Teen Science Research, Communication & Education Program (TSRCP)

Cohort 2 Evaluation Report

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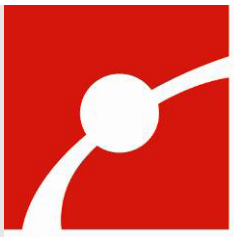

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Executive Summary

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), aimed to test and refine a model for having young people (specifically, students enrolled in high school) conduct and communicate with the public about experimental psychology research. Led through a collaboration between the Museum of Science, Boston (MOS) and Boston University (BU), TSRCP piloting involved two cycles of a year-long employment program during which teens: 1) engaged in research practices, 2) engaged in science communication practices, 3) engaged in science education practices, 4) experienced mentorship from STEM (science, technology, engineering, math) professionals, and 5) became members of scientific communities.

To assess the effectiveness of the program model and inform future work, the Research and Evaluation Departments at MOS and Children's Museum of Pittsburgh conducted a developmental evaluation of two cohorts. The focus of this report is on Cohort 2. Detailed findings from Cohort 1 are shared in "Teen Science Research, Communication, & Education (TSRCP) Cohort 1 Evaluation Report" (Todd & Weitzman, 2021). The schedule for Cohort 2 included one day per week of involvement during the school year (September – mid-June) that was primarily virtual, followed by an in-person summer intensive schedule for three days per week (mid-June – August). 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 for this evaluation involved surveys paired with interviews. The evaluation questions and key findings for each question are:

How do teens' science identities change over the course of the program? Teens expressed a high interest and affinity for science throughout the program, reporting that their varied experiences in the program refined their understanding of their individualized interests in specific aspects of science. Teens felt they developed greater confidence in their research skills and a better understanding of their own knowledge related to conducting research. They also reported building confidence in science communication and education skills, and that developing these skills contributed to feeling more like science communicators and educators than they did before the program. Teen participants also developed a greater sense of belonging in the MOS and BU communities, through interacting with mentors and other colleagues, sharing virtual and physical workspaces, and actively contributing to projects for both organizations. Case studies provide a detailed and nuanced understanding of the impact TSRCP had on each teen's science identity, particularly highlighting changes that were subtle in the aggregate analysis but appear to be meaningful for the individual.

To what extent do teens engage in the core program elements? Teens successfully engaged with all five of the core program elements and identified key program activities aligned to each element. They engaged in research practices throughout the program, primarily recognizing these practices in their multiple contributions to the BU-led "Structural Mindsets" project, as well as contributing to data collection efforts for the MOS-led "Productive Struggle" project and other MOS and BU projects. They felt that they primarily engaged in science communication practices through their contribution to a journal article, presenting findings to Museum staff, and writing caregiver handouts that described Living Laboratory studies. Teens practiced science education skills primarily through on-the-floor interpretations with Museum visitors, which they also felt

overlapped with practicing science communication. Regular interactions with select staff from MOS and BU were the most noticeable elements of mentorship in the program for the youth. Opportunities to feel like part of the MOS or BU communities were primarily identified by teens as connected to when they were meaningfully contributing to projects as members of BU or MOS teams and when interacting with staff at either institution.

How do the core program elements contribute to changes in teens' science identities? Teens frequently connected their engagement in research practices to their high levels of interest in science. Youth tended to feel that engaging in research, communication, and education practices influenced their skills and confidence; in some cases, engagement in these practices led to declines in confidence, at least initially, and teens were highly aware of ebbs and flows in their confidence as their reflections recurringly indicated having learned that there was even more to learn. The program's activities designed to offer mentorship and immerse teens in science communities were effective in supporting teens' sense of community and belonging, both in-person and online.

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I. Introduction

1.1 Project overview and goals

The Teen Science Research, Communication & Education Program (TSRCP) described in this report was developed with support from the National Science Foundation. *Developing A Program Model for High School Science Research, Communication and Education Experiences in Living Laboratory (*DRL-1811276) is a pilot and feasibility project that has developed, refined, and tested a model for involving teens in conducting and communicating about experimental psychology and related areas of research. This project was collaboratively led by the Museum of Science, Boston (MOS) and Boston University (BU).

TSRCP builds off the Living Laboratory® model, which fosters partnership between museums and research organizations to study human development and learning while simultaneously engaging the public in education and science communication about these topics. Through collaboration and mutual professional development activities between researchers and museum educators, Living Laboratory provides tools and processes through which researchers learn about and practice informal education and science communication strategies and museum staff and visitors gain insights about the latest research from developmental psychology and the psychological and learning sciences more broadly. The model centers on researchers conducting their studies in museums and providing experiences for museum visitors to learn about researchers' on-going work as they participate in active experiments and educational activities about the research process. Museum educators also engage visitors in hands-on, participatory activities about developmental research methods and findings. The MOS launched Living Laboratory in 2005 and, with significant investment from the National Science Foundation, the model expanded to more than 30 sites around the country (Beaumont et al., 2016; Biarnes et al., 2017; Corriveau et al., 2015; Soren, 2009).

Whereas the original Living Laboratory model was developed with a focus on partnership between adult professionals, as the model spread around the country, many sites began to organically engage youth involved with their organizations in leading the educational activities and even supporting the researchers in their scientific process. TSRCP sought to capitalize on this evolution by exploring strategies and building out tools to involve high school students in Living Laboratory activities in an intentional and structured way. The goals of TSRCP were to:

1. Pilot a program in which high school students both conduct 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.

This report evaluates the pilot program and the strategies that MOS and BU used to support it (goals 1 and 2). During the course of a two-year pilot program, the Museum hired two distinct cohorts of six teens each into year-long employment positions and teens had simultaneous, year-

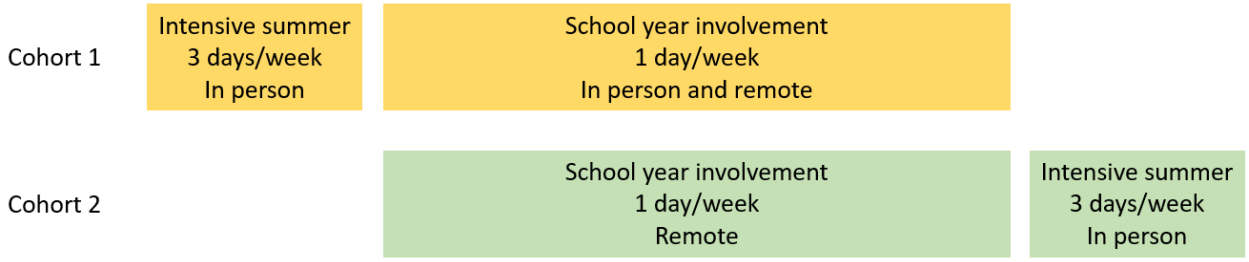
long co-appointments with BU. As BU and MOS developed the curriculum for the program, the partners organized activities around five core program elements, for youth to:

1. Engage in research practices: Teens replicate published research protocols, conduct novel research, and analyze data.
2. Engage in science communication practices: Teens develop communication products such as academic posters, social media products, and educational handouts.
3. Engage in science education practices: Teens prototype and facilitate hands-on activities and work on the Museum floor as science educators.
4. Experience mentorship from STEM professionals: Teens have mentors both from the MOS and from Boston University.
5. Become a member of a science community: Teens are integrated into scientific communities as Museum staff and contributing members of Boston University's Social Development and Learning Lab.

1.2 Cohort 2 description and comparison to Cohort 1

This report focuses on the second cohort of TSRCP, with comparisons to the first cohort when appropriate. Todd and Weitzman (2021) documented an evaluation of Cohort 1, which is freely available on informalscience.org. There were six teens in each cohort and both cohorts shared the same core program elements. However, the schedules for the two years were notably different. Cohort 1 ran from July 2019 to May 2020, beginning with an intensive summer schedule and then involving the teens weekly throughout the school year. Due to museum closures associated with COVID-19, Cohort 2 was not able to start in Summer 2020 as planned; instead, the teens started the program in October 2020, worked remotely through the school year, and then engaged in an in-person intensive summer experience in July-August 2021. During the school year, teens worked one day per week, whereas during the summer, they worked three days per week (approximately 460 program hours per participant). Figure 1 summarizes the curriculum for the two cohorts.

Figure 1. Curriculum summary table for Cohort 2



Cohort 2 began the program in October 2020 with virtual orientations to the MOS and BU. Throughout the school year, all six teens gathered virtually for two-hour workshops on Saturday afternoons, where they engaged in community building activities, learned research and educational skills, and collaboratively worked on shared projects. Museum staff from various departments and researchers from BU shared about their current work and career journeys to promote a sense of community. Teens also worked independently (solo and in pairs) an

additional five hours during the week. Activities included reading and summarizing research literature, learning about research ethics, completing human subjects research training, participating in museum evaluation studies, learning statistics and the R programming language, and assisting research teams at both organizations with on-going projects. During this time, the teens contributed to two other NSF-funded projects led by the Museum. They worked on a literature review of research about imagination, STEM, and informal learning as part of the *Conference: Interdisciplinary Perspectives on Imagination in Informal STEM Environments* project (DRL-1906899) and contributed to data collection for a study of an online exhibit for the "Productive Struggle" project, titled *Developing Guidelines for Designing Challenging and Rewarding Interactive Science Exhibits* project (DRL-1612577). Co-PI Dr. Peter Blake also invited teens to participate in BU's Social Development and Learning Lab through virtual lab meetings, where they met additional researchers and learned about ongoing work. On the research side, a primary goal of the school year was to prepare the teens to carry out data collection for one of Dr. Blake's studies. Teens met regularly with mentors from BU and MOS to guide their learning and skill development. While working remotely, and later when working on-site at the Museum, the teens' work was supported through digital channels hosted by MOS: youth communicated using MOS email addresses and Microsoft Teams as a primary collaboration platform.

