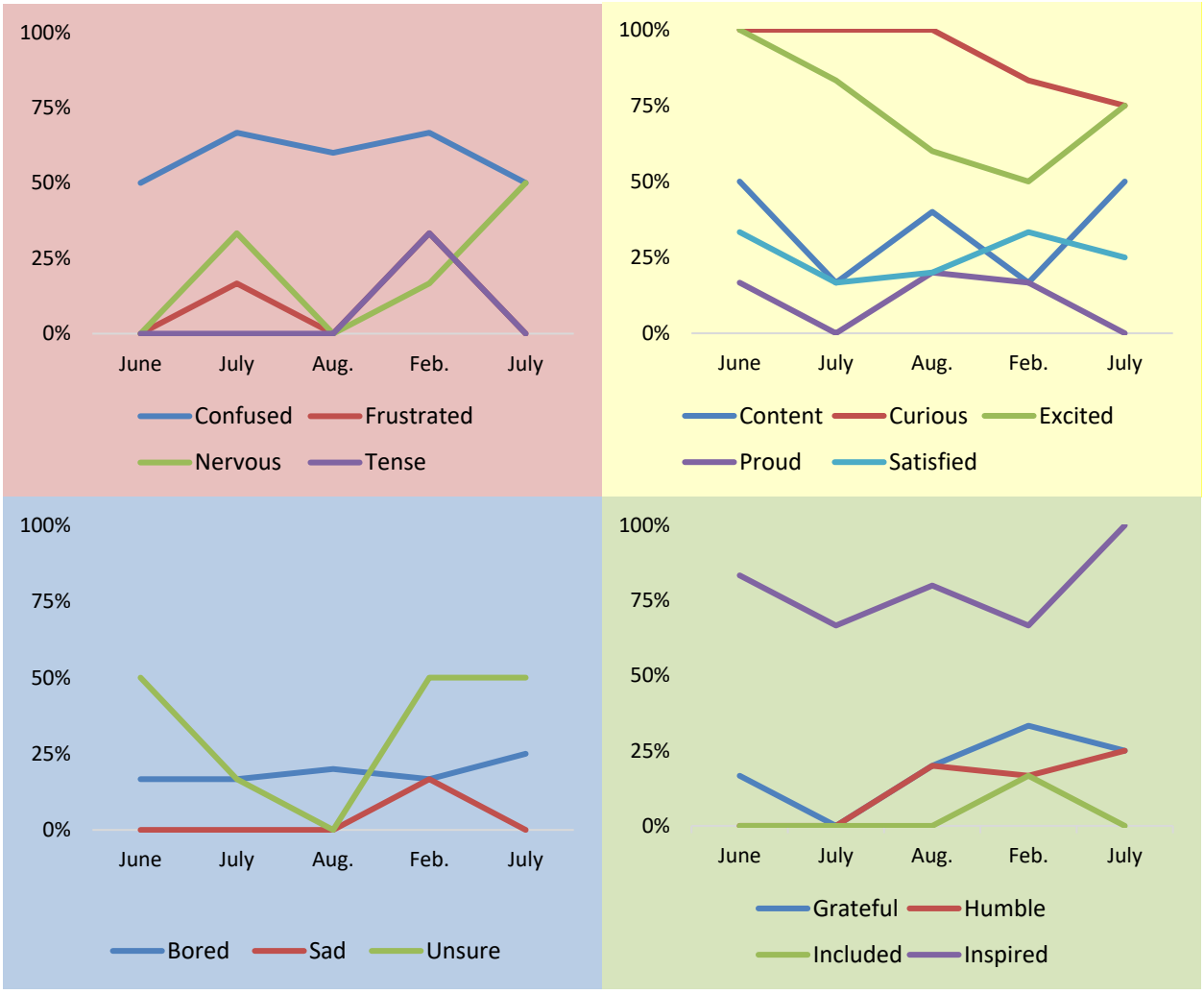
Figure 3. Which aspects of TSRCP are most interesting to you? (Select up to 3) (n=6)



An assessment of teens' affect related to science showed minimal change over time but a consistently healthy variation of emotional experience. Recognizing that emotional experience is intertwined with interest, the survey instrument asked teens to indicate what emotions they felt when doing science. Figure 4, below, shows the average of these data points over time. The graph is organized by quadrants according to the Yale Center for Emotional Intelligence's mood meter (Nathanson et al., 2016). At the top left, in red, are high energy, negative emotions. The top right contains high energy, positive emotions. The bottom right includes low energy, positive emotions. Finally, the bottom left quadrant is for emotions with low energy and negative valence. The graph shows a wide range of emotional experience, which is the sign of healthy, emotionally accessible views of science (Rappolt-Schlichtmann et al., 2020). Overall, curious (yellow quadrant) and inspired (green quadrant) were the most common emotions associated with science, with curious fading somewhat over time and inspired rising in frequency over the course of the program. Excitement (yellow quadrant) declined over much of the program as teens became more familiar with their work, but rebounded towards the end, perhaps as teens were making connections between science and their futures beyond the program. Confusion, which is

known to support learning (D'Mello et al., 2014), hovered around 50% for the duration of the program. Only one teen reported feeling "included" when they thought about science in February, and no one reported this feeling at any of the other time points. Given the similarities between this feeling and the sense of belonging and community that the program considers to be part of science identities, the low sense of feeling "included" could be notable.

Figure 4. When I think about science, I tend to feel... (Check all that apply) (n=6)



3.1.2 When considering science research, communication, and education skills that were part of the TSRCP program, teens tended to report relatively consistent levels of confidence across the program, although they reported a decrease in confidence for writing up a study for a scientific audience at the end of the program. In thinking about the broader ability to contribute to science, teens indicated a decrease in confidence over the summer that then increased over the course of the school year.

To assess teens' self-efficacy over time, the survey asked teens to rate their confidence in a range of research, science education, and science communication skills. Across the board, the data show a pattern similar to some of the interest data above, where teens tended to enter the program with very consistent ratings across the different areas of interest, but as the program went on they made clearer distinctions among what they perceived to be their stronger and weaker skills. Figure 5 shows data related to research skills. In looking at these data, conducting statistical analyses stands out as being the skill for which teens felt least confident. As the case studies and findings sections further describe, most of the teens connected statistics with math and several indicated that they thought they were bad at math. Confidence in this area rose slightly in August after the teens had their intensive statistics training, but then declined again, corresponding to a period of the program when the teens were not regularly applying the statistics learning they had gained over the summer. For the other skills, teens' confidence modulated somewhat but did not show strong evidence of change over time.

Figure 5. How confident are you in your ability to do the following science research skills? (n=6)

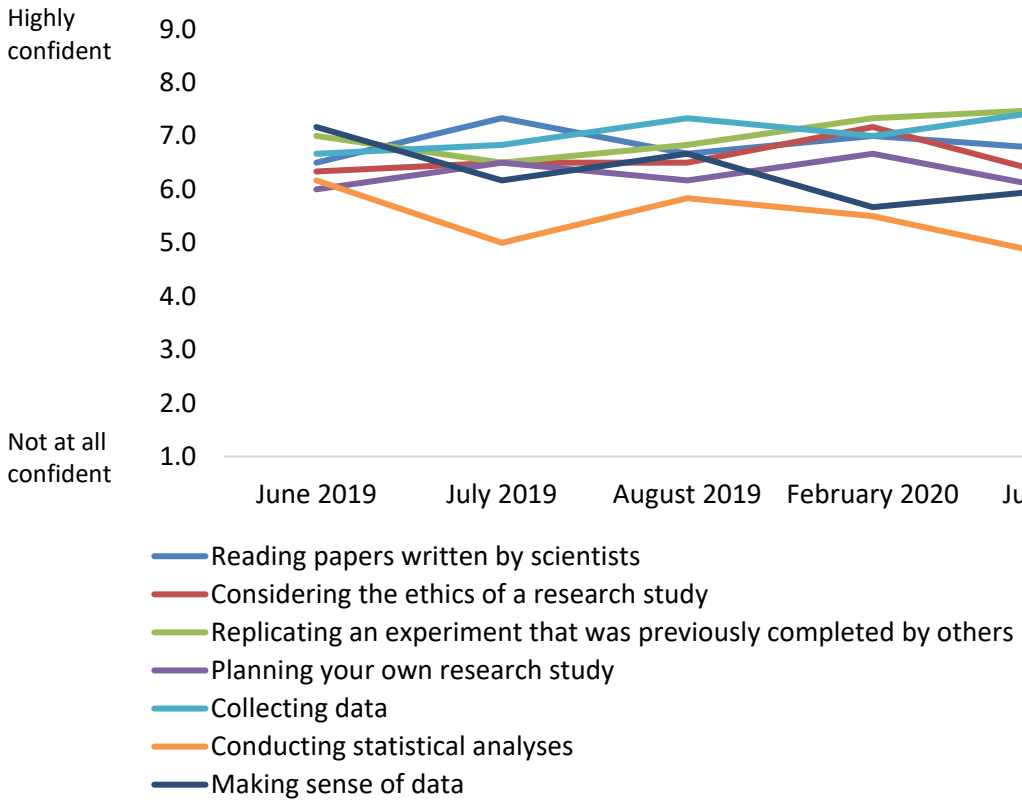
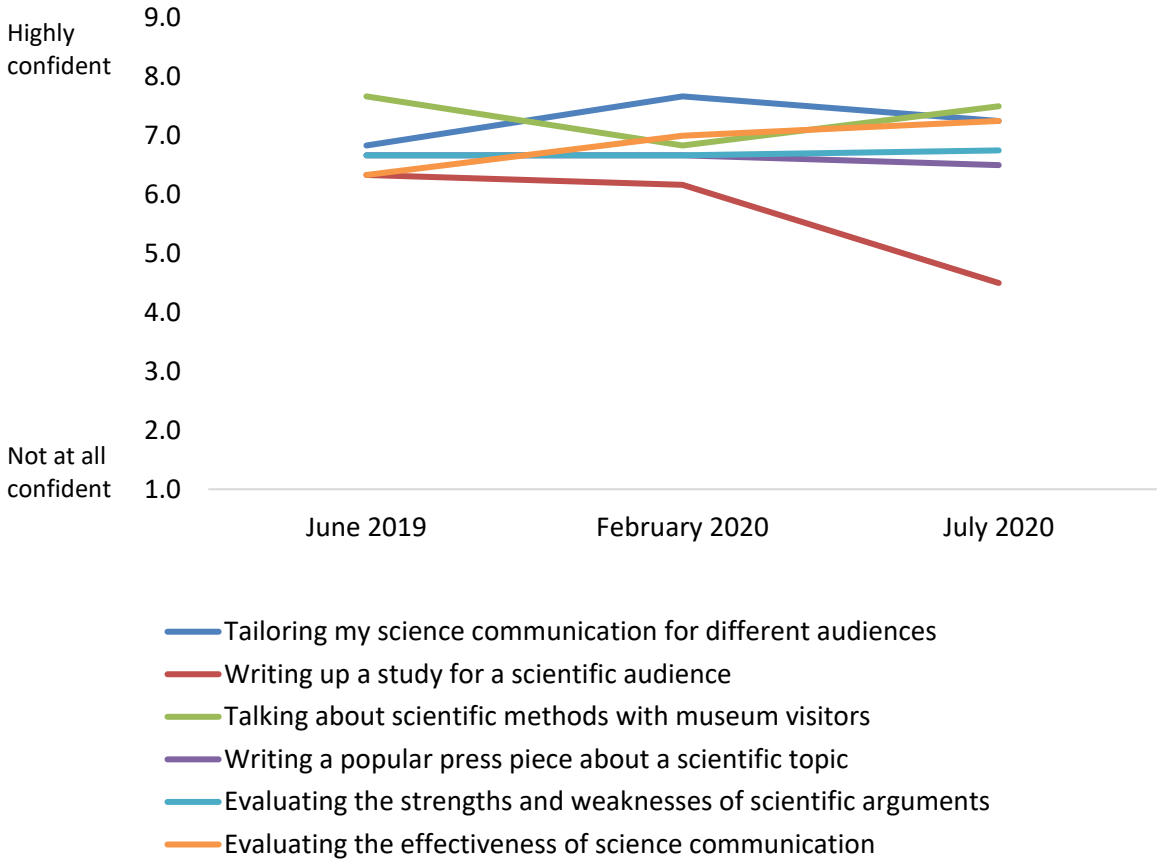


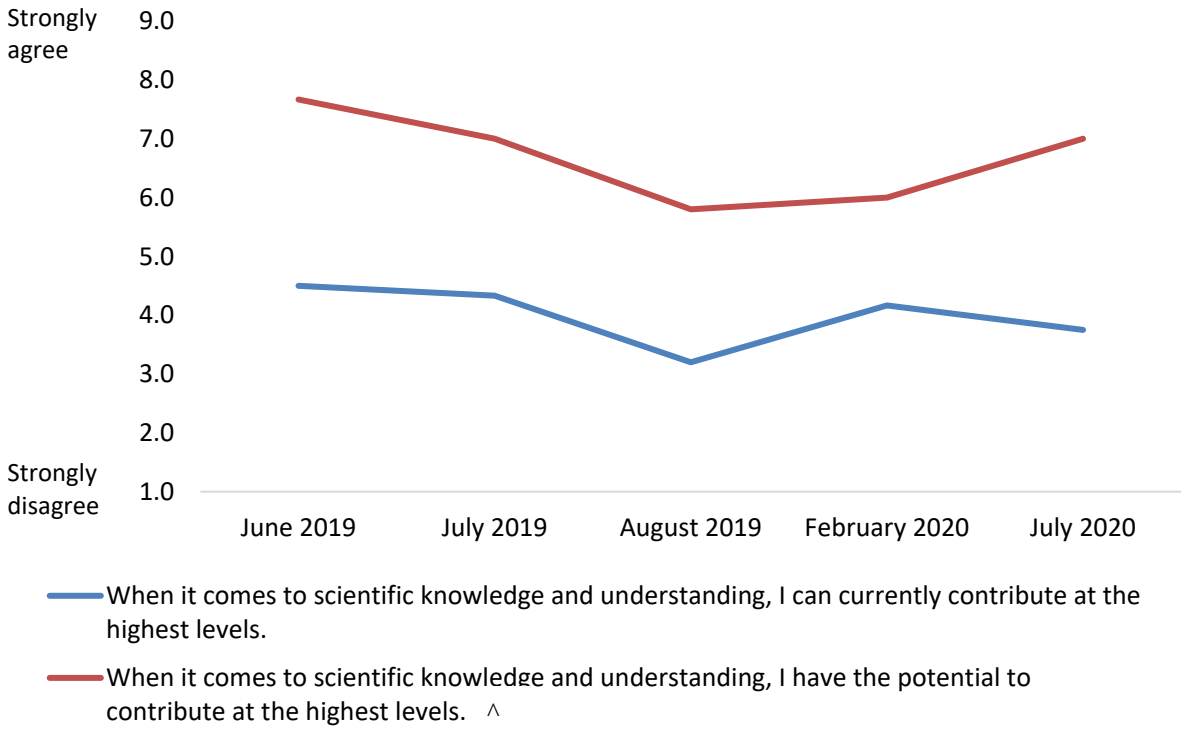
Figure 6, below, shares data from the survey questions about science education and science communication. These questions were omitted from the July and August surveys due to teens' concerns that the data collection had become burdensome. Similar to the science research skills, most of the responses are fairly stable over time, with expected minor fluctuations. The one skill that stands out is writing up a study for a scientific audience, which declined sharply between February and July. This is likely due to the fact that the teens had expected to write up their study in the spring, but this did not occur due to the pandemic.