Beginning in late June 2021, the teens were able to come on-site to the Museum for their summer intensive. During the summer (July-August 2021), teens piloted and iterated on the procedure for Dr. Blake's Structural Mindsets study and contributed to a pre-submission of the protocol on Open Science. Then, teens engaged in data collection, data entry, and coding of the data and began to write a paper about the study. Teens also continued to be involved in the Productive Struggle project, researching an online exhibit; they worked with a Museum researcher to conduct quantitative and qualitative analysis, presented findings to two groups of museum professionals, and drafted a poster that was presented at the Association of Science-Technology Centers conference in October 2021. On the education side of things, teens learned to lead three different hands-on activities with visitors in the Museum. These interpretive activities used natural objects like eggs and shells to guide young learners and families through practicing observation and classification skills. Teens were also involved in an exhibit prototyping process, developing content and interactive ideas for components, and gathering and sharing formative data toward the launch of a new exhibition focused on artificial intelligence. To supplement their authentic work with specific project teams, teens engaged in professional development about science process skills, Universal Design for Learning, executive function, developmental stages, the role of emotion in learning, and museum pedagogy. As with the school year, teens met with and collaborated with their mentors, worked together in small teams on various projects, and the full cohort of teens met weekly for summer workshops on Wednesdays. Table 1 shares key activities youth engaged in, related to each of the five core program elements.

Table 1. Selected youth activities by core program element

Core Program Element	Youth Activities
Engage in research practices	- CITI ethics training - Pilot testing and refining research protocols - Data collection for BU's "Structural Mindsets" (in-person) study and the Museum's "Productive Struggle" (on-line) study - Quantitative and qualitative data analysis and statistics
Engage in science communication practices	- Writing a methods description for a journal article - Developing text and visuals for a conference poster - Writing a handout about BU's Structural Mindsets research for museum visitors
Engage in science education practices	- Leading hands-on interpretation activities in the Museum exhibit halls - Professional development focused on child development, facilitation, and pedagogy - Developing content and prototyping museum exhibit interactives
Experience mentorship from STEM professionals	- Regular workshops and check-ins with primary mentors from BU and MOS - Collaborative work with BU researchers and MOS researchers - Working meetings with exhibit project team members (designers, content developers, educators, evaluators)
Become a member of a science community	- Working in the Museum exhibit halls alongside BU researchers, and MOS researchers and educators - Participating in meetings alongside MOS staff and BU students and faculty, including lab meetings and department meetings - Shared projects with museum staff and university staff at various scales - Sharing offices and physical workspaces with MOS staff - Sharing virtual workspaces with MOS and BU staff

1.3 Science identities

The project's leadership developed the TSRCP model with the goal of impacting the teens' science identities, based on research that has demonstrated the connection between science identities and longitudinal STEM involvement (Chang et al., 2011; Chemers et al., 2011; Estrada et al., 2011; Stets et al., 2017). Although there are numerous scholarly traditions for studying identity, TSRCP takes the theoretical perspective that identity formation is a fluid and constantly changing process (Calabrese Barton et al., 2013; Carlone et al., 2015; Farland-Smith, 2012; Rahm & Gonsalves, 2012). The goal is not simply that the project will make teens like science more than they did at the beginning but rather that the program guides teens in exploring their

relationships with different aspects of science such that they can better articulate what role, if any, they wish for science to have in their futures.

To provide conceptual clarity, this evaluation's operationalization of science identities draws on Hazari et al.'s (2010) model. The TSRCP exploration of teens' science identity focuses on three areas (see Figure 2). First, the evaluation team investigated teens' interests and affinities with science to better understand how students feel about different aspects of science and which parts they are most drawn to and which they distance themselves from. Hazari et al. (2010) and Johnson et al. (2017) have found that these interests affect career choices as well as youth's connections with science outside of employment contexts. Second, the evaluators have explored teens' perceptions of their skills and self-efficacy in a range of research, communication, and education activities. Living Laboratory work involving undergraduate students, and informal learning contexts more generally, have been effective in supporting this development of self-efficacy in the past (Beaumont et al., 2016; Hazari et al., 2010; Johnson, 2017). Third, evaluators encouraged teens to reflect on their sense of belonging within scientific communities, particularly building on research about the importance of mentorship and community (Adams & Hemingway, 2014; Aschbacher et al., 2010; Chemers et al., 2011; Farland-Smith, 2012; Hazari et al., 2010). In addition to these three research-based aspects of science identities, the project provided opportunities for teens to describe their identities in an open-ended way. This allowed for emergent insights and encouraged youth to consider the important intersectionalities that make them who they are and that affect their relationships with science. The open-ended approach that the evaluation team embraced draws on insights from McCreedy and Dierking (2013) as well as intersectionality theory (e.g., Crenshaw, 2017) which recognizes the compounding societal and structural influences that make us all who we are.

Figure 2. TSRCP model of science identity

II. Methods

2.1 Overall approach and evaluation questions

The Museum of Science, Boston's Research & Evaluation Department and Children's Museum of Pittsburgh's Learning & Research Department led a developmental evaluation of the second TSRCP cohort to investigate how the program model met its goals and to provide data to inform its ongoing improvement and the creation of program deliverables. Developmental evaluation is an approach well-suited to new and innovative models because of its continuous use of data for both assessing progress and promoting improvement. As Patton (2011) writes, developmental evaluation "supports the development of innovations and adaptation of interventions in dynamic environments" (p. 23). Gamble (2008) notes that the developmental evaluation approach is particularly valuable for the early stages of projects, such as the TSRCP pilot and feasibility stage.

As noted previously, this project's evaluation focused on the construct of science identity and understanding the ways TSRCP supported the development of science identity for teen participants. The evaluation looks at how the core program elements (engaging in scientific research, education, and communication; receiving mentorship from STEM professionals; and becoming a member of STEM communities) and emergent aspects of the program contributed to changes in the teens' science identities, with particular attention to their interest in and affinity with STEM; their STEM skills and self-efficacy; and their sense of belonging in STEM communities.

To best understand the relationship between the program elements and the teens' identity development, the evaluation investigated the extent to which the teens participated in each of the core program elements, studied how the teens' science identities changed over time, and gathered data to inform changes to the programmatic model and eventual deliverables. Three evaluation questions guided this inquiry:

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?

2.2 Participants

The primary participants in this evaluation were the six teens who comprised Cohort 2 for TSRCP. Professionals involved in implementing the program—both from the MOS and BU—served as secondary participants who contributed information about the program over the course of the year. Cohort 2 of TSRCP took place from October 2020 through August 2021. Two of the six teens continued as employees of the MOS in the year that followed (their senior year of high school); another teen participant was accepted as a BU undergraduate and continued to work with the Social Development and Learning Lab throughout their freshman year of college.

Cohort participants applied to be part of the project through the Museum's Human Resources-driven hiring process. This involved submitting a written application and participating in an interview. The hiring process for the second cohort differed from the first cohort in that the Museum had changed its policy around eligibility for teen staff positions. During the selection

for Cohort 1, the Museum had a policy designed around a career ladder that required teens to complete a minimum of 40 volunteer hours before they were eligible to apply for a staff position. Recognizing that this requirement could act as an inequitable barrier for youth who may not be able to volunteer for a wide range of reasons, the Museum abolished this requirement. Thus, whereas all participants in Cohort 1 had previously worked with the Museum, this was not true for Cohort 2; only one of the selected applicants for Cohort 2 had previously volunteered at the Museum. Cohort 2 was comprised of five teens that identified as female and one that identified as male. Four of the teens had recently completed their junior year in high school at the start of the program and two had just completed their sophomore year.

2.3 Data collection

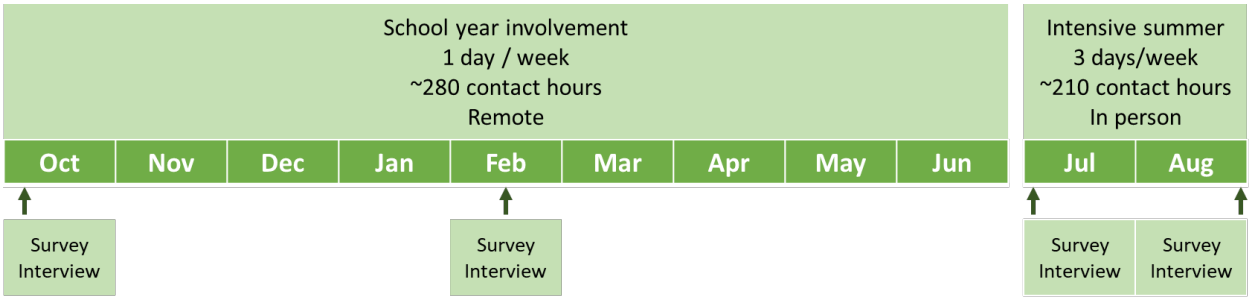
To investigate the development of science identities among teen participants in TSRCP and to explore the ways the pilot program supported this development, the evaluation team gathered multiple types of data. All instruments are provided in appendices at the end of this report, and information about each data collection approach is summarized on the pages below.