Figure 6. How confident are you in your ability to do the following science education and science communication skills? (n=6)



A third survey question related to skills and self-efficacy focused on teens' evaluations of their current and future potential to contribute to science at its highest levels. These data are visualized in Figure 7 (below). As might be expected, the two lines track similarly over time, with confidence about current ability to contribute being lower than future potential. From the start of the program, confidence was relatively high; however, it declined over the course of the summer when teens were engaged in their intensive programming. In the post-summer focus group with program leadership, there was a sense that the summer had been too demanding, which may be reflected in these data. Encouragingly, over the school year when involvement was less intense, confidence began to rise, although the sense of current ability to contribute fizzled after the program stopped. It is positive to see that even though current ability to contribute declined when the teens were no longer a part of the program, the sense of future potential actually increased.

Figure 7. How much do you agree or disagree with the following statements? (n=6)[2]



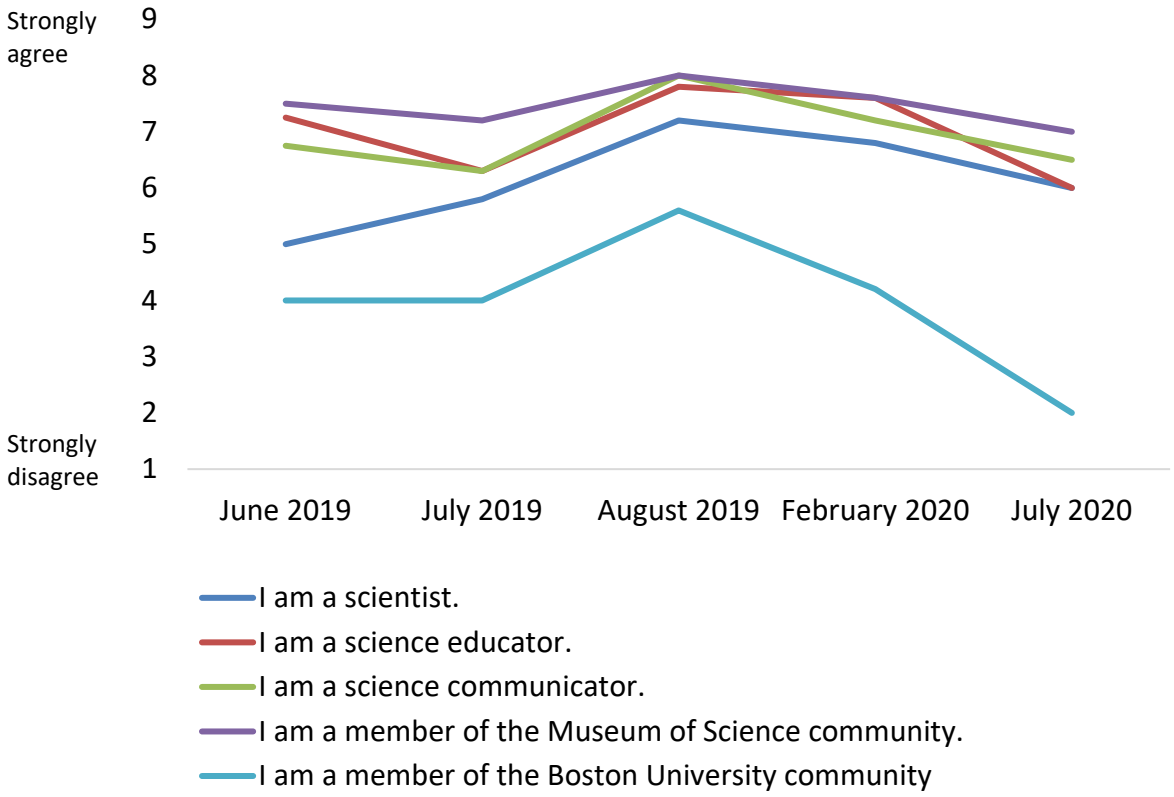
To further understand these data about ability to contribute at the highest levels of scientific knowledge and understanding, the survey asked teens to explain what came to mind when they thought about the highest levels of science. Two teens defined the highest levels in a way that required experience that teens could not have, such as "PhDs" and "college and graduate school students who have been in the scientific field for a long time." Research was central to two teens' responses: "research, studies and experiments" and "research studies and groundbreaking, innovative discoveries." One teen thought complexity was the key to the highest levels of science, saying, "Complex, real-world problems that require a high level of knowledge to carry out." The other teen connected science communication to the highest levels, describing, "Knowing a lot of information and difficult to understand concepts, and the ability to contribute to communicate that information in an effective way."

[2] The statement marked with a ^ has been recoded for the sake of comparative data visualization. The actual question item was, "When it comes to scientific knowledge and understanding, I will never be able to contribute at the highest levels."

3.1.3 Teens' sense of community and belonging tended to increase towards a peak at the end of the intensive summer followed by a decline during the school year. Over the course of the program, teens' sense of self in relation to science became more internalized and less focused on other peoples' opinions.

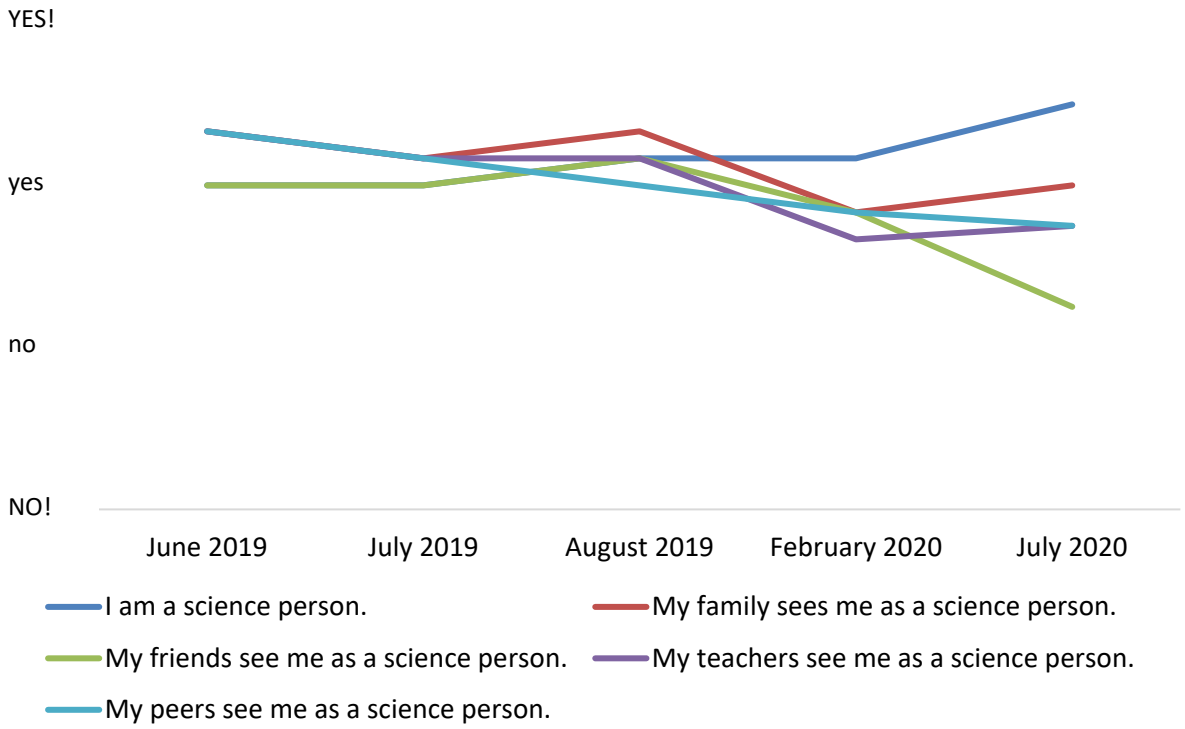
To assess teens' sense of community and belonging, the survey asked a series of questions about respondents' identities related to science, science education, science communication, and the MOS and BU communities. These data are visualized in Figure 8. As the graph demonstrates, there tended to be slight increases in teens' sense of self between the start of the program and the end of the summer, although there were slight dips in science education and science communication in July. These dips may be due to the fact that the youth had prior experience in these areas through their previous roles with the Museum, but the summer portion of the program largely focused on engaging in research, rather than practicing these prior skills. However, the overall positive trend shows that, despite the intensity of the summer program as mentioned in the previous section, the teens indicated stronger science identities as they entered the fall. Unfortunately, the trend turned downwards after August. Teens' sense of self as a member of the MOS community and as a science communicator returned to levels similar to the start of the program, and sense of self as a science educator dropped slightly below the initial levels. Although sense of self as a scientist did decrease slightly from the August high point, it remained higher than when teens started the program. Some teens identified that they were members of the scientific community by virtue of participating in the program and doing the corresponding activities—as Participant 1 noted, "I am definitely part of the scientific community, working at the Museum of Science you can't not be." The outlier among these data is the trend for feeling like a member of the BU community. This was consistently the lowest across all time periods, but the decline after August is striking. The fact that the BU data are lower than the Museum's is unsurprising, given that program activities almost entirely took place at the Museum and the youth had all volunteered with the Museum before the program. It is encouraging that the sense of belonging with BU increased over the summer when teens were regularly interacting with their mentors and when they visited campus. As noted above, the teens' primary BU mentor graduated in the middle of the school year, and as a result the interaction with BU became less intensive, which corresponds to the decline in sense of community with BU as shown in the graph below.

Figure 8. Please indicate how much you disagree or agree with the following statements (n=6)



The survey also included Vincent-Ruz & Schunn's (2019) science identity scale. Rather than asking whether someone views themselves as a scientist (as in Figure 8), this scale asks about "science people." These data are shown in Figure 9. Like in some of the previous data, the visualization shows how teens started the program with similar views across the different aspects of the scale: seeing one's self as a science person, as well as one's peers', friends', family members', and teachers' views of whether someone is a science person. By the end of the program, however, teens were better able to differentiate how these different viewpoints varied. Perhaps most notably, at the beginning of the program, teens' own sense of themselves as science people was tied for the lowest average value, a 3.0 on the 4-point scale (friends' views were tied, with a matching average value of 3.0). By the end of the program, teens' sense of themselves as scientists was the highest of all the survey items and was the highest average value seen at any point in the program, at an average of 3.5 out of 4. This suggests that the teens transitioned from primarily having others think of themselves as science people to a primary self-definition of self as a science person.

Figure 9. Please rate your response to the following statements (n=6)



PARTICIPANT 1 CASE STUDY

Participant 1 entered the program with a strong interest in psychology. Over the course of the program, she became less interested in pursuing science as a career, but felt connected to the MOS community and built confidence in her science skills.

Participant 1 entered the program with little formal science education. Having been primarily home-schooled, she had never had a formal science class until the prior year in school. At the time of the beginning-of-summer pre-interview, she expressed some trepidation about regarding herself as a scientist or a science person just yet. She stated that she was "not a science person until this year. [It's] not my strong suit." She stated that she "would like to identify as a scientist," but "can't fully yet. [I'm] not fully in that world yet." However, she spoke enthusiastically about her strong *interest* in science, and particularly in psychology. Her pre-program meaning maps showed some overlap between her concept of science and her sense of self. Both her "me" map and her "science" map had the word "problem-solving" on them. The word "psychologist" was on her "me" map, while "research/researchers" was on her "science" map, as well as the suffix "-ology."

Describing the one year of formal science education that she had received so far, she explained that what she liked about it is that it "makes sense" and "is logical," as opposed to English, which "doesn't make sense." She also appreciated that you can "see it in everyday life." However, she disliked the more rote aspects of science education: "It's not fun to just listen to someone talk about science. Some parts aren't relatable. No connection." She described a sense of wonder at what scientists have been able to accomplish—"It's incredible that we've been able to define all this stuff." Overall, her interest in science mainly related to how it illustrated her own experiences in the world.

During the post-summer interview, Participant 1 described her interest in science in largely similar terms, if not a little more strongly than she had done before. On her post-summer survey, she indicated that "doing scientific research" was one of the three aspects of the TSRCP program that most interested her. She explained that she was still "interested in psychology generally," and that "research gets at that." Her responses to close-ended questions meant to gauge interest in science were almost all identical to her pre-summer responses, and uniformly showed a high level of interest. On the survey, she said that when she thinks about science, she tends to feel a mixture of active emotional states, such as curious and confused, alongside more reflective states, including grateful, inspired, and satisfied. By way of explanation, she echoed what she had said in the pre-interview—that "science is really important for our lives," and that it's "incredible that scientists have been able to study so much."

However, whereas at the beginning of the summer, she expressed that she was interested in becoming a scientist or a science person, by the program's mid-point, Participant 1 stated that she did not identify with science. The survey data from her mid-summer journaling show a noticeable drop in self-recognition as a scientist, and perceived social belonging in scientific communities. Although her self-recognition as a scientist and science community member rebounded on her end-of-summer interview, her interview responses continued to indicate a distancing from science. When explaining the relationship between two meaning-maps that she

had created to describe herself, and to describe science, she stated: "[I have] a lot of the traits that I associate with science-y people, [but] I don't feel that I identify much in that way." When asked to describe her identity in the area of being a scientist, she recognized that she had developed science skills that she is able to practice, but she has not internalized an identity through that process. She explained: "I am sort of a scientist because I do science and take classes, [but it's] not my primary identity." However, she felt strongly that she was a part of the Museum of Science (MOS) community—being a member of the community "gets ingrained in you." She spoke fondly of the MOS, saying that she loves it, and wants "to stick around for a while." So, even though the development of her science skills was supported throughout the summer, and even though she maintained her interest in science and psychology and increased her sense of belonging in the MOS community, Participant 1 did not seem to consider herself to be a scientist or a science person at the end of the summer.