2.3.1 Surveys

Evaluators gathered surveys from teen participants using the Qualtrics online survey platform four times during their yearlong experience: at the beginning of the program in October 2020; mid-way through the school year in February 2021; at the end of the school year in early July 2021; and at the end of the program in August 2021 (Figure 3). The surveys asked the same questions each time to facilitate comparison, with minor language adjustments based on the project stage (i.e., asking about what part of the program the teens were most interested in at the beginning of the program vs. asking what the most interesting part had been for the post-survey). Additional questions were included on the first and last survey that were designed to specifically inform the program development (in the first survey at the beginning of the program) and assess overall programmatic activities (in the last survey at the end of the program). The first survey also included some demographic questions for each participant. Each survey had three main sections that followed the program's approach to science identity. First, a section about interest and affinity asked about teens' interest in specific aspects of TSRCP as well as general science activities and topics. The general questions about interest used Hidi and Renninger's (2006) model of interest and drew on prior NISE Net research and evaluation about measuring interest in informal learning settings (e.g., Todd et al., 2018; Anderson et al., 2021). Drawing on prior research about emotions in museum learning (e.g., Rappolt-Schlichtmann et al., 2017), the survey gathered data about teens' affinities with science through a question asking them to indicate the emotions they typically feel when doing science. Evaluators worked with the project team to co-develop the questions about skills and self-efficacy such that they were aligned with the program's activities. The questions involved lists of science research, science education, and science communication skills and asked the participants to indicate how confident they were with each skill. For example, teens rated their confidence in skills such as conducting statistical analyses, tailoring science communication for different audiences, and talking to museum visitors. To learn about the teen participants' sense of belonging and community, the survey included Vincent-Ruz and Schunn's (2018) science identity scale and several additional items that the evaluators co-created with the project team to gather data specifically about the program.

Survey questions are included in Appendix A, which includes notations indicating the survey each question was included on.

Figure 3. Program and data collection schedule.



2.3.2 Interviews and meaning maps

Soon after each participant completed their survey (typically within 24 hours), they would meet with an evaluator for an interview on Zoom, the schedule is outlined in Figure 3, above. The first interview at the beginning of the program focused on getting to know the participant and their past experiences with science. Subsequent interviews integrated transformative perspectives on member-checking (e.g., Koelsch, 2013) to involve the teens in making meaning of their own identity stories. This served as a validity tool for evaluators, adding additional context that enhanced the interpretation of data. It was designed to aid teens in reflecting on their changing identities to boost participants' abilities to articulate their interests, enhance awareness of growing confidence, and support metacognitive recognition of community relationships. It also embraced the program's approach to immersing youth in the process of research by including them as co-evaluators of the program and drawing on the data analysis skills that they were learning with their program mentors. The evaluators' approach to member-checking involved showing each participant a graph of their survey responses for each of the program's three categories of science identity (interest and affinity, skills and self-efficacy, and belonging and community) and asking them to interpret the data. Member-checking interviews included formative evaluation questions that asked youth to describe what the program was doing for each of the core program elements, to share which elements the teens thought the program was doing most and least effectively, and to consider what the program could do to improve.

During the first interview at the beginning of the program, the evaluators guided participants to create meaning maps that described who they were and how they viewed science. During the final interview at the end of the program, the evaluators showed teens the meaning maps they made at the beginning of the program and asked them what, if anything, they would change. The meaning map process drew on prior work from Falk et al. (1998) and McCreedy and Dierking (2013). Falk et al. (1998) first introduced meaning maps as a data collection tool that uses a relativist-constructivist frame to identify individual differences in informal science learning settings, describing how "Each individual brings varied prior experiences and knowledge into a learning situation and these shape how that individual perceives and processes what he or she experiences" (Falk et al., 1998, p. 109). The actual procedure that TSRCP evaluators used was inspired by McCreedy and Dierking (2013) in that participants made two maps, with one focused on describing themselves and a second that focused on their concepts of science. Whereas teens

made meaning maps on paper during evaluation of the first TSRCP cohort, teens in the second cohort used PowerPoint.

Taking advantage of a timeline extension, the evaluators conducted a member checking interview with participants in the spring following teens' participation in TSRCP. At these interviews, the evaluator shared the case study written about the participant, based on their survey and interview responses. Participants were invited to reflect both on their case study and on their overall experience participating in TSRCP after the program ended. Case studies were then updated with the teens' feedback.

2.3.3 Data analysis

To analyze the data, evaluators used a multiple case study approach. This involved an ongoing balance of reviewing high-level trends across the six participants and closely analyzing the data from each individual teen participant, with each participant serving as a single case for analysis (Stake, 2006, p. 46). To analyze data at the case level, evaluators reviewed all data from each participant one at a time and created a descriptive case study that reflected that person's experience with the program, focused on the three components of the project's science identity model and interactions with program activities. These case studies provided rich, qualitative descriptions that illustrate the development of teens' science identities as they emerge in a complex puzzle of individual factors such as different prior experiences and starting identities, different types of engagement with the program, and relationships with mentors and peers. Case studies are included at the end of Section 3.1.

To provide a counterbalance to each individual descriptive case study, the evaluators also looked across the cohort for trends. Due to the small sample size of the cohort, the evaluators used descriptive statistics to analyze the quantitative data, focusing on measures of central tendency (mean and median) and spread (minimum and maximum) over time. To analyze the trends in qualitative data, the evaluators started with the coding scheme developed for Cohort 1 (Todd & Weitzman, 2021) which offers two levels of analysis: first, it identifies evidence of science identity with attention to the three parts of the program's model (interest and affinity, skills and self-efficacy, and belonging and community). Second, the codebook offers codes for the different core program elements and the specific program activities that fit under each program element. Although the structure of the codebook remained the same as it was for Cohort 1, the specific program activities needed to be adjusted to reflect differences in this second year of the program. The process of adapting the codebook involved meeting with one of the program mentors to generate a list of project activities and using an inductive coding approach to track emergent themes in the teens' interview responses. Evaluators coded transcripts using the Dedoose qualitative analysis software. Two evaluators coded each of the interview transcripts, then met to discuss disagreements, refine definitions, and come to a coding consensus. Once coding was complete, the evaluators divided the work by topic to synthesize findings, checking in at regular intervals.

III. Findings

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

The following section looks across the participants to describe 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. This section describes the activities supporting the core program elements and to what extent the teens participated in each area; changes in science identity; and how the program connected to or impacted these changes in science identity. In addition to the data about program elements and science identities, this section summarizes case studies that describe each teen's experience in the program and how their identities changed over time. First, we present trends and share quantitative findings from the surveys, supported by responses from the interviews. The case studies that follow summarize rich, primarily qualitative descriptions of each individual's experience. Longer case studies were written as part of the analysis process and can be found in Appendix C.

The findings for this section include:

3.1.1 Teens had a high interest and affinity for science throughout the program and they refined their understanding of their interest in specific aspects of science during the program.

3.1.2 Through the program, teens felt they developed greater confidence in their research skills—particularly for data collection—and refined their understanding of their own knowledge. They also reported that they built confidence in science communication and education skills through their experiences with the program.

3.1.3 The skills that the teens developed contributed to them feeling more like science communicators and educators than they did before the program. They also developed a greater sense of belonging in the MOS and BU communities, through interacting with colleagues and actively contributing to projects for both institutions.

3.1.4 Case studies provided a detailed and nuanced understanding of the impact TSRCP had on the teens' science identity, particularly highlighting changes that were subtle in the aggregate analysis but appear to be meaningful for the individual.

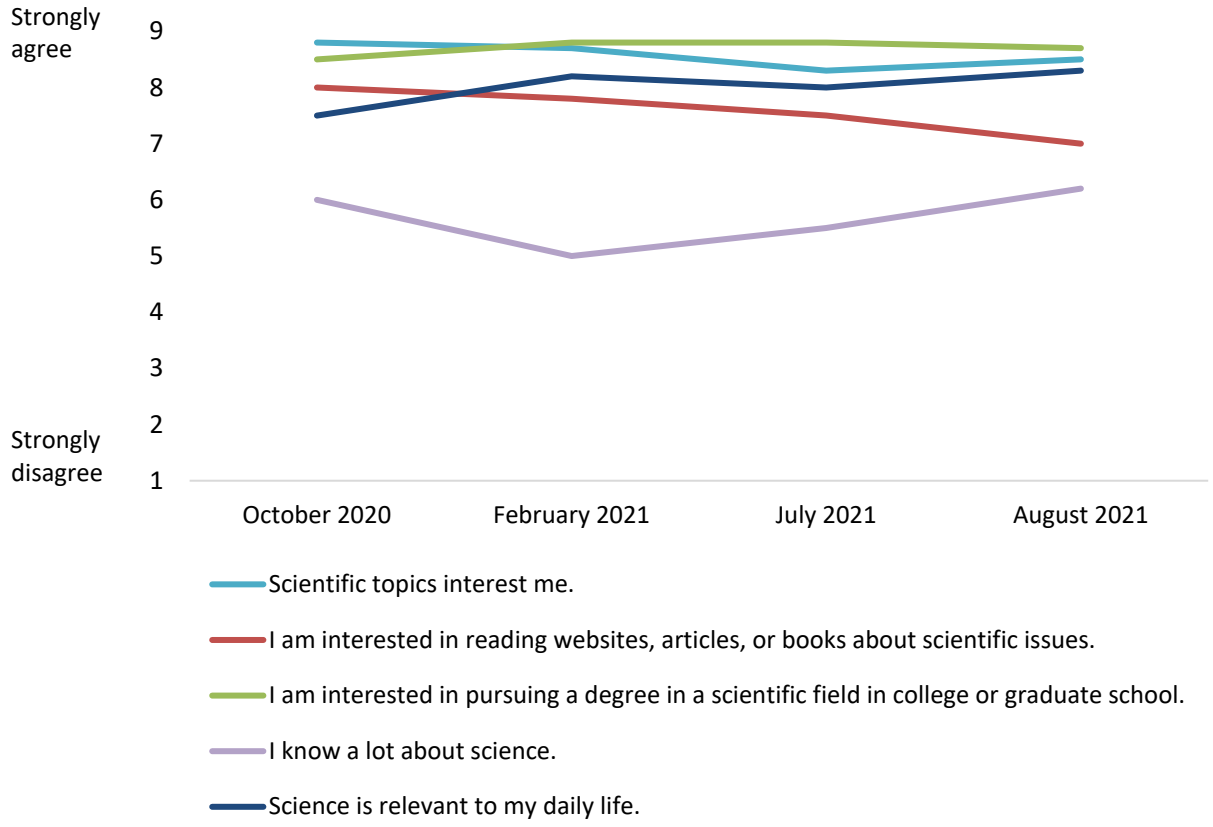
3.1.1 Teens had a high interest and affinity for science throughout the program and they refined their understanding of their interest in specific aspects of science during the program.