In February and July of 2020, Participant's survey and interview data showed these trends continuing, but she spoke about them with more clarity and complexity as time went on. In February, she identified unequivocally as a member of the scientific community by virtue of the fact that she worked at the MOS—"you can't not be" a member of the scientific community while working at the MOS. However, her confidence that she would ever be able to contribute to science at the highest levels dropped precipitously. She explained that this was simply because she wasn't interested enough to learn to contribute at the highest levels—she's "not enough of a science person to see [her]self as motivated enough, even if [she] did science, to become a super high level scientist". In the same vein, she said in July that her interest in doing research as a career had decreased throughout the program, essentially as a consequence of trying it out and realizing that she likes "other aspects of psychology" more, and finds them especially interesting.

Participant 1 explained more about how the program had affected her relationship to the scientific community, or rather, that she felt it had *not*. She said: "[The program] changed the way I view the scientific community, not really changed my relationship with the community." Through the program she had learned more about what the scientific community looks like, and how scientists work, but the program hadn't affected her identification with that community very much.

In July of 2020, Participant 1 spoke again about her (lack of) confidence that she would ever be able to contribute to science at the highest levels. This time, she explained that the program had given her a clearer idea of "just how high the highest level is." We showed her the survey data we collected over the year, which showed her feeling less confident that she could ever contribute at the highest level, over time. This surprised her somewhat, and she made an amendment that felt was not captured by our quantitative data—her "confidence in general went up in the program." She added that "being able to talk to different kinds of people about lots of different kinds of things" through the program made her feel more confident, whereas she had felt shy when she was younger. This gives the impression that the program may have helped her develop social and professional skills that she found valuable, potentially even outside of the context of scientific research.

When we showed Participant 1 her meaning maps from the beginning of the program, and asked her to reflect, she said that she still agreed with most of it. She said that she might get rid of some

things on the “science” map, like “details” and “labs,” “because a lot of science is not labs.” Participant 1 said that she still identified with everything on her meaning map about herself. She noted the overlap between the two maps, with “problem solving” being on both, but clarified that “some things on the ‘me’ map aren’t science,” indicating that the program modified her view of what science is, but didn’t necessarily produce a great change in the way she identified with regards to science.

Participant 1’s interest in doing scientific research, and her identification as a “science person” declined, or failed to solidify, over the course of the program. However, it is important to recognize that she speaks about the program as a positive experience, and that her core interest in psychology, and identification as a member of the MOS community, remained strong and valuable to her over the course of the program. Participant 1 unequivocally recognized her membership in the scientific community through her participation in the program, even though the program helped clarify that she was less interested in pursuing a career in science, identifying as a *science person*, or specializing in research as she had been at the beginning of the program.

PARTICIPANT 2 CASE STUDY

Participant 2 entered the program with mixed feelings about science. While she struggled to feel connected to scientific communities, the program reinforced her interest in scientific research.

At the beginning of the program, Participant 2 had somewhat conflicting feelings regarding her interest in science. She "didn't like science" very much early in her schooling, and found it difficult, especially that it was "related to math." What she found most uninteresting about science was the "conceptual stuff"—when looking at things "down to the molecular level," they don't "look like anything you see" in real life. The "bigger picture" is what she found more interesting. Her meaning maps at the beginning of the program showed some overlap, but were organized differently. Her "me" map focused on activities like "school" and "hobbies" as well as "home" and "family," though it did contain references to "science" and "MOS" branching off from "extracurricular activities." Her "science" map showed a sort of wheel, with arrows leading in a cycle between "people," "applications," and "discovery."

Starting in high school, she started participating more in class, being "more motivated by grades," and found that participating and asking questions made science class "more interesting" for her. While this made science class "less boring now," she described that it still wasn't as fun for her as "stuff you can see and touch." Regardless of her conflicted interest in science class, she participated in a couple of extra-curricular science activities—volunteering at the Discovery Center (an exhibit at the Museum of Science designed for early learners where many project activities take place), and competing on the science team at school. She found that "[in] out of school science you get to choose more, see what catches your eye and what interests you."

The skill that she reported the highest confidence in on the pre-survey was "making sense of data"— she said that this was based on her experience in school, where she had "more success with math and numbers," (despite mentioning discomfort with numbers at other times in the interview) and that she could take a "bunch of data and look for a pattern or trend." Some of the skills that she had the least confidence in were reading scientific papers and writing up research studies. She said that she had little exposure to these and that scientific papers made her think of "hard vocab, specific terms and concepts that are specific to that researcher."

When describing her identity with respect to science education and communication in the pre-interview, Participant 2 said sharing information was what she was "supposed to do" at the Museum of Science. In terms of science research, she said she did science, "but not all the time." In the post-summer interview, she was still ambivalent about these identities. Describing her identity as a science educator, she said once again that science education was a role that she was "supposed" to fill while in the Museum. When prompted to describe her identity as a scientist, she said: "In a way, aren't we all scientists? I do more science than a person who doesn't come to the Museum every week."

At the end of summer, Participant 2 expressed similar ambivalence with regards to her interest in science. She said her chemistry class at school "wasn't interesting" and "stressed [her] out." Science, to her, was "very general," and included things that she found boring (like school).

However, she spoke about interest in the ways science could be applied, saying, "Applications are more interesting, reading in the news what's been discovered, how it could be used to make the world a better place." When asked if anything about her interest in science had changed over the course of the summer, she said her interest in psychology had increased.

At the end of the summer, Participant 2 reported the highest confidence in "Writing a popular press piece about a scientific topic"—she said that she had never done this, but thought it would be easier than a research paper. The skills that she expressed the lowest confidence in were "planning your own research study," because, as she explained, she had not done that yet, and "conducting statistical analyses." With regards to her experience learning statistics and R in the program, that she still does not "know what any of it means without digging deeper." She further explained her misgivings about this portion of the program: "I don't know if it's the program or if it's [that] I'm not a numbers person, I think I'm a numbers person [but I'm not] able to imagine it in that form." She added that more time would be helpful, and that the one-day statistics lessons were "condensed." When she was interviewed later on in February, Participant 2 continued to express somewhat ambivalent feelings towards science and towards the program, but she continued to clarify where her positive and negative feelings lay.

Throughout the program, Participant 2 was struggling to feel like a member of the science community. As we saw with most of the participants, Participant 2 did not feel much connection to the Boston University community, because the teens had "been there once for a tour." She said she and the other participants would joke about how they were "supposed" to feel like members of the BU community, but they did not feel very connected. However, her responses also indicated that she was feeling disconnected from the MOS community. She said; "I'm not sure where we are in the museum, [we're a] different department technically. Not really Discovery Center, kind of isolated in a sense, but still connected." She was feeling some uneasiness about understanding where the TSRCP program fit into the museum's organizational structure. Later in the interview, she added, "We're this small group, and we do our own thing. We're kind of supposed to be associated… we're not a part… not associated with other parts of the museum, not supposed to be a factor." With this in mind, it is worth noting that the Museum was restructured during the course of the program. While Participant 2 was likely unaware of the full extent of the changes, this change may have affected her experience. We also heard second-hand reports that TSRCP participants were sometimes questioned by confused staff members who did not understand their roles. These factors combined may have contributed to her sense of alienation and uncertainty about where she fit in the Museum.

On the positive side, Participant 2 expressed a clear interest in doing scientific research in her February interview. She said that it was interesting because it was something that she had not done before, and felt that it was "[in a way] helping… the scientific community." She then drew a connection between research and science education, saying that it's "fun to debrief families about it." She felt that science education was the strongest core program element—they spent a lot of time in the program on the floor, "telling people what's happening with the research toys." This was similar to what she had done in the Discovery Center before the program, except "instead of interpreting the exhibit, interpreting research." Correspondingly, her survey responses with regards to her skills and confidence in science communication and education rose compared to the responses she had given in August. Specifically, she more strongly agreed that

she was a very good science communicator, and more strongly disagreed that it was hard for her to tell when she had been successful during an educational interaction with a museum visitor.

When we spoke with Participant 2 in July, after the program had been suspended, many of the same themes were still present, though in retrospect she had some more positive reflections to share about her relationship to the scientific community. She spoke more strongly about how the program had reinforced her interest in scientific research. She said, "The program definitely made me more interested in the research side of things. People knew what was going on, the different ways you can be active in it… I didn't realize research was such a thing, specific part of [the program]." She also said that interest was a strong motivating factor for her pursuing scientific activities. When asked an interview question about whether interest and affinity, confidence and skills, or community and belonging were more important to her relationship to science. In her response, she synthesized a relationship between these three components of science identity, and explained that she saw her interest in science as a potential catalyst to build skills and relationships with the science community. She said, "I think as of right now it's interest. I see it as a sequential thing. First you need interest and then you need the community to build your confidence. Right now I'm thinking my interest is a major driving factor in my participation in activities about science. That would change as I grow."

In July, Participant 2 said that she felt the strongest program elements were science education, science communication, and mentorship from STEM professionals. She felt like science education and communication had been prominent and successful, because "a big part of the program was us on the floor interacting with people, visitors and non-visitors." She felt that mentorship from STEM professionals "kind of intertwined the most" with the other successful elements, because "they helped us the most and guided us through the program elements"

When shown data about her confidence in the skills that she had used throughout the program, she was surprised at some of the ratings that she had given (for example, having the highest confidence in "writing a popular press piece about a scientific topic" at the end of the summer). However, she felt that overall, her confidence had increased. She said, "I feel like I am more confident in my skills. Like... the program definitely boosted my confidence in my ability to do these skills listed."

When we showed Participant 2 her meaning maps from the beginning of the program, and asked her to comment, she did not see any change in the relationship between the "science" map and the "me" map. If she were to change anything, she would add more to the "science" map. She said, "I'd put, like, diversity in the people and things you can look into. And procedures. There's a lot of different steps to doing the designs and different paths you can take." While she may not necessarily have seen the program as changing her relationship to science, it did give her a broader view of what science is about, and how it is done.

In her post-interview, Participant 2 still talked about the alienation she sometimes felt within the museum. She talked about how the data collection setup felt cumbersome and awkward to her. Rather than collecting data in the Discovery Center, she was collecting data in the Blue Wing, using "a table wedged in front of a bench." She commented that it felt "put together quickly and it made it seem more informal like it was planned a little last minute or something." This feeling

that she was lacking the right materials and was in the wrong place seemed to make her uncomfortable. Additionally, her survey data indicated that she was feeling less connected to the MOS community, and identified less strongly as a science educator. When we showed her this data, she commented on this dip, nothing that "being part of the program definitely made me feel like more of a part of the scientific community." While these feelings of identification did decrease in the months after the program was cut short, she felt her engagement with the program increased her connection with the scientific community despite the misgivings that she had expressed in February. This is consistent with quantitative data that shows that people feel less like scientists, but more like science *people*, at the end of the program.

PARTICIPANT 3 CASE STUDY

Participant 3 entered the program with strong interest, confidence, and identification with science and retained his strong science identities throughout the program. His connection to science was particularly tied to his friend group, which bonded over shared interests in science.

Participant 3 entered the program with high levels of interest and engagement in science. He freely identified as a "science type of person" in the pre-interview, before the interviewer had asked any questions about being a "science person." In the pre-interview, he described how his friend group had a shared interest in science, saying that "my friends relate to science," and having friends who shared that interest with him led to mutual "drive, motivation [and] competition." He spoke about pursuing some particularly quantitative, STEM-related activities outside of the classroom, like looking at "numbers and datasets, social media, trend lines, [and] datasets on google." On the pre-survey, he answered "yes" that he is a science person, and that his family and friends see him as a science person, and "YES!" that his teachers and peers see him as a science person.

The meaning maps that he created at the beginning of the program to describe "science" and himself do not overlap much, at first glance. The "science" map mostly had concrete nouns related to the process and institutions of science, like "experimentation," "lab," "hypothesis," "numbers," and "psychology." His meaning map about himself focused on his social relationships with friends and family, his work and leisure activities, like "school work" and "YouTube," and personal qualities, like "fun," and "determined." However, when asked to describe the relationship between the maps, he had plenty to say—he saw a connection between himself and science "mostly through schoolwork, [and] firsthand experience]". In schoolwork and homework, he did activities like "hypothesizing and predictions, [and] re-evaluat[ing]," which might relate to the elements of his "science" map that reflect scientific process and methods.

Participant 3 stated extremely high levels of confidence across the board in scientific skills at the beginning of the program. His highest rated skills were "writing up a study for a scientific audience" and "evaluating the strengths and weaknesses of scientific arguments," both of which he rated 8 out of 9 on a Likert scale ranging from 1 (Not at all confident) to 9 (Extremely confident). However, in spite of his high ratings, he mentioned in the interview that science communication was new to him. Overall, he rated no skill lower than 6 out of 9. When asked to rank his agreement with a series of statements on a Likert scale from 1 ("strongly disagree") to 9 ("strongly agree"), he ranked the statement "When it comes to scientific knowledge and understanding, I can currently contribute at the highest levels" at 7 out of 9.

Although other teens came in with high confidence, most, as literature would suggest, had a dip in self-efficacy as they discovered the complexity associated with the scientific tasks. However, Participant 3 remained highly confident over the duration of the summer. For example, his confidence in "writing up studies for a scientific audience" rose to 9 out of 9 (with 9 being anchored on the survey as "extremely confident") by the end of the summer. Again, he ranked his ability to contribute at the highest levels of scientific knowledge and understanding as a 7 out

of 9. His lowest confidence in the end-of-summer survey was in "evaluating the strengths and weaknesses of scientific arguments," which fell to 6 out of 9. In describing this rating, he explained that he was "still learning and taking other people's perspectives."

At the beginning of the program, Participant 3 expressed interest in being a part of the Boston University community, and by the end of the summer, his agreement with the statement "I am a member of the Boston University community" had risen. He also agreed more strongly that he was a scientist by the end of the summer. Curiously, while he reported strong interest, self-efficacy, and belonging with regards to science on the surveys, his meaning maps showed an interesting disjuncture between the way that he described himself, and the way that he described science. His post-summer "science" meaning map showed single words relating to science ("Chemicals," "lab," "hard"). His personal meaning map described himself in terms of relationships—with family, friends, and even strangers. This may be a telling link; while Participant 3 primarily derived his identity from social relationships and he happens to be in a friend group (as mentioned above) that supports an identity as a scientist. This suggests that social connections of the TSRCP program may be particularly important for this teen.

Unfortunately, we do not have any interview data about Participant 3 past September 2019. The team scheduled an interview with him in February 2020, which he did not attend, and we were unable to reach him in July 2020 for a final interview.

PARTICIPANT 4 CASE STUDY

TSRCP helped Participant 4 recognize that being a science person didn't have to mean giving up his love of history. He came to see connections between psychology and the humanities and he valued his ability to practice and improve his communication skills through the program.

When Participant 4 began the program, he described himself as curious and caring. He wanted to be a teacher and was drawn to the program primarily because of an interest in education. Although he identified as a person with a speech impediment which can make it difficult sometimes, he noted that he loved talking to others because he learned so much from their conversations, and found the science communication aspects of the program particularly exciting. Demonstrating awareness of his socio-economic positionality, Participant 4 indicated that he saw working at the Museum as a privilege because he did not have to worry about food and his parents paid a lot to give him access to educational opportunities, including private school.

At the beginning of the program, Participant 4's family and school experiences with science gave him a negative view of the field and contributed to his sense that he did not want to be a scientist. Participant 4 characterized his experience in science classes in broadly negative terms, saying, "My school is old school, big thick textbooks. There's information, [teachers] expect it to diffuse through your head. Tedious to remember things. I don't need to know what "disruptive selection" is outside of high school. It's pretty bland. I prefer things I can actually touch and move around, which is why I enjoy the MOS more than my school." Aside from school, Participant 4 described how his father, a chemist, worked in a lab, and Participant 4 did not find his father's work interesting. In his pre-interview, he began by describing science as, "Make a procedure, follow science procedure. Analyze data, write scientific paper to help inform the science community of what you'd been doing. Repeat experiment a lot." Participant 4 described how his father, a professional scientist, was "trying to push [him]" in the direction of being a scientist, which caused him to "feel a disconnect." He stated starkly that he didn't want to go in that direction, noting, "[I] distance myself from seeing myself as a scientist."

Despite these negative views of science, Participant 4 also shared that he saw some relevance in science. Suggesting that his initial definitions reflected a "jaded version" of science, he added, "Science connects to medicine, connects to humanity." He was also interested in the ways informal science education could be compelling. He shared, "At MOS we have lots of interactives. It's different than textbook education. More engaging. We're all scientists!" Participant 4 added, "Even when we step out of our world we're constantly observing things, making hypotheses, even unconsciously putting people in different categories…For me, [a science person] can be anyone who has an interest in research. It doesn't have to be a lab. For me a scientist can use this data to inform the public about something,"

By the end of the summer, Participant 4's interests remained stable. He said that he was interested, "still mostly in science communication and making things accessible." Whereas at the beginning of the program Participant 4 talked about his views of science being informed by school, his family, and the Museum, at the end of the summer he described his overall views of

science as primarily being driven by his experiences at school and in the TSRCP program. When asked how he tended to feel when he thought about science, he said, “Bored. Mostly during school, things like activation energy and changes in E are not as fun. Doing chemistry this year, I loved my teacher, he gives us ideas, but I get stuck and feel sad.” In contrast, he said he felt, “excitement through the [TSRCP] program. A lot of research questions like sticker sharing are super interesting. At first I wasn’t super into sharing studies, but the more you know about something, the more interested you get. This program increased my interest.”

In terms of his skills, Participant 4’s confidence declined in the middle of the summer but rebounded by September. He felt was due to not knowing how hard things would be and over-rating his skills at the beginning of the program. He was especially confident with data collection at the end of the summer. In contrast, he was less confident in his writing skills because he thought he was slow and he thought the statistics workshop when he had learned R went too fast and was not hands-on enough for his learning style, which left him feeling less confident in that area.

By the beginning of the fall, Participant 4’s distinctions between science and humanities were blurring. He shared, “I realized you don’t have to be a humanities person, you can still like the sciences and be someone who likes the humanities. It’s not strictly defined; you can like both.” Participant 4 had also begun to find a specific affinity with psychology as distinct from science on a whole, noting its connections to the human side that he appreciated in humanities. Participant 4 also saw potential for generalizing his experience doing science outside the classroom, wondering whether his dislike for science might have been more his dislike of the way science was taught in school. He mused, “The more you get to know something, the more you like it. I learned that science is pretty interesting. Being in a class, it’s much more different when applying outside of the classroom. I didn’t like learning about biology. It was tedious, and I thought I didn’t like science in general. But maybe I could try biology in real life. A lot of science taught in school is different from psychology. I’m more of a science person now.”

In the winter, Participant 4 was in the thick of his research and shared that he was enjoying things but was also somewhat frustrated by logistical constraints. On the one hand, he said, “It’s really cool to have the opportunity to make a study from scratch” and “[Research] makes me feel like I’m doing something useful with my life.” On the other hand, the IRB approval had been slow and he was not getting as many participants as he had hoped. He also felt less connected to the BU community than he had during the summer.

Participant 4’s definitions of science continued to become more complex over the school year such that he saw himself within science even if he maintained his other interests, as well. He articulated, “When I came into this program, I was thinking like lab and biology chemistry. A lot of these stereotypical kinds of settings. That’s definitely changed—what I think of as a science community is people who collaborate on something they love. It doesn’t have to take place in a lab. It can take place in a museum.” In reflecting on his own relationship to the scientific community he said it had “increased a lot” and “I definitely see myself more as a scientist.”

After the end of the program, we asked Participant 4 to look back at his prior responses and to talk about how his relationships to science had changed or stayed the same over the course of the

last year. Overall, his sense of self was stable; he still identified primarily as a curious history lover. Yet, some of the interconnectedness between science and his other interests—which had been nascent and conflicting at the beginning of the program—were solidified. For instance, he said that if he were to re-do his conception of science, he would "map the process of science with education. Even if you're following the procedure, you can tell other people who might not be in your age range about the study. I think I can see how I clearly segmented parts of, this is the science science, and this is the humanities, and they can't interact, but I think coming out of this study, psychology is very related to the humanities and to history. History is just people talking about how people behave over a long period of time, how they change. That's what we're seeing right now with psychology. The program helped me make the connection that there's no singular science person or humanities person. You can be both and that's completely fine."

Looking across his responses about his interest in different aspects of science, Participant 4 noted that in general, his interest had peaked at the end of the summer when momentum was strong and he had been involved in the program for several months. During the year, the slow pace of the research turned him off, and his interest was at the lowest point in the winter. However, COVID-19 renewed his interest because he saw the importance of science for real-world events. Despite a general increase, one aspect of science remained low when we talked with him at the end of the year: his interest in pursuing a degree in a scientific field in college or graduate school. Participant 4 described how, over the spring, he had become more certain of following a path in the humanities.

In considering his responses about his confidence and skills over time, Participant 4 thought that doing the various program activities—from data collection to considering ethics to talking to different audiences—increased his confidence in these things, but not always his interest. He described the process of evaluating scientific arguments as "kind of boring. I'm more of like, I like to be on the floor doing things. I understand talking about things is important too, but I'm more of the cohort of the doing things, communicating to people rather than kind of reading in the musky basement." Participant 4 felt most of his skills had been fairly consistent over time, but he had a drop in his confidence that he can currently contribute at the highest levels of science as well as his future potential to contribute at the highest levels between the middle of the school year and the summer when we conducted his post-interview. He shared that he thought this was due to the fact that it was hard when the program transitioned to being online and then ultimately stopped, and he was now no longer actively doing science.

In reflecting about his overall sense of science, Participant 4 thought back to his initial comments from the beginning of the program about how his father had informed his views of science. He described, "Dad has a PhD in chemistry. He showed me his lab, and I had gotten the notion that science is like labs and you deal with confusing compounds and stuff. He works on polymers or something. It's foreign, weird. He showed me his lab's publication in *Nature* and I read it when I was like 12 and it was just really confusing. I thought science was a bit foreign. This program offered a different way of seeing things. Science doesn't have to confuse you. There are a lot of different types of science."

As a parting thought in his final interview, Participant 4 shared, "I just think the program helped introduce psychology as a concept for me, and also that all these people who work at labs, Dr.

Blake was a nice guy. I expected some weird grumpy professor who would speak in language we wouldn't understand. It made it accessible because as a high schooler you don't get a chance to run a study and analyze what you're doing. Work with real life science. Accessibility of science is something that I got from this program, would not have gotten elsewhere." Although Participant 4 does not plan to pursue a career in science, he sees it as an integral part of his life that informs health, interactions with other people, and fulfills his natural curiosity about the world we live in. He credits the program to making science more relatable and for giving him practice with valuable communication skills.

PARTICIPANT 5 CASE STUDY

Participant 5 especially valued the mentorship and community-building aspects of the program. For her, being employed to do research was a more legitimate way to learn about science than school, and she said it, "Made me feel like a real scientist."

At the beginning of the program, Participant 5 described herself in four main ways. First, she was a student, especially interested In English, history, biology, psychology, and, to a lesser extent, philosophy. Connected to her interest in English, the second way she described herself was as a writer, especially as it related to book reviews and essays both in and outside of class. Third was her identity as a reader; she loved young adult fiction and *Harry Potter*. Finally, Participant 5 described herself as a dancer. She danced—ballet and contemporary—engaged in choreography, and taught dance.

When Participant 5 described science, she talked about different disciplines as well as broader considerations of process and ethics. She named physics, chemistry, astronomy, biology, and psychology. Participant 5 saw connections between these fields and people, plants, the earth, and life; she thought of science as describing who we are, where we are, and how we are. Thinking broadly, Participant 5 viewed science as an interpretation of our environment and she spoke about the process of scientific experimentation as being about repetition, facts, and logic in pursuit of truth. Then she posed a big ethical question for the field: "What do we have the right to do for the sake of science?"

Aside from considering herself a student of biology, science was not a major part of Participant 5's identity when she began the program. She said she was "hesitant to call [her]self a scientist," because she "didn't have a real job in science—[I'm] only a scientist in class." She seemed to feel that there was a professional dimension involved when qualifying a person as a scientist, and that she was not quite there yet. Furthermore, she suggested a hesitance around mathematical aspects of science, expressing relatively low confidence in "conducting statistical analyses," which she said "sounded the most like math."

Even though Participant 5 did not see herself as a scientist at the beginning of the program, she had interest in and curiosity about science. She was excited about doing scientific research as part of the TSRCP program, because she felt that research can let you explore topics that you find interesting. On her pre-survey, she expressed that she was particularly interested in psychology, which was not offered at her school, and that she was excited to "actually put the skills we learn to use in real world situations" by conducting research. Participant 5 described how she was drawn to science both on an abstract, conceptual level, and on the practical level of seeing how scientific concepts can describe the world that she lives in. For example, she said that she felt inspired when thinking about science, describing that there are "so many big concepts, abstract [concepts]" that "govern who and how we are. Science connects to all of them, all of us."

At the end of the summer, Participant 5 more confidently identified herself as a scientist and as a member of a scientific community. Over the summer, she had come to see science as creative and imaginative, and she had connected with those aspects as important pieces of who she was.

She shared, “You have to be able to come up with questions to answer. Designing, problem-solving, mental flexibility to think about things in different ways.” She added, “[Science is] really cool. [We are] looking at questions that I hadn’t thought of before. Methods of finding answers is cool, it’s cool to think about that.”

Her experience doing research through the TSRCP program made Participant 5 feel more qualified to call herself a scientist. She said,“[I] feel that [I am] more of a scientist now than before the program, [I’m] doing research.” Participant 5 spoke to the difference between TSRCP and science class at school — to quote, “school science class isn’t as legit as this.” She said that it “was cool to do” this kind of “more serious research,” and expressed that she was “looking forward to [science in the] academic year.” So, while science class wasn’t as “legit” as TSRCP, Participant 5 indicated that TSRCP supported her interest in science in school. In light of her previous low confidence in statistical analysis, we asked how the portion of the program relating to statistics had gone for her. She shared that the statistics part of the program “wasn’t great.” However, she did say that learning R was fun.

At the end of the summer, Participant 5 told us that she found the community-building aspects of the program especially valuable to her. In her post-summer survey and interview, she talked about how “being a member of the MOS community” was one of the most interesting aspects of the program to her, because of the friendships that she had made with the other teens in the program. She also stated that “being mentored by STEM professionals” had been one of the more interesting parts of the program for her, because it gave her “a look into the real science world.” Although she felt the program had given her good insight about science, she did not feel she had done much science education in the program, saying, “education would be a strong word for the impact of what we’re doing.”

When we checked in with Participant 5 in the winter, she was feeling positive about the program. She told us, “[I] like it a lot” and even though her study hadn’t been approved by the IRB, she was “excited for that to happen. I don’t know if we’ll have time, but I want to move to the next stage in the process: writing, analyzing, and sharing.” Considering all the program elements, Participant 5 said she was most interested in learning about psychology, designing her own study, data analysis, disseminating findings, and being mentored by scientists.

Participant 5 felt her science communication skills had improved through the program, whereas her confidence in math had declined. Consistent with what she told us at the beginning of the program, Participant 5 reiterated that she was good at writing and she “felt like I could do [scientific writing] very well.” The program helped Participant 5 expand her sense of confidence beyond writing to science communication more broadly. She told us, “Over the course of the program, I have gotten better at [science communication]. I definitely have room to grow so I didn’t put it higher, but I’m a lot better at it than I was before the program.” Aside from science communication, Participant 5’s initial discomfort with math declined even further by the winter, as she said, “Before, I was more confident in that I hadn’t seen what the process was. I remember form the summer and stuff, [a BU mentor] was showing us all these math things, computer programs. I didn’t realize it was that complicated. I still need to learn how to do that a lot better, how to make that happen.”