At the beginning of the program, teens indicated that they had high interest and affinity for science. Overall, these interests remained relatively consistent throughout the program, but through the interviews, the teens indicated ways that they had refined their interest in specific topics or aspects of science. Figure 4, below, displays survey data about teens' interest in various science topics, presented as the average rating across the six teens at each check-in point. Teens entered the program feeling strongly that *scientific topics were interesting* to them and that they were *interested in pursuing a degree in a scientific field*. These types of interest varied little over

the course of the program. In terms of their *interest in pursuing a science-related degree*, one youth explained that this had increased because "conducting research has been a very cool experience and something I'd be glad doing for a career." Similarly, one teen shared that "This program did reinforce my interest in pursuing psychology and confidence that is a subject I can understand and enjoy learning about." In addition to gaining a better understanding of what they found interesting, one teen learned that psychology was not a field they wanted to pursue professionally. They shared that they were, overall, still interested in science and said that "I might have narrowed down what aspects of science interested me. This program had a lot of focus in psychology, which I thought I really liked but over the course of the program realized was not for me – it wasn't bad, just not for me." In each of these examples the teens were able to refine their own understanding of their relationship with and place in science.

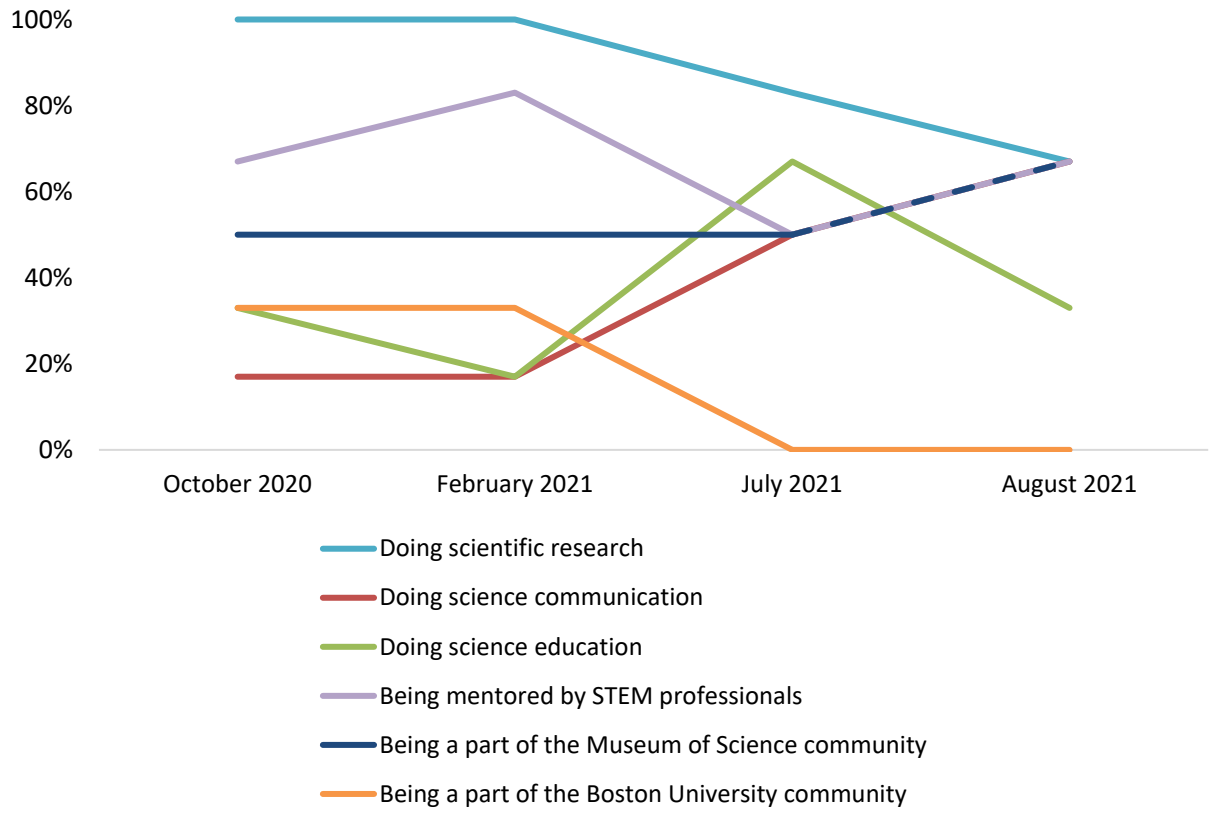
Through the interviews, the teens reflected on how much they felt they knew about science. At the beginning of the program, teens were very confident that they *knew a lot about science*, but by the middle of the school year they were less confident. Three of the teens explained that they gained a better understanding of their own science knowledge. Two specifically mentioned the Dunning-Kruger effect, a phenomena that they had learned about during the program. As one teen explained when reflecting on their survey data, "down for [I know] a lot of science, the Dunning-Kruger [effect] - the more I learn about science the more I learn I don't know, more I wasn't aware I didn't know."

Figure 4. Please indicate how much you disagree or agree with the following statements. (N=6)



Looking across the five main aspects of the program, *doing research* was initially one of the most interesting elements for all of the teens, as shown in Figure 5. One teen explained their interest was due to research being something they were not familiar with, while another emphasized that research was something that they hoped to pursue in college. As explained by one teen, "I think doing research is just really interesting to me, I plan to do that in college, hopefully make that a career." Between the beginning of the program and the middle of the school year, interest in the program elements did not change very much, but once the teens were onsite at the Museum and working on a variety of projects their interest in the program elements shifted. By the end of the program, teens had diversified the areas of the program that were most interesting to them. Notably, at the beginning of the program only one teen was most interested in *science communication*, but by the end this was an area that four of the teens found most interesting.

Figure 5. Which aspects of TSRCP are most interesting to you? (Select up to 3) (N=6)

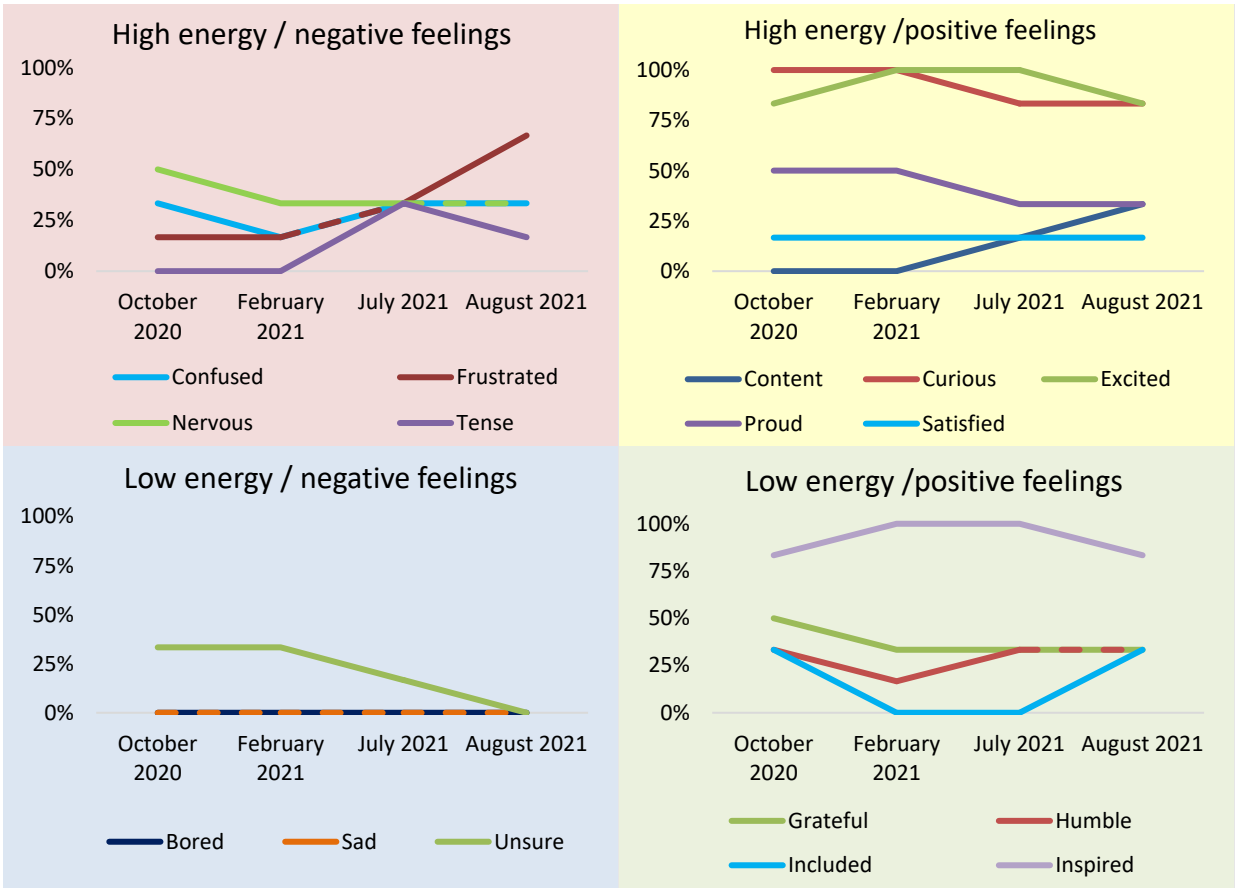


Recognizing that emotional experiences are intertwined with interest, the survey instrument asked teens to indicate what emotions they felt when doing science. Figure 6, below, shows the average of these data points over time. The graph is organized by quadrants according to the Yale Center for Emotional Intelligence's mood meter (Nathanson et al., 2016), plotting the negative and positive feelings along the x-axis and low and high energy along the y-axis. At the top left (red) are high energy, negative feelings. The top right (yellow) contains high energy,