Overall, in the winter Participant 5 felt like the program had helped her feel more connected to the scientific community, which she now saw as extending beyond traditional scientific disciplines and contexts. She described, “The scientific community can exist in many places. School and college, but also here, more casual locations. Lots of different jobs.” Participant 5 thought that doing research and the connections to Boston University were particularly valuable in helping her see herself in the scientific community. She told us, “I’m more a part of it now than I was before the program” because of “being in this program and designing our own studies and stuff.” Similar to what she told us at the end of the summer, Participant 5 reiterated, “[It’s] valuable that we have a connection to BU, another part of the science community, through [our BU mentors].”

When we caught up with Participant 5 after the program ended, we asked her to react to the data she had provided throughout the year. In conceptualizing science, she felt psychology and biology were a bigger part of what came to mind than they had been at the beginning of the program. She said, “Something that I’m kind of interested in more is moral psychology almost. I’d emphasize that more, maybe deemphasize physics and chemistry.” She had found the program’s focus on psychology compelling and she added, “Psychology is the scientific field I’m most interested in.” Participant 5 also thought that COVID-19 had helped her see the importance of science in everyday life. She shared, “I mean, given coronavirus, I definitely find myself valuing science a lot, and it’s upsetting when people don’t value science and don’t wear their mask, things like that. I definitely value science. I think it’s important that people are, people have access to science and feel like they can trust it and things like that. I guess I’m just grateful that I’m in an environment where people do value science, in a place where I can learn about it, where it’s encouraged to learn about it.”

Participant 5 thought the program had helped her see herself more as a scientist. She told us, “I think just being a part of the program made me feel more connected to science, a real scientist, whatever that means.” Participant 5 also drew connections between science in and outside of school. In her post-interview she shared, “While school and TSRCP were largely separate things, separate things in my mind, there were those occasional links, so that was cool.” For example, she shared, “There were moments when we would talk about something [at school] and I’d be like, I kind of knew that from TSRCP.” Wrapping up that thought, she repeated, “Being a part of the program made me feel like a real scientist.”

In thinking about her scientific skills, Participant 5 thought the summer had been especially valuable in building her confidence while she was doing research intensively but that her self-efficacy had declined somewhat since the program had ended. She shared that her confidence “kind of peaked in August because we were kind of in the middle of the program, doing research with a professor. It was kind of real to me. [Now my confidence] went down because I’m not in the program anymore. It’s higher than last year because I have done the program now, but because I’m not presently in it right now, that’s why it went down.”

Even though Participant 5 found science to be a valuable part of her future and the program had helped her build skills, being away from the program had dampened her views of science and she thought her plans primarily laid in other fields. Looking at how she had described herself at the beginning of the program, she thought, “I feel like I’m still the same person” but she added “I

guess over the last few months, I've kind of solidified my interest in English and history and writing and stuff." While she noted that she was "still very interested in science," she had "come to learn that I really do value English and history, reading and writing. Knowing that about myself, I'm more likely to study those things in college. I definitely want to continue with science but my focus will be something different."

Reflecting on the change in her relationships to science over the course of the program, Participant 5 told us, "At the start of the program I didn't feel like I was a scientist, a science educator, and all that. During the program, all of those things went up. I was actually doing research, literally doing science. Now that the program is over and the pandemic caused those things to fade away, that went down. I'm not doing that science anymore. Are you still a scientist even if you are not in the present moment doing science? Does that stay a part of your identity? I guess in my opinion from the data is no." After a few minutes, Participant 5 clarified that she said, "I guess it really does come down to how you define what a scientist is. I think our thinking is still linking being a scientist to having a job that is doing science. I wouldn't call myself a scientist if I was just like taking physics in school because I have to take physics. I think my thinking still links being a scientist with having a science job."

PARTICIPANT 6 CASE STUDY

Participant 6 entered the program with extremely high interest and confidence in all aspects of science, science education, and science communication. Over the course of the program, her exposure to new experiences helped her articulate what she was most and least interested in and where her strengths were.

When Participant 6 entered the TSRCP, her strong interest and identity in science were highly intertwined. Describing herself overall, she told us how she loved rock climbing, chocolate, animals, the color purple, and weird food. She also thought her interest in biology and her experience working at the Museum of Science were major parts of who she was. She said, "I work here [at the Museum of Science]. The way I think about things is analytical and statistical. I don't get people my age because I don't understand why they're doing things. People tell me I'm analytical and 'such a scientist' because I just add logic." In her pre-survey, she gave the highest possible ratings of agreement to the statements, "I am a scientist," "I am a science educator," and "I am a science communicator." Participant 6's identification with science was consistent across contexts. In addition to her connection to the Museum, she found science in school "always interesting," especially now that she was in high school and taking specialized science classes — this helped her discover that she "really like[s] bio." Also, she bonded about science with her mother, who "helped me start out with science."

Perhaps related to her interest in biology, Participant 6's concept of science was largely related to living things. She described biology, body systems, genetics and heredity, DNA, carbon, water, the earth, medical science, and plants and animals. Structurally, she discussed the Museum of Science as influencing her view of science and the idea that science was typically done within scientific institutions. She described how science was driven by hypothesis testing. When she charted her concept of science on paper, Participant 6 placed the word Science in the middle of the paper with a big exclamation point after it.

In conjunction with her identification with science, Participant 6 began the program with particularly high confidence. For example, she noted on her pre-survey that she was "extremely confident" in tailoring science communication for different audiences and talking about scientific methods with museum visitors, and she explained she had "[done] those things in class," and "know[s] where to start" with them. When we inquired further, she offered some granularity about scientific subject areas, saying she "might be less comfortable about chemistry or physics."

At the end of the intensive summer, Participant 6 still spoke mostly in positive terms about science, and about the program, yet her enthusiasm was tempered. She said that she "really like[d] the [sharing] study," and that "doing a research study after practicing is a lot of fun." In explaining her identity as a scientist, she said that "from being at the Museum for that long, [she had] always been told that everyone can be a scientist." Describing her identity as a science educator and science communicator, rather than the complete confidence she had expressed at the beginning of the program, she explained that "education and communication are more practice skills," and that she "[has] to keep working on them." Participant 6 also reported a declining affinity with science, including less identification with the statements "I am a scientist," "I am a science educator," and "I am a science communicator," although overall she

still agreed that she saw herself in these ways. We asked if anything had changed about her interest in science in general over the course of the summer, and she said she wasn't sure, because it was her first time doing anything related to psychology, and that she had done "a lot of learning."

This sense of learning and decreased confidence was evident in Participant 6's data about skills as well. For example, at the beginning of the program she had been highly confident about her ability to read papers written by scientists, despite the fact that she was unsure if the papers that she had read in science class had been written by scientists. In the post-summer survey, after she had read papers written by scientists as part of the program, her confidence declined. She expressed similar decreases in confidence in conducting statistical analyses. When asked about statistics, she explained that "math can be kind of hard," and that it's "difficult how to figure out what statistical analysis [to use]." We probed about her experience learning stats in the program, and she reported that it's "too difficult to teach that much stats [...] in one summer."

Despite dampening confidence and enthusiasm, the Museum continued to be a key connection point between Participant 6's sense of self and science. In her post-summer interview, she said that she "really like[s]" the MOS, and that she finds it to be a "fun place." When she diagrammed her sense of self and her sense of science, there was little in common across the two diagrams except that the MOS logo was present on both maps.

We caught up with Participant 6 in the winter and she said the program was going well even though there had been some delays and changes in the plans. Her interest in science had rebounded since we had talked to her at the end of the summer, and once again on her survey she indicated having the highest possible interest values in solving scientific problems; reading websites, articles, or books about scientific issues; and pursuing a degree in a scientific field in college or graduate school. When we asked her what was most interesting to her, she responded, "all of those things interest me" and she described her self-motivation for these topics, adding, "Science has always been very interesting so I like that. Solving scientific problems, also always interesting, and reading websites, articles, or books about scientific issues I even do that outside this program."

While Participant 6's interest in science was particularly high, the program had widened Participant 6's exposure to science in ways that had made her more modest in her assessment of her abilities. In general, she told us her confidence was clearly tied to how much time the program had dedicated to the different activities. For instance, she maintained high confidence in considering the ethics of a research study and replicating an experiment previously completed by others and she noted, "We had really extensive ethics and CITI training over the summer, almost most of the summer we had a lot of things about ethics. I feel comfortable pointing out what was wrong. We also spent a lot of time replicating a study over the summer. Over the summer we were here more often, two to three times a week, so I got really confident with them." Similar to what she shared at the end of the summer, Participant 6 indicated that she had low confidence in conducting statistical analyses and added, "We only did that once or twice the whole time." In summarizing her thoughts about her confidence, Participant 6 told us, "I feel like the longer I'm in the program, the more people I've met who are much smarter than me and know much more about science, I just ended up with even more questions, and there are a lot of places to go."

Participant 6 echoed this sentiment of questioning when we asked her about her relationships to scientific communities. At the beginning of the program, Participant 6 felt she was absolutely a member of the science research, science communication, and science education communities and saw those communities as deeply intertwined. Now, half way through the school year, she saw more distinctions and shared, “I’m not sure [how I would describe my relationship to the scientific community]. I feel like there are different groups of scientific communities, and I don’t know where I quite fit in yet.” When we asked her to further explain this thought, she said there were, “People who teach science, that is their career. There are science teachers and professors, people who work at the museum who interpret are also part of that. There are also people who are mostly doing interpreting, who are people like at the museum. And there are researchers, and people who what they do, they aren’t a scientist but do science, like doctors and stuff.” Despite her uncertainty about quite where she fit within the many different science communities she identified, Participant 6 indicated that the program had helped her build a connection with research communities. She said, “I entered in a different little group. Before, I was in the interpretation scientific community group. Now I’m in the research scientific community group.”

Unfortunately, after the program ended early due to COVID-19, we were unable to reconnect with Participant 6 to learn how her perspectives had changed and how her science identities continued to develop.

3.2 TO WHAT EXTENT DO TEENS ENGAGE IN THE CORE PROGRAM ELEMENTS?

This section reviews interview data about the teens' perceptions of the extent to which the program activities carried out the intended goals. As described in the introduction, the program set out to have youth participate in five core program elements:

1. Engage in research practices: Teens will replicate published research, conduct novel research, and analyze data.
2. Engage in science communication practices: Teens will develop communication products such as academic posters, social media, and more.
3. Engage in science education practices: Teens will facilitate research toys and work on the Museum floor as science educators.
4. Experience mentorship from STEM professionals: Teens will have mentors both from the Museum of Science and from Boston University.
5. Become a member of a science community: Teens will be integrated into scientific communities as Museum staff and contributors to Boston University's Social Development and Learning Lab.

The findings for this section include:

3.2.1 Despite some challenges in logistics and communication, the program was highly effective at engaging teens in research practices.

3.2.2 Science communication activities were integrated into the TSRCP research, although not all teens recognized them as being science communication practices.

3.2.3 Although teens enjoyed the science education they did in TSRCP, less program time was dedicated to science education than other program elements.

3.2.4 Teens found the program's mentorship to be strong, especially during the summer.

3.2.5 Participants felt well-connected to their peers and mentors, while they sometimes felt distanced from the broader Museum and Boston University communities.

3.2.1 Despite some challenges in logistics and communication, the program was highly effective at engaging teens in research practices.

The research process was the centerpiece of the TSRCP program's curriculum, and although there were some logistical challenges, the research stood out as a highlight for most of the teens. For example, Participant 1 shared, "Engaging in research practices [has been the best part of the program] because that is what we are mostly focused on." Participant 6 echoed a similar sentiment, telling us, "We have done so much research, and there's been a big focus on research."

When describing their involvement with research practices, teens most often highlighted planning research studies, collecting data, and statistics. The planning process, which involved creating a study, was exciting for several of the youth. Participant 4 told us, "It's really cool to have the opportunity to make a study from scratch." Participant 2 thought planning a study was a valuable learning experience, saying, "The program has taught me a lot about research. I didn't really know how much thought and how precise you have to be when doing research. A lot of the ethics involved in planning out a study and how it benefits certain people and the purpose of the study, how you word things and how to make it useful."

Although the planning process was valuable, teens indicated that the communication about what to expect from this process had been inconsistent. Participant 1 shared, "I was told we got to create our own research study, and that sort of happened, but they said "Here are the themes we want you to explore." We didn't have as much free choice [as I thought we would]." Participant 6 had expected to have full flexibility about designing her study and found it frustrating that she was limited to what she perceived as too narrow a scope. She described, "We did altruism over the summer and now almost everyone is doing wealth. It's very limited." For Participant 5 the time allocation was unexpected. She said, "I expected to spend more time on like designing and running my own research, whereas the first half to two thirds was more doing Dr. Blake's study and things like that, which was also fun and I'm glad for the opportunity, it was just different from what I expected."

Aside from the research planning process, teens spent a large amount of time collecting data. Participant 4 described how he had gained confidence in data collection after doing so much of it. He shared, "Every Tuesday me and my partner had to collect data for four hours to be able to balance it. Because I've spent eight weeks of this summer, 32 hours, I've had a lot of practice with that." Although the program did allocate time to data collection, by the spring teens indicated frustration that there was not enough time to get the amount of data they needed. By February, Participant 4 described that he was committed to his project and wanted to get enough data to write it up. He told us, "I wish we had more time to collect data. It's hard collecting data. Each week we look at two or three real participants."

Another aspect of research that teens found pivotal was doing statistics. Teens tended to enjoy the statistics aspects of the program but found that the timeline and approach could have been improved. Initially, half of the participants said that they were not good at math. For instance, Participant 1 shared, "Math and I have an interesting relationship…math is hard." Despite this, several participants shared positive views on learning statistics. Participant 5 said, "Learning R was fun," and Participant 4 said, "[Learning statistics] was interesting. Stats is really important for analyzing data." Especially given the interest in statistics, it is notable that three participants shared a desire for spending more time on the topic. Participant 4 told us, "R was really helpful but we didn't have enough time. I'd like to learn more. A lot of it was us watching while [mentor] did it. I need more hands on. They did give us a workshop, but it would be helpful to have more hands-on stuff in the long run." Participants 2 and 6 both said they wanted more time, as well, with Participant 6 sharing, "It's too difficult to teach that much stats to learn in one summer." For Participant 5, who had previously taken a statistics class, the statistics aspect of the program was just right. She shared, "That was done really well."

3.2.2 Science communication activities were integrated into the TSRCP research, although not all teens recognized them as being science communication practices.

Three of the teens identified science communication as the element that the program was doing the best, with a fourth saying it was one of the best. The teens often described science communication as intertwined with science research and science education. For instance, Participant 1 shared, "I would say engage in science communication practices [was what the program has done best]. Pretty much everything we did was that in some way. We were out on the floor talking about research, doing poster presentations, etc. That one got reinforced the most." Similarly, Participant 4 said, "Engaging in science communication has been one of the best things that the program has done, because you're out on the floor but even in a more proactive way you have to go to different adults and kids, convince them to come do your study." In fact, Participant 6 explicitly said she thought there should be no boundaries between science research, science communication, and science education. She said that for a "well rounded scientist" there should not be any difference between the three areas.

Other participants held a stricter distinction between science research, science education, and science communication. These participants tended to feel like the program had not done as much in this area. Whereas others thought the research process involved science communication, Participant 1 said, "I'm not sure what part of the program let this happen, but all we are doing is the research, preparing for research, doing the research, or piloting research. I'm feeling like it's imbalanced at this point. I feel the other stuff is getting shunted to the side." Participant 5 shared, "We made a couple of posters, writing inserts and stuff like that" but ultimately thought there had been less of a focus on science communication.

When teens discussed science communication activities, writing and developing posters were what came up most often. Participant 4 shared, "We definitely made a lot of science communication papers. Over the summer we made two." For Participant 3, not only was writing a key element of the program, but doing that writing helped build confidence. He described, "As I started to write the research paper I became more comfortable with that, [writing up] the inductive coding and sticker study gave me a lot of experience. It's something I can say I'm confident in. I thought it would be hard but it was easier than I thought it would be." After having done the posters, Participant 5 was eager to do more. She told us, "I really liked the process of analyzing data and making the posters and stuff. Thinking about how to best present our findings and summarize it well. I'm excited to do more writing about the studies and stuff." In follow-ups after the program, there was disappointment that teens had not been able to complete and write up their studies due to the pandemic.

One other science communication activity that three teens discussed during their interviews was social media. All three of these participants indicated that they had worked on social media posts but that they had never been posted, which had been discouraging. Participant 6 described the situation, saying, "For science communication practices, we started a bunch of things and then we did our part or didn't finish our part and then didn't receive more time, or the part we passed off to someone else never got done. We started a social media post and they were like "we'll post

it for you" over the summer. We created our social media post with an example image and caption and passed down to social media. They were supposed to get back to us and it never happened even though we spent a lot of time on it. It was very sad." Despite these disappointments, science communication was the only program aspect that all post-survey respondents selected as one of the three most interesting aspects of the program; engaging in these practices made participants find them compelling.

3.2.3 Although teens enjoyed the science education they did in TSRCP, less program time was dedicated to science education than other program elements.

When they entered the program, all six teens had prior experience volunteering at the Museum, and thus they had experience with science education. In many cases, the teens felt confident in their science education skills at the beginning of the program and looked forward to doing more of it. For instance, Participant 4 shared, "Education drew me to the program" and "I want to be an educator when I grow up." On their pre-surveys, half of the participants indicated that science education was one of the three most interesting aspects of the program.

Two participants thought that the Museum setting for the TSRCP program had been a strength of the program and its ability to do science education. Similar to science communication, these teens saw science education as an integral part of the research process because of the Museum setting and the emphasis on research debriefs. Participant 2 thought science education was one of the best aspects of the program and noted, "Since we're in a museum, a lot is focused on visitor experience. We're on the floor debriefing all the time, telling people what's happening all the time with the research toys. Telling people what research has been done in the past. It's similar to what we've done before the program. Instead of interpreting the exhibit, we're interpreting research." She continued by discussing how the research toys had been a good learning experience, noting "I learned a lot from it" and, "Doing research toys, all that stuff I didn't really know how to do before." Participant 4 also felt that science education was the strongest aspect of the program and said, "We've done a lot of research toys and worked on the Museum floor."

For other participants, it felt like science education had been deemphasized. In February, Participant 5, who had come to the program for its educational aspects, told us, "We don't go out on the floor as much…We were gonna choose our own research toy to dive into and stuff, but we didn't get the chance." When we followed up with her in July, she continued this thought, saying "We did do the research toys but that was more towards the beginning of the program. That more sort of faded away…I guess the focus of the program was more about the research, less about the research toys and that sort of thing, so it makes sense that it kind of faded away. If the goal was more of the science education type of stuff, we could have stayed engaged with the research toys for maybe longer." Participant 4 also felt that it would have been preferable to have more time devoted to science education. He shared, "I like to be on the floor doing things. I understand talking about things is important too, but I'm more of the cohort of the doing things, communicating to people rather than kind of reading in the musky basement." When we spoke with the program leaders during a focus group at the end of the summer, there was a sense that teens' confidence was low at the end of the summer because they had done so many new things.

The team indicated that shifting the balance to allow more time with science education might be an enjoyable way for the teens to use skills they were more familiar with from their prior experience with the Museum.

3.2.4 Teens found the program's mentorship to be strong, especially during the summer.

All of the teens spoke positively about their experience with mentorship as part of the TSRCP program, using terms like "really great," "cool," and "nice." Participant 2 indicated that the mentorship tied the program together, saying, The STEM professionals helped us do everything and guided us through the program elements." For Participant 4, mentorship helped make science more approachable. He shared, "[Mentor] was a nice guy. I expected some weird grumpy professor who would speak in language we wouldn't understand. It made it accessible." Mentorship was a new experience for Participant 3, who found the mentorship to be, "The most interesting part [of the program]."

Three participants differentiated mentorship from traditional schooling. Participant 5 shared, "It's a different experience being mentored by someone in a STEM field. You learn more about what I might like to do for a job [than through school]…It gives us a look into the real science world. Science class isn't as legit as this." Participant 4 felt that the mentors at the Museum had fostered a different type of environment in which it was alright to make mistakes. He described, "Mentors at MOS are insistent that it's ok to be wrong here. This is something that school doesn't normally tell you; [at school] they reward you when you get the right answer." For Participant 6, the benefit of mentorship was the mentors' deep expertise in their focus area. She told us, "It's cool to work with people who know a lot about what they're doing. From private school, when [teachers are] trying to teach a broad range, they don't understand everything specifically. I ask very specific questions. People who specialize know their subject really well." Two additional teens spoke about appreciating the mentors' expertise as well.

As the program transitioned from the summer to the school year, all program activities became less intensive, including mentorship. Rather than having weekly workshops and working alongside mentors three times each week, the teens shifted to working more independently one day a week and having the mentors provide feedback on their work, which sometimes happened through email rather than in person. Furthermore, the frequency of BU mentorship was challenged by turnover, when the primary BU mentor graduated in December. Although there was continued interaction with the primary faculty member at BU, this change in staffing was noticeable to the teens. Participant 1 summed up this change by saying, "Over the summer we had a lot of that [mentorship], and that was really great. We had workshop days. Once we got to the fall, we were more on our own. Not literally on our own, but doing more of our own stuff and having less of that mentorship. That was one I'd like to have some of the stuff from the summer carry over into the school year." For Participants 4 and 5, there was a notable change in tone as time went on. After the summer, Participant 4 told us they "Definitely also experienced a lot of mentorship. A lot of mentorship from STEM professionals" and Participant 5 shared, "Mentorship is happening a lot." Several months later, the comments changed. Participant 4 described, "I did appreciate BU's help but we only met once a week. Less contact" and

Participant 5 said, “We haven’t really seen [BU mentors] for a while because it’s the school year now. We’re really only here [at the Museum]. I don’t know if it’s possible to bridge that gap more. If so, that could be nice.”

3.2.5 Participants felt well-connected to their immediate peers and mentors, while they sometimes felt distanced from the broader Museum and Boston University communities.

The previous section shared teens’ positive views of their relationships with their mentors. Their interview data also indicated that they tended to feel connected to one another. For instance, three of the teens described the other participants as their friends. Participant 5 shared, “In our little group, we felt more like a community as time went on…our group was a pretty solid group.”

The teens entered the program with an existing relationship with the Museum and, for the most part, they maintained a strong sense of community with the Museum throughout the course of the program (see Figure 8, above). Participant 1 shared, “I love the Museum. I’ve been coming here since I was four…you walk through the doors and you’re part of the community. Even if you haven’t done anything, it’s like, “You’re part of our community!””

Beyond the existing relationship, however, some teens found that the program shook their sense of community with the Museum. For Participant 2, the institutional restructuring that occurred in the middle of the summer may have contributed to the feelings of confusion and disconnection that she expressed. She shared, “I’m not sure where we are in the Museum. A different department, technically. Not really Discovery Center. We’re kind of isolated in a sense…We’re this small group and we do our own thing. We’re not supposed to be associated…We’re not a part…not associated with other parts of the Museum.” Participant 6 echoed this sentiment, saying, “Members of the science community could be better because we’re here at the Museum all the time but we’re separated from the Museum. I used to do other things in the Museum and be very much in the Museum, but as research assistants we’re not in the Museum as before.” Other factors that contributed to this feeling of disconnectedness were related to the physical space. Teens disliked the office areas they used and found the location for their data collection to be undesirable, which they interpreted as the Museum not valuing their presence. In the focus group of program staff, one program leader mentioned that other staff in the Museum had made comments to the teens that made them feel like they were not supposed to be there.

For the Boston University community, the field trip was highly successful but teens wished they had more, although they recognized logistical constraints. For instance, Participant 4 said, “It was really cool to go to BU’s lab at the end of the summer but we only went there once. I don’t know how we could be more involved with BU. We had people come over from BU who were doing research there. That was definitely really cool.” Participant 5 highlighted the importance of where the program physically took place, saying, “[Mentor] said we could say we were part, but meh…we’re not really physically even there. We really only see [Mentor]. We don’t do anything related to BU other than put it on the posters and say it, use the IT thing to look up stuff from their libraries.” Participant 1 echoed the importance of physical presence at BU and articulated,

We only went to BU once. [Mentor] comes and helps, but all the work is at the Museum." When probed about what would make her feel more like a part of the BU community, she said, "Not anything realistic. Going to BU more often, collecting data at BU at the labs and working with BU undergrads." As Participant 1 highlighted, some of these changes may be unrealistic within the legal constraints and organizational policies that the program falls under. For instance, there were limits to the number of hours the mentors could be involved and travel off-site was strictly limited.

3.3 HOW DO THE CORE PROGRAM ELEMENTS CONTRIBUTE TO CHANGES IN TEENS' SCIENCE IDENTITIES?

To assess the relationship between the program activities and teens' science identity, the evaluation team coded data based on program element and science identity factors and then assessed the co-occurrence of these codes. Based on this approach, the program elements that most commonly occurred alongside teens' descriptions of their changing science identities were engaging in research practices (all 6 teens and 84 excerpts), engaging in science communication (all 6 teens and 37 excerpts), and engaging in science education (5 of 6 teens and 25 excerpts). Additionally, the program focus on psychology was an emergent factor that was commonly connected to teens' science identities, and was present in 22 excerpts from 5 of the teens. The following pages describe these findings in further depth, assessing the specific program activities and how they contributed to the three areas of science identity included in the TSRCP model of science identity: interest and affinity; skills and self-efficacy; and belonging and community.

The findings for this section include:

3.3.1 The program focus on psychology, ability to plan a research study, talking to visitors on the Museum floor, and mentorship were most often associated with interest in science.

3.3.2 Teens indicated that increases in their skills and self-efficacy went hand in hand with what they thought they spent the most time doing: research and science communication.

3.3.3 Teens felt that being a member of the MOS community, doing science education, and engaging in research practices contributed to positive science identities.

3.3.1 The program focus on psychology, ability to plan a research study, talking to visitors on the Museum floor, and mentorship were most often associated with interest in science.

The program element that teens most often described in conjunction with a positive interest and affinity for science was the program's content area of psychology. Four of the youth mentioned this focus in conjunction with positive interest in science. One aspect that they found helpful about psychology was that it was not seen as a hard science and so it was more approachable than some other scientific fields. For instance, Participant 1 shared, "I definitely feel like, for most of my childhood, I didn't think of myself as a science person, I still sort of don't. I visited MOS, took some classes, then started working there and got interested in psychology. I think of it as an edge science kind of. It's not a super sciencey-science." In a similar vein, Participant 4 valued psychology's similarities to the humanities, and came to see the two fields as having overlaps. He said, "I realized you don't have to be a "humanities person." You can still like the sciences and be someone who likes the humanities." Two teens spoke about how psychology was an uncommon focus area for teens, which was something they valued. Participant 4 said, "The labs my friends are working at are very like chemistry and computer based. This is one of

the only ones I've heard of that focused on psychology." Likewise, Participant 5 shared, "I haven't gotten to do psychology before. I'm excited to do that, learn about it."

Another aspect of the program that contributed to positive interest and affinity in science was the ability to plan a research study. Three youth described this connection. Participant 6 described, "I want to focus on my skills of setting up experiments. I think I have a talent for finding faults in people's reasoning." Participant 4 noted, "It's chill. It's really cool to have the opportunity to make a study from scratch, go through all these steps." Participant 5 shared, "Like it a lot. We've been able to go through the process of designing and writing a study." The ability to design a study also contributed to youth's sense of buy-in with the research process, which was evident in responses about how much they wanted to collect data and write up their studies. This buy-in may have heightened some dissatisfaction with the slow process of getting the studies up and running. For instance, Participant 4 said, "I was just a bit frustrated like during the process of getting the study on the ground, just because, yeah, but I understand that because the Museum is big it will take time to get things done."

The third component of TSRCP that encouraged youth's positive interest and affinity in science was doing science education by talking with Museum visitors. As mentioned previously, this was a skill with which all participants had prior experience and comfort. Four of the youth described talking to visitors and positive interest within the context of the TSRCP program, indicating that talking to visitors was enjoyable and meaningful in a way that had lasting impacts. For example, when Participant 4 reflected broadly on what he enjoyed and did not enjoy doing, he said, "I like to be on the floor doing things" before sharing a contrast that he was less interested in learning through reading and lectures. Compared to the "musty" activities that took place in more traditional learning settings, he noted that "I enjoy [talking to visitors] a lot." Participant 6 similarly thought talking to visitors was "a lot of fun." She earnestly stated, "I love what I do here at the Museum. Talking about things I know and learning more" before laughing and adding, "There's nothing that wrecks your ego more than a 5 year old who knows more about giraffes than you do."