positive feelings. The bottom right (green) includes low energy, positive feelings. Finally, the bottom left quadrant (blue) is for emotions with low energy and negative feelings.

Figure 6 shows a wide range of emotional experiences, which is the sign of healthy, emotionally accessible view of science (Rappolt-Schlichtmann et al., 2020). Overall, the most common emotions were curious, excited (high energy, positive feelings), and inspired (low energy, positive feelings). Teens consistently reported these as emotions they felt in connection to science, often relating these emotions to general or specific interests in learning about science topics. Some of the teens also felt humble (low energy, positive feelings) or confused (high energy, negative feelings). They explained in interviews that these feelings were connected to recognizing that there was so much to learn about science. Some teens also described feeling nervous or frustrated, which was related to concerns about making mistakes, not understanding material, or not being able to contribute as they would wish to. As described by Participant 4, “"For the frustrated part, what I was talking about earlier, when [mentors say] the research stuff and we just stare back I get frustrated at myself for not having something to say, and I’m nervous for the same reason."

Figure 6. **When I think about science, I tend to feel... (Check all that apply) (N=6)**
Note: Overlapping values are indicated with dashed lines



3.1.2 Through the program, teens felt they developed greater confidence in their research skills—particularly for data collection—and refined their understanding of their own knowledge. They also reported that they built confidence in science communication and education skills through their experiences with the program.

Teens had opportunities to learn about and practice a variety of research, communication, and education skills. Overall, they started the program with moderate to high confidence in *research skills*, due to prior experience in or out of school. Looking across the teens' average responses, confidence in many of the research skills fluctuated over the course of the program (see Figure 7). The fluctuations between each of the check-in points were more pronounced in the individual responses; these individual variations are discussed in each case study. During interviews, the teens often expressed that they were more confident or had learned more about a particular research skill and suggested that any decrease in confidence was due to realizing what they did not know about that skill. Some of these teens recognized their responses fitting the pattern for the Dunning-Kruger effect, which they had learned about in the program.

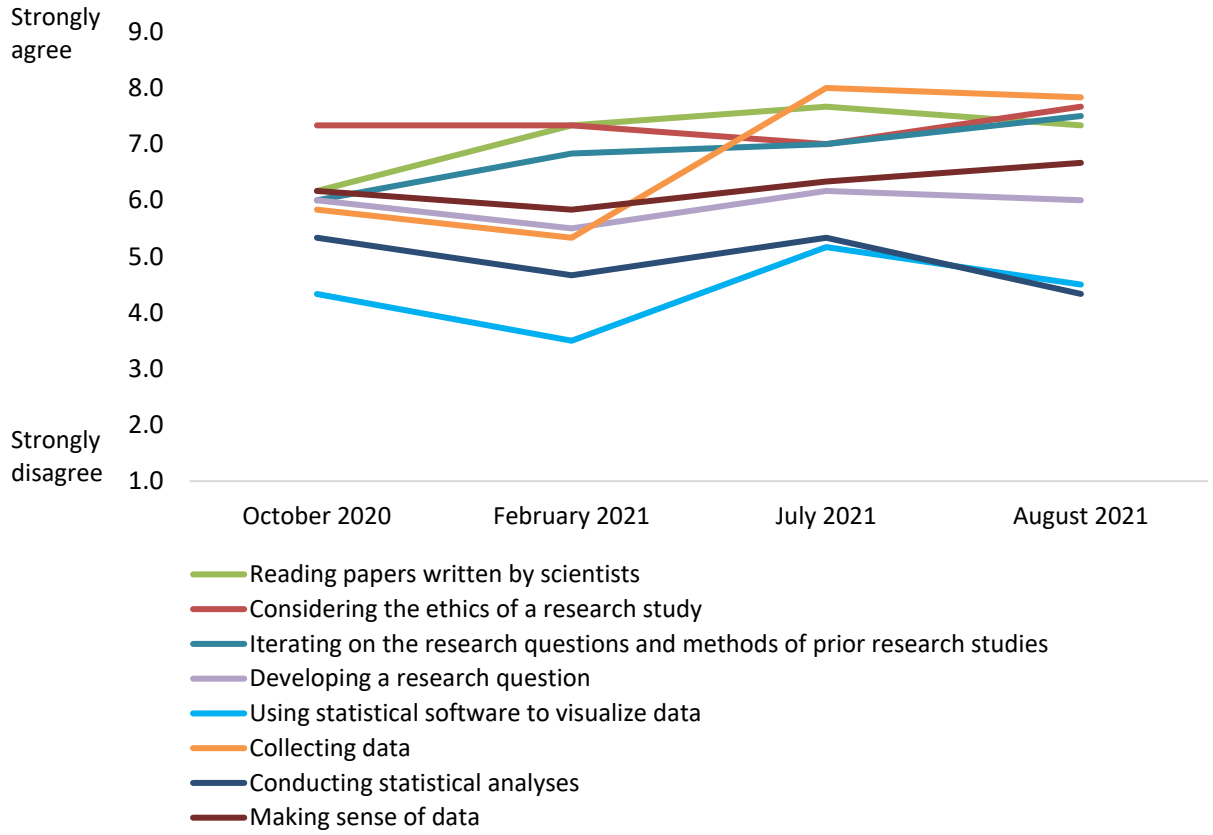
At the beginning of the program, the teens were most confident in *considering the ethics of a research study*, with an average rating of 7.3 on a 9-point scale. Teens attributed their initial confidence to prior experiences in school or elsewhere. While this stayed consistent throughout most of the program, by the end of school year their average confidence rating was at 7.7, with some teens sharing that the work they did in the program discussing ethics with mentors as they designed their own study reinforced their existing confidence. As one teen explained, "I also feel that I had a background in that when I came into the program. The program reinforced those skills so I'm more equipped to apply that at a broader level."

The area with the greatest change was *collecting data*, where the teens were moderately confident when they started at the beginning of the program, with an average rating of 5.8. By the middle of the school year that had dropped slightly to 5.3, with one teen explaining their lower rating as due to "not realizing how much there was to collecting data." After they started regular data collection activities their average response greatly increased, with an average confidence rating for collecting data at 7.8 by the end of the program. When talking about data collection in their interviews, one teen explained that "being able to collect a lot of data when [we] came back in person, helped [my] confidence."

Initially, teens were the least confident with *conducting statistical analyses* and *using statistical software to visualize data*, indicating moderate confidence (5.3 and 4.3, respectively). Some of the teens had learned about statistics in school, but in general this was an area where they described having the least experience. By the middle of the school year, the teens' confidence decreased as they started to learn about statistics and recognized gaps in their own knowledge. One teen talked about recognizing there is more to learn, saying "conducting statistical analysis something I can grasp at some point but not right now, need to learn more about what things mean in terms of statistical significance." By the end of the program, teens tended to be less confident in conducting statistical analyses (4.3) and about the same level of confidence for using statistical software (4.5) than they were at the beginning. While their survey ratings showed small decreases overall, rating fluctuations throughout the program indicated a more nuanced outcome where teens both gained confidence in statistical analyses and using software and an iterative understanding of what they had yet to learn. One teen talked about learning to

apply what they had learned in school, saying "I took a stats class last year so on paper I understand but there's a difference in an application and I learned the difference."