A fourth part of TSRCP that youth felt contributed to positive interest and affinity with science was the program's mentorship. Three of the youth spoke about this connection. Within their comments, there were two themes: it was valuable that the mentors had real-world STEM expertise and it gave access to the STEM world in a way that was uncommon for teens. Describing the value of expertise, Participant 5 said, "Being mentored is cool because they're in the field and they know" and Participant 6 noted, "It's cool to work with people who know a lot about what they're doing." For Participant 4, access to mentors made science more understandable. He said, "[Mentorship] made it accessible…accessibility of science is something that I got from this program and would not have gotten elsewhere." Participant 5 shared a similar idea, saying, "[mentorship] gives us a look into the real science world…being in classrooms with teachers is a different experience to being mentored by someone in a STEM field."

3.3.2 Teens indicated that increases in their skills and self-efficacy went hand in hand with what they thought they spent the most time doing: research and science communication.

Whereas the teens spoke about specific program activities in relation to their interest and affinity, their descriptions of how their skills increased tended to reference the broader program categories of research and science communication. Many comments indicated that confidence increased simply because the teens had done something that they had not previously done before. All six of the teens talked about how engaging in research practices contributed to increased confidence. For example, Participant 5 said, "We've done that now. I know that I know how to do it. I understand it best because I've done it before." Describing the change over time, she added, "In terms of just doing the research, I don't know if I had low confidence at the start, but I knew I didn't have a lot of experience. I knew I was just excited to get started. My confidence went up over time, being able to get experience doing that." Two of the participants mentioned how the summer was particularly effective in building confidence because of its intensive nature. Participant 1 said, "What we did over the summer, beginning of the summer we did CITI training and ethics, and reading papers and doing research. The work was much more intense over the summer. We were in 3 days a week. I feel like I got a more solid grounding because of doing them more." Similarly, Participant 6 described, "We also spent a lot of time replicating a study over the summer. Over the summer we were here more often, 2-3 times a week, so we got really confident with them."

Although teens felt that engaging in research practices helped contribute to their confidence, four of the teens also noted that there were aspects of the research process that shook their confidence. For Participant 4, this was a continuation of the point above; the summer was very positive because of its intensity, but when the program transitioned to the school year and the teens were involved for fewer hours, the confidence diminished. He shared, "[My confidence] started decreasing as we went into the year. Weird reasoning, but I thought that because the study wasn't going on, I thought I would never be able to contribute at the highest level." The other area of research that contributed to low confidence was the statistics portion of the program; four of the teens described statistics—and its similarity to math—as hard, or that they felt like they were not good at it. Participant 4 suggested that the program spend more time teaching statistics and learning R, the programming language the teens used to do their quantitative data analysis. He offered, "There could have been more time spent on analysis. I know we were kind of on a squished timeline, but to know a coding language is hard."

The second aspect of the program that teens frequently discussed as being connected to confidence and skill-building was science communication. Five of the six teens made this connection. Similar to research, the teens felt that doing the science communication activities helped enhance their confidence, suggesting that these program aspects were effective. For example, Participant 3 said, "As I started to write the research paper I became more comfortable with that, the inductive coding and sticker study gave me a lot of experience. It's something I can say I'm confident in. I thought it would be hard but it was easier than I thought it would be." Participant 4 shared a similar thought, saying, "A lot of the last 2 weeks [of summer] was a lot of science communication, poster presentations to the Museum and general public. I feel

comfortable with that." Participant 2 specifically credited the program with increasing her science communication skills, noting, "I feel like I am more confident in my skills. Like, the program definitely boosted my confidence in my ability to do these skills." Likewise, Participant 5 shared, "I like presenting and stuff. My confidence was low, and being able to practice and stuff, it got it a little bit higher."

Like with research, science communication activities were not always positive for teens' confidence, although the negative experiences were much less common. Rather than indicating that they were bad at science communication skills, two teens shared that they wanted to continue improving their skills. Participant 5 said, "I have gotten better" but "I still want to work on it" and Participant 6 noted that science communication was one of her "practice skills" and she had to "keep on working on them." Participant 4 shared, "writing takes me a long time," with the implication that the program had not always allocated sufficient time to complete communication projects to the desired standard.

3.3.3 Teens felt that being a member of the MOS community, doing science education, and engaging in research practices contributed to positive science identities.

Four of the youth discussed how the program's community-building efforts—especially being a part of the MOS community—effectively contributed to their sense of community and belonging. Participant 6, "From being at the Museum for that long, I've always been told that everyone can be a scientist." Similarly, Participant 1 described, "I am definitely part of the scientific community. Working at the Museum of Science you can't not be" and added, "I love the Museum." With parallel certainty, Participant 2 indicated, "Being part of the program definitely made me feel more like part of the scientific community." Appreciating the networking among program partners, Participant 4 shared, "You're way more connected than you think you are" and confided, "Other kids in the program are my friends now." On a broad level, Participant 5 said, "I guess I'm just grateful that I'm in an environment where people do value science, in a place where I can learn about it and where it's encouraged to learn about it."

Four youth found the science education aspects of the program effective in contributing to their science identities, especially their sense of being science educators. Participant 1 described that she felt like a science educator because they "enjoyed learning" and "did a lot of science education, talking to kids, visitors." Participant 2 indicated that the program's expectations contributed to their sense of self as a science educator, saying "[science educator] is the role that we're supposed to be on the floor." Both Participants 4 and 6 also discussed how doing science education through the program contributed to their positive identities as science educators. Participant 6 concluded, "We do a lot of science communication and educating children in science areas. I was told if you can't explain it you don't understand it."

Finally, two teens talked about the research process as contributing to their science identities. Through the program's research aspects, Participant 4 developed a sense that a science person is "Anyone who has an interest in research." The Museum setting for the program's research was also influential in Participant 4's conceptualization of science identities. He noted, "It doesn't

have to be a lab. For me, a scientist can use this data to inform the public about something. This is what I've learned, to hopefully be a contribution to the public." Participant 5 solidified her views of what it meant to have a science identity as well, concluding that the act of doing science regularly was what made you a science person. She detailed, "At the start of the program I didn't feel like I was a scientist, science educator, and all that. During the program all those things went up. We were actually doing research—literally doing science. Now that the program is over, and the pandemic caused those things to fade away, that went down. I'm not doing that science any more. Are you still a scientist even if you are not in the present moment doing science? Does that stay a part of your identity? I guess my opinion from the data is no."

IV. DISCUSSION AND CONCLUSION

This evaluation report describes the outcomes of the first TSRCP cohort. Overall, it shows that the program offered a valuable experience for the 6 teens who participated, allowing them to participate in authentic science research. Here we summarize the results. First, we overview findings about three aspects of science identity: 1) interest and affinity in science; 2) skills and self-efficacy in science research, education, and communication; and 3) sense of belonging within scientific communities. Second, we review data about the extent to which teens engaged in the project's core program elements: 1) engaging in scientific research, 2) engaging in science communication, 3) engaging in science education, 4) receiving mentorship from STEM professionals, and 5) becoming members of scientific communities. Third, we consider connections between science identities and program elements to evaluate which elements were effective in supporting the development of science identities. Finally, we reflect on the findings' implications for future project work.

Science identities

Looking at teens' interest and affinities for science, we saw that all six of the teens entered the program with strong interest in science. Their interests continued to be high throughout the program, and interest in science communication tended to increase over the course of the program. In many cases, teens had more granularity in their interests at the end of the program than the beginning; rather than just being generally interested in science, they shared more specific examples of which aspects of science were interesting and disinteresting to them. For many teens, there was a dip in interest in science during the summer, when the program was most intensive. There was a sense that the fast pace of the program was wearing teens out and may have contributed to a dampening of enthusiasm. However, interests rebounded in the fall and remained high throughout the rest of the year when the program was meeting less frequently.

Teens' confidence in their scientific research, communication, and education skills tended to be fairly consistent over the course of the year. One exception was that teens' confidence in writing up a study for a scientific audience declined sharply at the end of the program. This is likely because teens were scheduled to write up the results of their study in the spring, but the pandemic prevented them from finishing their data collection and doing the writing. Teens may have felt confident prior to that point because they knew the program would scaffold them through the process, but then lost their confidence when they realized they would not have that opportunity and support. Similar to the dip in interest over the summer, teens' confidence in their overall ability to contribute to science dipped over the summer, as well. This is likely due to the participants learning more about what was entailed in these various skills and recognizing how complex and difficult they could be. Teens also indicated that they felt rushed at some points in the summer—especially that the statistics workshop was too short and that they did not have as much time to finish their posters as they would have liked. Yet, teens' confidence in their overall ability to contribute to science rose over the course of the year.

The data about teens' sense of community and belonging showed a different pattern as compared to the data about interest and confidence: rather than the summer being the low point, as it was for the two other constructs, teens' sense of community tended to peak in the summer. It seems that, although the teens perceived the summer as difficult and intense, their reaction was to rely

on each other and build meaningful and supportive relationships. The schedule of working on the program multiple days per week facilitated these relationships. In the fall, when teens were only involved in program activities once a week, the sense of community with MOS and BU waned, although the teens continued to feel a sense of connection to the members of their group. Over the course of the program, teens shifted from having their science identities being driven largely by others—as in, they felt like science people because their friends, family, peers, and teachers thought of them as science people—to being primarily self-motivated in science. This internalization could be a key strength of the program. It should be noted, though, that teens did not necessarily see their sense of self as a science person as indicative of their future plans. Several teens thought that, over the course of the program, they had actually become more sure that they would *not* pursue a career in STEM. Yet, they still felt positively about science and felt confident that they would use STEM in other ways, even if it was not the core discipline of their future academic and professional tracks.

Engagement in core program elements

The centerpiece of TSRCP was having teens do authentic science research, and although there were some challenges with logistics and communication, the program was highly effective at engaging teens in this work. Much of the curriculum was devoted to research in order to get through the ambitious plans. Teens found this to be a strength of the program. Aspects of research that stood out for teens were planning research studies, collecting data, and statistics. Planning a research study was an exciting endeavor for the teens, which seemed to elevate their commitment to the work. However, the program ran into logistical difficulties with the feasibility of teens creating their own studies from scratch. At first, teens got the impression that they could do whatever they wanted, but when it became clear that the choices needed to be more limited for practical reasons, the teens voiced dissatisfaction at the added constraints. Another part of the research that was particularly prominent for teens was data collection. Much program time was dedicated to data collection and teens thought their skills improved in this area. Yet, they were frustrated that it took longer than expected and that they were ultimately not able to get enough data to complete their projects. Teens shared mixed perspectives about the statistics portion of the program. On the one hand, several participants enjoyed learning R, the statistical programming language that TSRCP used. On the other hand, they tended to think the program rushed through the statistics portion quickly and regretted that they were not given the opportunity to practice their skills over time. The participants also strongly connected statistics to mathematics, which several of them disliked or considered themselves to be bad at.

TSRCP integrated science communication and research activities. For teens who saw the connections between communication and research, they tended to feel that the program had been successful in giving them opportunities for science communication. Other teens saw the same activities as part of research, and thus felt the program had not devoted enough attention to science communication. When teens described the science activities they did, they most often focused on writing, making posters, and social media. The writing and poster development process helped build teens' confidence in science communication, and the teens tended to find these activities enjoyable. For the social media, teens tended to feel discouraged because they spent a lot of time developing social media posts that were never actually posted.

Although teens enjoyed the science education they did in TSRCP, less program time was dedicated to science education than other program elements. The teens all had prior experience with science education and seemed to find it comforting in its familiarity. One teen told us that the program's stated focus on education was what made him decide to do the program. Like science communication, some teens thought science education was fully integrated into the program because they were doing their work on the Museum floor and teaching people about research through their debriefs. However, they usually felt that the program allocated little time to science education, prioritizing research instead.

Participants found the program's mentorship to be strong, especially during the summer. The teens perceived mentorship as one of the most uncommon aspects of the program, and saw it as giving them a look into the real world of doing science that was highly unlike the science experiences they got at school. Mentorship was strongest during the summer, when the teens regularly saw their mentors from both the Museum and BU. In the school year, the teens felt their mentorship waned. This makes sense given the frequency with which they saw their mentors and the types of interactions they had. In the summer, mentors gave workshops and worked alongside teens multiple times per week, whereas in the school year teens only worked one day per week, were much more independent, and a portion of the communication with mentors was via email rather than in-person. Furthermore, the primary BU mentor graduated in December. On the MOS side, two mentors were furloughed or laid off due to the pandemic in the spring. While these changes are atypical, they highlight the challenge of turnover for the mentorship aspect of the program.

The final program element was being a member of science communities. One challenge was that it was sometimes hard to determine what program activities fell into this element; the ways teens described this element often made it seem intertwined with mentorship or more like it was an overarching aspect or outcome of the program. Participants tended to feel connected to their mentors and to one another, and they valued these connections. At the Museum, teens entered the program with existing relationships that helped them feel connected (all of the teens had volunteered at the Museum before they started the program), but they also struggled to understand organizational changes that led to them changing office spaces, and they did not always feel like they had access to optimal space for their work. On the BU side, teens consistently talked about how the field trip to BU had been great, but one field trip, t-shirts, and logins to BU databases did not make them feel like full members of the community. The fact that the BU mentors met the teens at the Museum made it feel like they were physically distanced from BU. To assess the program's ability to engage youth in science communities, the evaluation team set out to assess the extent to which teens felt connected to BU and MOS. However, the emergent finding from this section is that the aspects of the program that made the participants feel most connected to scientific communities were not ties to these large institutions but the personal relationships they developed with each other and their mentors.

Connecting program activities to science identities

The program focus on psychology, the ability to plan a research study, talking to visitors on the Museum floor, and mentorship were most often associated with teens' developing interest in science. Psychology was particularly interesting for teens and for most, the program was their first introduction to the subject. In addition to its novelty contributing to teens' interest, teens

appreciated psychology because they saw it as a gateway science, or a good entry point into the world of science. Some teens had strong connections to the humanities, and they came to see psychology as supportive of that interest. Planning a research study was another aspect of the program that helped boost interest in science, both because teens enjoyed the process and because they developed ownership and a sense of personalization to their involvement with science. As mentioned previously, the teens felt comfortable with science education, and the ability to continue spending time talking to visitors on the Museum floor was supportive of their interest. This may connect to the prior point that teens found the summer somewhat overwhelming. Having the chance to do something that was more familiar rekindled their existing interests in science and science education. Finally, mentorship boosted teens' interest and affinity in science, as well. Teens valued the mentors' specialized expertise and the way they made science feel more accessible because the mentors were approachable and kind.