Figure 7. How confident are you in your ability to do the following science research skills? (N=6)



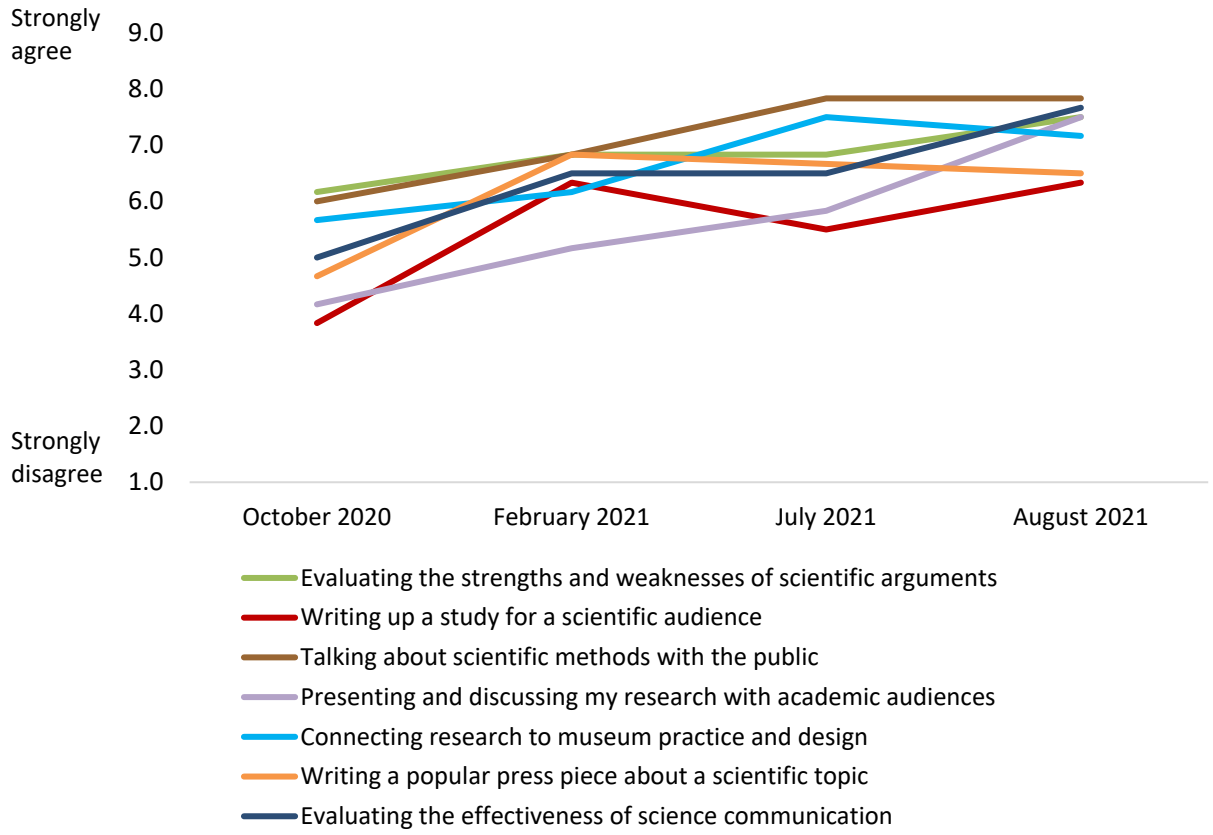
In addition to looking at research skills, the team was interested in *science communication* and *science education* skills. The project team recognized overlaps between these skill sets, but also made a distinction between these two areas. Science communication skills were primarily focused on directly translating research and data for scientific and public audiences through developing journal articles, presentations, posters, etc. Science education skills were more focused on educational design and practice, such as learning about museum interpretation and facilitation strategies, actively teaching science process skills to others, and designing exhibits. Through the interviews, it became apparent that not all teens felt there was a clear distinction between communication and education. The area that was most unclear was how to categorize on-the-floor interpretation or similar interactions with the public (some teens felt this was science communication while others felt it was science education). Beyond that, one teen defined communication as "just transferring information" whereas education is "teaching concepts behind it." Another teen associated science shared at the Museum and informal settings with communication, and formal school experiences with education. Ultimately, the distinction the project team made was most useful for analyzing and presenting findings about the many skills that teens were working on and the implementation team felt that it was reasonable that the teens did not necessarily categorize the skills in the same way. In fact, this may reflect a valuable

intertwining that is reflective of authentic science practice, where lines between communication and education can be blurred.

Overall, teens started the program with low to moderate confidence in communication and education skills and were markedly more confident by the end of the program in most areas, as shown in Figure 8. Initially, the teens were, on average, most confident in *evaluating the strengths and weaknesses of scientific arguments* (6.2 on a 9-point scale). Their confidence increased over the course of the program, with an average rating of 6.8 during the school year, and 7.5 at the end of the program. As one teen explained, "the program has helped me learn about phrasing and how to break down an article and how to look into sources and what you should be looking at." Teens were also initially more confident in *talking about scientific methods with the public* (6.0) and by the end of the school year their confidence had grown notably (7.8). Multiple program activities contributed to this confidence, in particular teens talked about developing and piloting interactive experiences for the AI exhibit and recruiting visitors to participate in Living Laboratory research studies as contributing factors. These experiences taught them "how to be interesting and engaging while being accurate." Beyond talking about methods specifically, teens felt more confidence in sharing science with public audiences. This was due to "every day interacting with a lot of people. Interpreting, even with COVES [Collaboration for Ongoing Visitor Experience Studies, exit survey data collection], learning how to share information and talk to anyone."

At the beginning of the program, the teens were the least confident in sharing research with a scientific or academic audience. Teens began learning how to write for academic audiences early on in the program through theoretical exercises with their BU mentor, which contributed to an initial jump in confidence in this skill by the middle of the school year (from 3.8 to 6.3). On average, their confidence about *writing up a study for a scientific audience* then dropped between the middle and end of the school year (from 6.3 to 5.5), when they started to apply what they learned and began to actually write about research. In the process of putting ideas into words, teens realized it was more difficult than expected and there were aspects of writing that they needed to pay attention to that they had not previously been aware of. For example, one teen explained that they "have been daunted by jargon and keeping track of variables with people I am working with or talking to, more aware of how hard that it is, but feel like it is a skill that is being taught as part of the program." However, after they worked on writing conference proposals and the methods section for a BU study, teens' confidence in writing up a study rebounded to 6.3 by the end of the program. *Presenting and discussing research with an academic audience* was also an area where the teens were not generally confident at the beginning of the program (4.2) but were, on average, considerably more confident by the end (7.5). In this area, the teens talked about their experiences creating presentations about study findings, along with presenting research findings to the Museum's Research and Evaluation department.

Figure 8. How confident are you in your ability to do the following science education and science communication skills? (N=6)



3.1.3 The skills that the teens developed contributed to them feeling more like science communicators and educators than they did before the program. They also developed a greater sense of belonging in the MOS and BU communities, through interacting with colleagues and actively contributing to projects for both institutions.

To assess teens' sense of community and belonging, the survey asked a series of questions about respondents' identities related to being a scientist, a science educator, a science communicator, and feeling like part of the MOS and BU communities. For each of these identities and communities, the teens indicated a stronger alignment than when they started the program. This increased sense of community and belonging was often explained or tied to the experiences they had practicing research, communication, and education skills or interacting with the MOS and BU communities. These data are visualized in Figure 9.

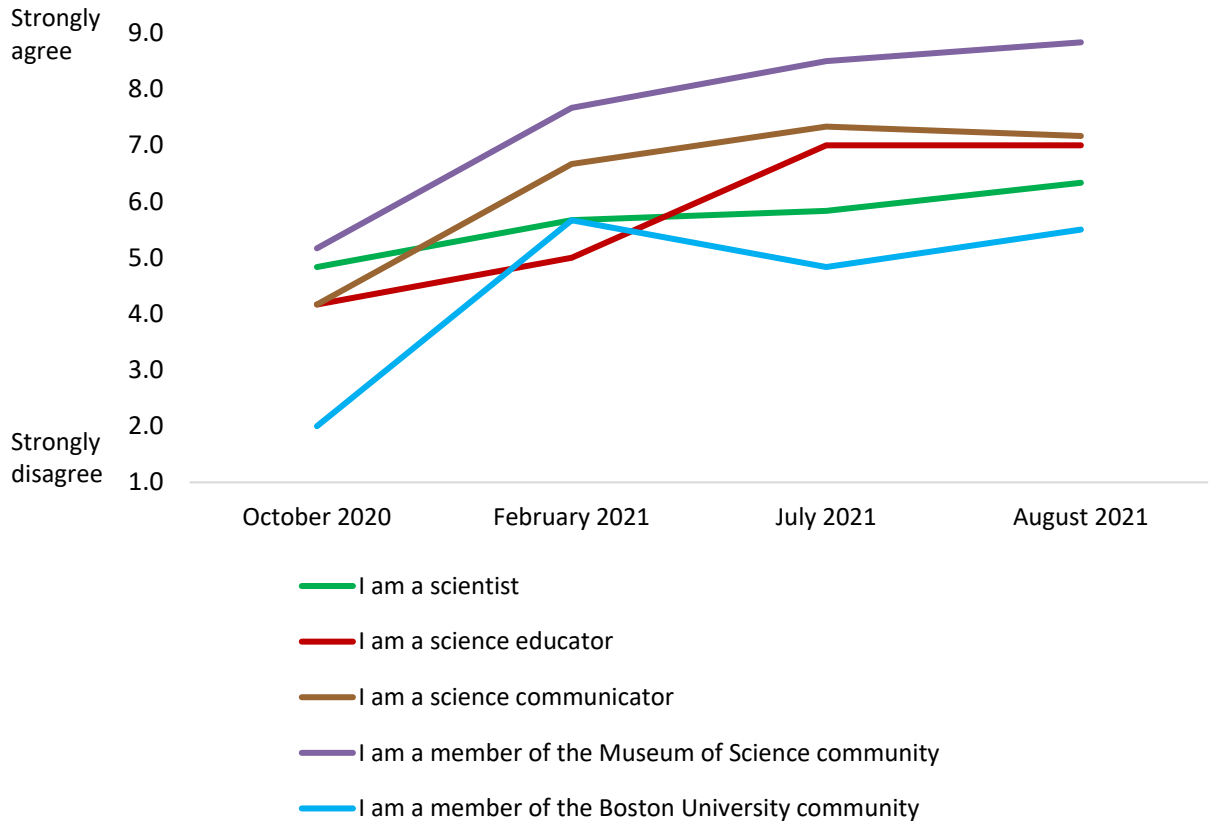
With regard to their individual identities, teens began the program feeling moderately like they were a scientist, a science educator, or a science communicator. All of the teens started the program with some level of interest in and experience with science, as would be expected for youth applying to be part of the cohort. This previous experience shaped their initial assessment that, on average, they were somewhat a *scientist* (4.8 out of 9.0). At the beginning of the program, the teens understood being a scientist in a few different ways, including as an experience, a career, or a mindset. One teen explained that they did not consider themself a

scientist, because they had not yet done research, but felt like they could become a scientist. Another teen associated being a scientist with a career, saying "I wouldn't say I was a scientist because I haven't made it a career or I don't work full time in it." Another teen thought of a scientist in terms of a person's mindset, with a scientist being someone who is curious and wants to understand how the world works. By the end of the program, on average the teens felt somewhat more like scientists (average of 6.3 out of 9.0); generally, this was attributed to being actively involved in facilitating the research process. When reflecting on their ratings at the end of the program, one teen noted that they felt more like a scientist because working on research and evaluation projects at the Museum "made me feel like I have the ability to participate in the work of a lab and a museum." And that experience was "useful in seeing what I am able to do in this environment and use these skills in the future in school and my career." Another chose to add "scientist" to their meaning map describing themself at the end of the program, because they had been told by mentors: "you are doing science, and if you are doing science that makes you a scientist."

Initially, the teens felt slightly less like *science communicators* (4.2 average agreement out of 9.0) than they felt like scientists. They explained that this was due to a lack of experience, with one teen saying, "for science communicator [I] haven't done it, can't say I am something that I've never done before." During the first half of the school year, the teens learned about science communication and did some work in this area, making them feel more like science communicators (6.7 average agreement). Once the teens were onsite at MOS more regularly and were more directly involved in executing both MOS and BU projects, they started to feel more like science communicators (7.2 at the end of the program). The teens identified program activities that they felt contributed to feeling more like a science communicator, including writing a Living Laboratory caregiver handout for the Structural Mindsets study, summarizing articles, and engaging visitors in interpretations (hands-in activities).

Similarly, the teens started the program feeling somewhat like *science educators* (4.2 average agreement out of 9.0). Thinking about their previous experiences in this area, one teen described themself more as a science student, rather than as an educator. Another teen had some experience tutoring their peers, which contributed to feeling like a science educator. Over the first few months of the program, the teens started to feel more like science educators (5.0 average rating in the middle of the school year) as they learned more about what was involved in doing that work. Once the teens started to work onsite regularly, they started to feel much more like science educators (7.0 average agreement from the end of the school year through the end of the program). In particular, the teens felt that presenting interpretative activities with visitors in the exhibit halls contributed to feeling like a science educator.

Figure 9. Please indicate how much you disagree or agree with the following statements (N=6)



Teens reported that they felt more like members of the MOS and BU communities through participating in the program. These feelings were largely influenced by their role on Museum and BU project teams, as well as their interactions with people at each institution. For both communities, on average, the teens indicated a similar magnitude of change for feeling that they belong, starting with a higher baseline of feeling like they were part of the MOS community. At the Museum, teens initially felt a moderate sense of belonging that strengthened over time, seemingly related to their work as employees of MOS. While the work with the BU mentor, lab director, and larger research team at BU built a stronger sense of belonging with the university, their sense of community fluctuated depending on the extent they were interacting with BU team members at that time. In addition to feeling like a member of the MOS or BU community, some of the teens connected their experiences in the program to feeling like they could be part of a scientific community in the future.

At the beginning of the program, teens reported feeling that they were somewhat a part of the MOS community (5.2 average agreement out of 9.0). Despite teens sharing that working in a virtual setting made it hard to feel connected, the average rating jumped to 7.7 by the middle of the school year and continued to increase once the teens were working onsite regularly during the spring semester. By the end of the program, the teens felt strongly that they were part of the MOS community, with an average rating of 8.8. Generally, being recognized as staff with responsibilities to the institution contributed to feeling like they were part of the Museum. This

included simple aspects such as having staff badges, getting emails, and getting to know other staff at the Museum. It also included the types of work they did at the Museum, such as "working with different groups on different projects, getting to represent the museum in certain activities and events, and participating in museum wide meetings and programs."

At the beginning of the program, the teens did not feel connected to the BU community (average rating 2.0 out of 9.0). However, by the middle of the school year the average rating had jumped up to 5.7, after the teens had started to work more directly with BU, which included working with their BU mentor, talking with the lab director, and having guest speakers from BU during their workshops. At the end of the school year their average rating dropped to 4.8, with one teen later reflecting that was "probably just from interacting fairly often [in the winter] to not much at all in the spring." Once the teens were conducting BU's Structural Mindsets study (onsite at the Museum), they felt more connected to BU and by the end of the program felt they were moderately part of the BU community (average rating 5.5). Although this remained the lowest of the identifications (as compared to feeling like a scientist, science educator, science communicator, and member of the MOS community), it was also the area that showed the largest growth between the beginning and end of the program. Overall, the elements that contributed to the teens feeling like part of the BU community were largely centered on their interactions with their BU mentor, contributing to the Structural Mindsets study, and representing BU through data collection in a public setting. While working with the BU team (remotely and at MOS) provided opportunities that fostered feelings of belonging with a small portion of the BU community, the lack of on-campus time may have dampened feelings of belonging with the broader BU community. Further, even when working as a BU team member, youth were accessing BU personnel and documents via MOS communication channels (e.g., MOS Microsoft accounts). When talking about having a lower rating for feeling like part of the BU community, one teen explained "[I] don't feel like I'm missing out much, because we're working on the study and the Museum is best place to do that."

3.1.4 Case studies provided a detailed and nuanced understanding of the impact TSRCP had on the teens' science identity, particularly highlighting changes that were subtle in the aggregate analysis but appear to be meaningful for the individual.

Since TSRCP piloting efforts involved small cohorts of six teens, in addition to analyzing their data in aggregate, the evaluation team wrote individual case studies about the trajectories of youth's science identities over the course of the program. These case studies provided insight into how the program impacted each teen, in addition to the changes highlighted through Cohort 2's average ratings. Each narrative combined that teen's surveys and interviews, exploring the overall experience they had with TSRCP and the impacts of the program on the individual. Several months after the end of the program, four teens reviewed their narrative as a member check and talked about additional impacts of the program. Through these case studies, it becomes clear that each teen experienced changes to their identity in different areas and to various degrees. They also developed a more nuanced science identity for themselves. Concise versions of each teen's experience are provided below, and the full case studies are available in Appendix C.

Participant 1 case study summary

The program helped Participant 1 gain confidence in research, education, and communication skills. They left the program seeing themself more as a science educator and communicator than at the beginning of the program, and now consider "museums" an aspect of their identity.

Prior to joining the program, Participant 1 had been attending a STEM school where "they really prioritize science." Participant 1 had taken classes in biology, chemistry, earth science, and physics. Participant 1 noted "they offered a lot of [science] opportunities" and "they allow us to explore a lot of things." Overall, they described science in school as "really interesting" although "sometimes it is tedious to memorize some of the things in science." Outside of school, Participant 1 had prior experience with STEM extracurricular activities about anatomy, physiology, neuroscience, and computer science.

At the beginning of the program, Participant 1 primarily identified as an artist because they liked to create things through drawing and coding. Being a student and being collaborative were also important pieces of Participant 1's identity. Their initial meaning map had included, "...mixed race, but also like how I get the best of both worlds, also bilingual." Looking to their future, Participant 1 shared, "[I have] no idea what I want to be when I grow up, I just know I'm interested in a biomedical field, biotechnology, something in that area. Also I like business I guess, how these companies do research and develop either treatments or things. I'll probably try to major in something biology related. Maybe business and technology." Participant 1 described science as "innovative," "creative," "broad because [there are] lots of fields: chemistry, biology, astronomy," and "beneficial to [do] work about and solve problems, think of research and inventions." In talking about connections between their own identity and science, Participant 1 identified how they were both "collaborative." On their pre-survey, they strongly agreed that they were a scientist but were less sure about science communication and education, saying, "I've never taught someone specifically about science."

When we met with Participant 1 in the middle of the school year, their interests in science remained strong. They described science research saying it is like being "on the frontiers" and adding, "discovering things is meaningful." In terms of skills and self-efficacy, Participant 1 shared how the research skill they were most confident with in the winter was reading papers written by scientists. They shared, "We have to do a lot of that and [the mentors] gave a lot of resources about how to do that." Although they were less confident in considering research ethics than reading, this was an area Participant 1 felt the program had helped them improve. They said, "We're thinking through a fake study and what we would do in setting it up. I've definitely become more confident, but also back to humble, I realize how many aspects there are." With regards to community and belonging, Participant 1 indicated on their winter survey that they had come to see themself more as a science educator, communicator, and member of both the MOS and BU communities, but that they still did not fully see themself in those roles. This had to do with defining these roles in professional terms. Participant 1 shared that a scientist was "anyone in a STEM field" and an educator was "more of a teacher role."