Teens' development of self-efficacy in science skills was strongly tied to the program activities that they felt they spent the most time doing. In particular, this involved science research skills and science communication. In terms of the research skills, teens thought replicating a study during the summer was a valuable way to build confidence by following an existing protocol before needing to develop their own. They also thought that the high frequency of program activities in the summer helped them keep their new skills sharp. One TSRCP research activity that was less effective in supporting self-efficacy was statistics. Especially because several teens felt that statistics was math-heavy and because they came in with low confidence in math, the fast pace of the statistics curriculum stood out as a weakness of the program. In regards to science communication, teens thought the program activities in this area—especially writing up a study and creating posters—helped them build their confidence. In contrast to the research skills, many of which had been brand new for the teens, several teens entered the program feeling like they were strong writers. The program exposed them to new types of writing which, in some cases, left them feeling like they wanted to continue practicing writing for these new genres. There was disappointment that the final TSRCP activities related to science communication had to be suspended due to the pandemic; it is possible that engaging in these activities would have helped teens regain their confidence.

Looking at the program elements that contributed to teens' sense of community and belonging with science, the relationship to the Museum, science education, and the research process were prominent. Teens had strong affinities for the Museum that extended beyond the program; many had been coming to the Museum for years and knew other Museum staff beyond the program. The Museum felt comfortable, familiar, and positive in a way that fostered a sense of community, even if, as stated in previous sections, there were areas for improvement. Similar to the teens' relationships to the Museum, teens felt a sense of community when they engaged in science research. They valued the conversations they had with visitors and their ability to feel knowledgeable and share that knowledge. The teens came to see themselves as science people and science educators because of this science education. Finally, being able to contribute to authentic research in the Museum setting helped teens see themselves more strongly as science people. This involved both changes in what they saw as science—a recognition that research could take place in informal settings and could focus on people rather than just chemicals, computers, and calculations—as well as changes in themselves from people who were modestly

interested in science to people who had actually been employed as researchers and had done real research.

Implications for future work

The design of this program as a pilot and feasibility study provides great opportunities for adjusting the model and innovating towards a more impactful structure. Drawing on the evaluation findings, we pose three overarching questions for the project team to consider as it restructures its work. We also recognize the limitation that, while this evaluation followed all participants in Cohort 1, the sample size of six is small. We look forward to continuing to learn from Cohort 2 to see how the findings from this report generalize or change when we integrate different perspectives and new program approaches. Our questions for the team are:

1) *How might the program and future evaluation rethink their conception of belonging in science communities?*
   The teens spoke fondly of their mentors, admired the mentors' expertise, and thought the mentorship aspects of the program had helped make science more accessible. They also felt that they formed meaningful friendships with one another. Initially, after talking to the program team, the evaluators set out to measure the extent to which teens felt connected to the Museum and Boston University over time. The results showed that the participants did not always feel fully integrated into these large institutions, especially during the school year. Moving forward, the evaluators recommend that the team consider whether a sense of belonging to these institutions is the goal of the program, or whether personal relationships and belonging in a science community—however the teens define it—is the intended outcome. If belonging with the institutions is the aim, we urge the team to think creatively about how to strengthen this sense of community with Boston University and the Museum, recognizing that physical presence on campus may be particularly difficult during a global pandemic on top of typical logistical constraints. If the personal relationships and youth-defined science communities are the goal, the evaluation team will plan to make adjustments to its measurement approach to better capture these data.

2) *How could TSRCP moderate the intensity of the summer to maintain community-building and skill development without compromising interest?*
   Teens indicated that the summer was good for forming a bond with the other participants, the mentors, and other program staff. The ability to repeat program activities with high frequency helped build skills, as well. Yet, the summer seemed rushed and somewhat overwhelming, leaving the participants feeling discouraged and less enthusiastic about the program than they had been previously. The evaluators recommend that the program team reassess the summer curriculum and scale back activities. We also suggest spreading out the statistics workshops so they take place both over the summer and during the school year, revisiting statistics regularly so teens can continue to use and develop those skills over time.

3) *What communication structures could help teens set realistic expectations?*
   A pilot and feasibility program has the ability to be nimble and make adjustments. However, the shifting expectations of the program were frustrating for teens, who thought

they had been misled. Teens expected to have their science communication work published on social media, thought they would have full control over designing their own studies, and thought they would be able to gather enough data to analyze and write up their studies. While the participants were forgiving of the pandemic interrupting their data collection and write-ups, the other program changes contributed to teens not feeling like full members of the Museum community; they felt undervalued and unimportant within what they perceived as a formidable bureaucracy. After the Cohort 1 experience, the project team recognizes that full autonomy for a research study is impractical for teens, and the plans for providing guided choices are promising. The evaluators recommend being very clear about expectations with teens, continuing regular communication to promptly explain any changes in plans, and being cautious about making promises that may not be possible to keep, recognizing that these changes have impacts on the science identities that the program is trying to foster.

In sum, the teens who participated in TSRCP gained valuable information about what doing science is like, both in terms of research practices they can do now and as a future career. This helped them evaluate and clarify their relationships to science and they came to articulate their strengths and weaknesses, interests and dislikes with more granularity. Teens valued the program model and left the program feeling a strong internalized sense of self as science people, even if they did not see themselves as wanting to pursue scientific degrees or careers in every case. The program helped expand boundaries of science beyond the lab, beyond school, beyond jobs, and into teens' lives as a way to pursue and enrich their varied ways of being in the world. We look forward to working with the members of Cohort 2 and deepening our understanding of how a program like this can support teens to grow in relationship with science.

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APPENDIX A: TSRCP SURVEY

Thank you for your willingness to complete this online survey! The purpose of this survey is to get feedback from participants in the Teen Science Research, Communication & Education Program (TSRCP).

Please complete this survey before your interview.

How long will it take?

- The entire survey should take about 10 minutes to complete.
- The survey includes some questions about what you think about science and then some questions to get your feedback about the program.

Information about your participation:

- This survey is optional, and you can skip any questions or stop at any time.
- Your survey responses will be anonymous.
- The information you provide will be used to improve experiences for visitors who participate in TSRCP.
- Because the information we collect may be useful for other studies, we may use this information in the future or share it with other researchers, without asking for additional permission. If we do so, your name and identity will not be shared with the future researchers.

Thank you for your willingness to participate and your efforts to improve TSRCP. Please contact Katie Todd at ktodd@mos.org with any questions about the survey.

[Pre-survey only] Why did you choose to do TSRCP?

Which aspects of TSRCP are most interesting to you? (Select up to 3)

- Doing scientific research
- Doing science communication
- Doing science education
- Being mentored by STEM professionals
- Being a part of the Boston University community
- Being a part of the Museum of Science community

Please indicate how much you disagree or agree with the following statements [1 – Strongly Disagree to 9 – Strongly Agree]:

- Scientific topics do not interest me
- Solving scientific problems is interesting
- I am not interested in reading websites, articles, or books about scientific issues
- Pursuing a degree in a scientific field in college or graduate school does not interest me.
- Science is relevant to my daily life

Please indicate how much you disagree or agree with the following statements [1 – Strongly Disagree to 9 – Strongly Agree]:

- I do science related activities often.
- I don’t know very much about science.
- I choose to do science activities even when I don’t have to.
- I don’t like to do science activities by myself.

When I think about science, I tend to feel... (Check all that apply)

- Bored
- Confused
- Content
- Curious
- Excited
- Frustrated
- Grateful
- Humble
- Included
- Inspired
- Lonely
- Nervous
- Proud
- Sad
- Satisfied
- Tense
- Unsure

What scientific skills do you most want to develop as part of TSRCP? (Select up to 3)

- Reading papers written by scientists
- Evaluating the effectiveness of science communication
- Replicating an experiment that was previously completed by others
- Tailoring my science communication for different audiences (scientists, educators, visitors, etc.)
- Planning your own research study
- Considering the ethics of a research study
- Collecting data
- Conducting statistical analyses
- Writing up a study for a scientific audience
- Talking about scientific methods with museum visitors
- Making sense of data
- Writing a popular press piece about a scientific topic
- Evaluating the strengths and weaknesses of scientific arguments
- Other (write in): _____

How confident are you in your ability to do the following science research skills? [1 – Not at all confident to 9 – Extremely confident]

- Reading papers written by scientists
- Considering the ethics of a research study
- Replicating an experiment that was previously completed by others
- Planning your own research study

- Collecting data
- Conducting statistical analyses
- Making sense of data
- Other (write in)

How confident are you in your ability to do the following science education and science communication skills? [1 – Not at all confident to 9 – Extremely confident]

- Tailoring my science communication for different audiences (scientists, educators, visitors, etc.)
- Writing up a study for a scientific audience
- Talking about scientific methods with museum visitors
- Writing a popular press piece about a scientific topic
- Evaluating the strengths and weaknesses of scientific arguments
- Evaluating the effectiveness of science communication
- Other (write in)

Please indicate how much you disagree or agree with the following statements [1 – Strongly Disagree to 9 – Strongly Agree]:

- It's hard for me to tell when I've been successful during an educational interaction with a museum visitor.
- I am a very good science communicator.
- When it comes to scientific knowledge and understanding, I can currently contribute at the highest levels.
- When it comes to scientific knowledge and understanding, I will never be able to contribute at the highest levels

When you think about the highest levels of scientific practice (see question above), what comes to mind?

How do your science skills compare to your peers' **scientific research skills**? [1 – My skills are the weakest to 9 – My skills are the strongest]

How do your science skills compare to your peers' **science education skills**? [1 – My skills are the weakest to 9 – My skills are the strongest]

How do your science skills compare to your peers' **science communication skills**? [1 – My skills are the weakest to 9 – My skills are the strongest]

Please indicate how much you disagree or agree with the following statements [1 – Strongly Disagree to 9 – Strongly Agree]:

- I am a scientist.
- I am a science educator.
- I am a science communicator.
- I am a member of the Museum of Science community.
- I am a member of the Boston University community.

Please rate your response to the following statements: [NO!, no, yes, YES!]

- I am a science person.
- My family sees me as a science person.
- My friends see me as a science person.
- My teachers see me as a science person.
- My peers see me as a science person.

Please list up to 5 words that describe psychologists.

Please list up to 5 words that describe scientists in general.

How much are these characteristics like you? [1 – Not at all like me to 9 – Exactly like me for each word listed above]

APPENDIX B: TSRCP INTERVIEW

Introduction

- **Thank you** for coming. We are so appreciative of your willingness to help us with this research.
- **My name** is [Name] and I'm a [Title] here at the Museum of Science.
- **Why we're asking for feedback:** The purpose of this interview is to evaluate the effectiveness of different aspects of the program and gather data that will help improve it. We're not the creators of this program, so don't worry about hurting our feelings if you think or feel something negative. We're hoping to ultimately expand this program across the country so it's important that we make it as good as it can be. Your honest feedback is a key piece in helping us do that.
- **What kinds of questions you'll be asked:** The interview includes some questions about your experience in the program as well as how you think about science in general. In particular, we will ask about what we call science identity, which includes things like what is more or less interesting about science, your skills and confidence for science tasks, and your sense of belonging in scientific communities. There are no right or wrong answers; we're just interested in your relationship to science and how it changes over time.
- **Your participation is optional:** Participation is voluntary. You will be able to skip any questions that you do not feel comfortable answering and can stop at any time. The full interview will take less than an hour.
- **Your responses are confidential:** Data gathered from this interview will be analyzed and presented as aggregate findings, and your name will never be associated with specific responses. However, given the small size of this program, we cannot guarantee confidentiality. Because the information we collect may be useful for other studies, we may use this information in the future or share it with other researchers, without asking for additional permission. If we do so, your name and identity will not be shared with the future researchers.
- **Note taking and audio recording:** We will take notes about your responses to the questions, and we are also audio recording interviews so we can accurately portray your responses for analysis. However, you may participate in the interview without being recorded.
    - Would you like to participate in this interview?
        - [If yes]: And is it alright for us to audio record?
        - [If no]: Ok, have a great day!

Meaning mapping activity

To start off today, we're going to do a meaning mapping activity. Here's a piece of paper, and I'll give you three minutes to **describe who you are** in whatever way most resonates with you. You can think about what you're interested in, what you're good at, what relationships matter to you, and that sort of thing, and you can depict them in words, drawings, diagrams, or whatever

makes the most sense to you. Ready? Ok, go…Ok, it's been three minutes so we can stop. **Could you describe what you put on your map and why?**

Now I'm going to give you a second piece of paper. This time, you'll take three minutes to **describe science**. Ready? Ok, go ahead…Ok, time is up. Thanks for doing that. **Could you describe what you put on this map and why**?

How, if at all, do you think the two maps relate to one another?

Great! Hopefully that got you thinking about yourself and science, and you can refer back to your maps throughout the interview if it's helpful.

Pre-survey introduction questions

What has science been like for you in your classroom education to date?

What have you found particularly interesting or disinteresting about science in classroom settings?

a. [If answers to the above are brief]: Do other people think you're good at classroom science? Why do you think so?

What types of science-related things have you done outside of classrooms, if any?

What have you found particularly interesting or disinteresting about those out-of-school science experiences?

b. Do other people think you're good at science outside of the classroom? Why do you think so?

Mid-and post-survey formative questions

In general, how would you say the program is going?

The core elements of the program are that you will: (Make sure they fully understand what each of these core elements means; put in chat)

a. Engage in research practices
b. Engage in science communication practices
c. Engage in science education practices
d. Experience mentorship from STEM professionals
e. Become a member of a science community

Which of these do you think the program has done the best? Why?

How could the program do a better job with these core elements?

Would you say the program has met your expectations? Why or why not?

What other changes would make this program more valuable to you?

Interest

When you talk to a friend or family member, what do you tell them about TSRCP?

On the most recent survey that you completed, you said that [responses] were the most interesting aspects of the program for you. Can you tell me what you find interesting about them?

On your survey you said you tend to feel [responses] when you do science. Why do you feel that way?

Self-efficacy

On your survey, you said that you were [most confident rating] in [skill(s)]. Why did you give that rating?

You said you were [least confident rating] in [skill(s)]. Could you explain why you felt that way?

Belonging and recognition

On your survey you [responses] that you are a [scientist, science educator, and science communicator]. Could you describe your identity in those areas?

On your survey you said you [were/not] a science person and that other people think you are (not) a science person. What do you think of when you think of a science person?

Conclusion

Is there anything else you'd like to add about your relationship to science?

Do you have any other comments?