In the spring, toward the end of the school year, Participant 1's interest remained strong except for a dip in interest in reading. They shared that the program "solidifies how I see that [science] is relevant in daily life." In terms of confidence, by spring Participant 1 felt their skills were increasing. Whereas at the beginning of the program they had said, "I wouldn't say I'm super confident in [research skills] but I am interested and hopefully getting better," by the winter, they

said, “I think I have definitely gained more confidence…having more experience and practice with that has increased my confidence.” They added that it was “not as intimidating as I thought.” Participant 1’s sense of self as a science educator, communicator, and member of science communities continued to rise in the spring, as well. Whereas their sense of self as a scientist remained steady at a 7 out of 9, in the spring Participant 1 rated themself higher as a science communicator (9 of 9), science educator, and member of the Museum community (both 8 of 9). They shared, “Now that we are on site and communicating and seeing people, [I] definitely feel more of a science communicator” and “[I’m] definitely part of the museum community. When we put on the red coats is pretty cool—you look like you have authority in the Museum and are a part of the Museum with the other interpreters.” Although their sense of self in relation to the BU community was lower than their other ratings (5 of 9), Participant 1 spoke about it positively, saying, “It’s a smaller community but we’re a group and we’re just focusing on one study…everyone in that group is excited about it and that makes it a community.” They also felt that they “didn’t feel like it mattered as much that [they were] not as connected with BU.”

By the end of the program, Participant 1 was appreciative of their involvement in the program and having “experiences that you wouldn’t normally have in high school.” Looking back at their initial meaning maps, they had nothing to change about their definitions of science and they felt that the things that mattered to them at the beginning of the program—like creativity, collaboration, curiosity, motivation, ambition, and being mixed race and bilingual—were still major parts of who they were. Additionally, Participant 1 said they wanted to add something to their meaning map about who they were: museums. They shared, “Museums, always liked that and mattered to me. [I] want to continue here so I might add that here.” Participant 1’s interests in science remained high throughout the program, with every item on our survey at its highest point at the end of the program (9 out of 9 for most items). Their confidence and skills in science research activities showed increases or sustained confidence at the end of the program as well, except for statistics. At the end of the program, Participant 1 felt more like a scientist, science educator, science communicator, and member of the BU and MOS communities than they had at the beginning of the program. Whereas their identity as a scientist remained relatively consistent throughout the program, other aspects showed greater increases. At the beginning of the program, they rated themself as a 3 for science educator and science communicator, and an 8 (for both) by the end. Reflecting on the program overall, Participant 1 said the program “definitely gave me more research skills and communication skills, and becoming part of the MOS community was helpful to see behind the sciences and I liked seeing there are people of all sorts of backgrounds – I consider them all scientists.”

During a check-in approximately eight months after the end of the program, Participant 1 reflected on the ways that the program affected their science identity. Participating helped them refine their interests in science, because “it helped me discover what I want to pursue now and what I don’t want to pursue; [I] realized how tedious some of the research things are, don’t like the stats part, but I’m fine with script writing” and this helped them think about where their interest falls with different science activities. In addition, they shared that the program helped increase their confidence in research skills because “practice makes you more familiar with it.” They also talked about other skills that they developed through the program that might not necessarily be “science skills.” Scheduling, for example, might not be a “science skill” but can be “applied everywhere,” including for science work. They also added that just participating in

the program strengthened their sense of belonging in scientific communities by being able to talk about working at the Museum or the research they were working on with friends and family.

Participant 2 case study summary

The program helped Participant 2 build confidence in research skills, helped them see science research as more collaborative, and expanded their sense of belonging in scientific communities. Participant 2 entered the program feeling like a member of the MOS community and was able to build a broader professional network through program activities.

At the beginning of the year, Participant 2 described themself as having two cultures, being bilingual, and being involved in activities such as sports and a religious community. They talked about loving learning and said, "I'm very science-centered. I really enjoy Biology, Chemistry, also Psych and also the Humanities, ethics studies, studying Greek or Roman history. I am just, like, very curious about a ton of different things." Participant 2 had also taken "a couple" college science courses, did an engineering and science fair, and taught "quite a bit of science" including serving as a helper in elementary school classes and teaching a biology course for middle school students. In their initial meaning map, they also reflected on their prior experiences visiting, volunteering, and interning with the Museum and shared, "I would identify myself as being a part of the MOS community...that's a big portion of myself as well."

At the beginning of the program, Participant 2 described science as "a playground to experiment, play, and learn things. It requires creativity to test hypotheses, have crazy ideas to make progress and expand your knowledge." On the other hand, they mentioned, "It's also very structured. It's strict and critical in its methods." They did not see themself as a scientist because they saw a scientist as someone who was employed full-time in the field. They felt differently about the roles of science educator and science communicator, agreeing that they were both of these.

By the middle of the school year, Participant 2's interest in science remained high. They reflected on how they started the program thinking science communication was more interesting, but as they engaged with research, that aspect became more interesting. They shared, "My overall feelings [about science] are just very positive. Just doing this work is making me more appreciative of science in general and the efforts that you take into account when doing research. The more I'm involved, the more I'm more excited to share with other people. I talk about my work a lot with my friends." While participating in research enhanced their interest in science, it also made Participant 2 less confident in a number of research skills. They were aware of this trend and reflected, "The more we talked about the kinds of things that go into developing a research question, the less confident I was about it. I forget the name of the phenomenon, but the less you know, the more confident you are. That happened over the course of this period." Participant 2 felt their sense of belonging with science communities and science identity was tied to their sense of confidence. While their survey indicated a slight increase in identifying as a scientist, they shared, "Wow, there's a lot I still don't know or I haven't known before so that made me less confident in being a researcher."

At the end of the school year, Participant 2's family situation dictated that they participate remotely while the other participants transitioned to being in-person. Participant 2 was grateful for the program's flexibility to accommodate their circumstances and found that, "Even not being there in person, I was able to do a lot and feel like I am a part of the program and still doing things." As in the winter, Participant 2's interests in science remained high and their

confidence in scientific skills fluctuated with exposure. For instance, Participant 2 felt that doing data collection and research planning made them more confident: “as we have learned more about research and putting those [skills] into practice more, that has helped raise a couple things in terms of confidence.” Yet with writing, practice had made Participant 2 less confident: “I had a little more confidence in talking about how it’s done but actually doing it is more difficult.”

At the end of the program, Participant 2 reviewed the meaning maps they had made at the beginning, and, overall, they thought the maps still reflected who they were. They noted, “[I] probably said this in the beginning, but I think science is a part of who I am as a person.” Thinking about their concept of science overall, Participant 2 felt they had come to see science as more collaborative. Looking at their meaning map about science, Participant 2 shared, “I would add another box saying how for each individual scientist there is a very minimal contribution, a small portion that as a whole, collectively, helps expand whatever field or study that they are part of. Also needs to be a lot of communication between different people, and collaboration.”

Participant 2’s interest in science continued to be strong and they noted that they were able to better articulate specific aspects of science that were particularly interesting or less interesting. Looking at their survey data over time, they shared, “I would say [my interest] was kept pretty constant, I think that really depends on which science topic it is. I think I’ve grown in interest more in cognitive science and child development, but overall don’t think there was much change in science topics in general.” Between the end of the school year and the end of the summer, Participant 2 reported strong increases in confidence for almost all of the project’s focal research skills and more modest changes (both increases and decreases) for the project’s education and communication skills. For example, after rating their confidence in making sense of data as a 1 at the end of the school year, this rose to a 7 at the end of the summer. For skills in science education and communication, presenting and discussing research with academic audiences rose from a 3 (at the end of the school year) to a 6 (at the end of the summer). All other education and communication skills stayed the same or fluctuated up or down by one point. Reflecting further on this, Participant 2 shared how their definitions of education and communication shifted over the course of the program. They said, “I considered education like lectures and talking about science in a formal setting like in schools, and I’ve considered that, nowadays I extend that to interpretations and interacting with the public. Used to think of the interpretations as part of science communication, but now communication is talking to other researchers and in the museum about what you are doing.”

Overall, Participant 2 found that the program effectively connected them to scientific communities. Although their affinity with the MOS was particularly strong throughout the year, they felt their network of scientific communities grew over the course of the year. Participant 2 noted, “I think [my sense of community] extends beyond the Museum at this point; I made a lot more relationships with other people that would extend beyond the museum but would be a part of science.” Their connection to the Museum expanded, as well. Participant 2 shared, “It definitely helped in feeling like I’m a member of scientific communities, being connected through the museum, through BU, through the research and evaluation department, and with other researchers as a whole through the ASTC conference. That has helped sense of community. Research too, actually [being] able to conduct some research.” Ultimately, Participant 2 valued the program and found that it helped them articulate what aspects of science were most interesting to them, built confidence in research skills, and helped them see themself more as a scientist and member of multiple scientific communities.

Participant 2 did not have many thoughts to add to their case study when reflecting eight months after the program ended, feeling that what they initially reported represented their experience well. They did note that the experiences in the program, particularly those around research skills, were beneficial to what they were currently doing in college. Particularly, the program "helped me have a better frame of reference for things I encountered [in college classes]."

Participant 3 case study summary

Participant 3 came into the program with a strong interest in science and psychology. Although the program actually turned them off to psychology research, it helped them realize their interests and build their skills in science education and communication.

When Participant 3 began the program, they described themself first by their academic interests in molecular biology and bioengineering, noting that they would major in these fields with a minor in Psychology ("My ideal career would be to be a professor in either Molecular Biology or Bio Engineering. Two fold. I love to teach and doing research"). They also described loving learning, working with kids, and being a dancer. Participant 3 thought science was "everything," sharing, "The way I go through life, things like dance that aren't a science, but thinking of it in the right way, understanding what you can do, asking questions, becomes the physics of how you turn, it all meshes together." Participant 3 had clearly articulated interests and disinterests in science from the beginning of the program. While they were strongly drawn to the process and mindset of science, they also shared that they "could not care less about the topic" of geology and that they did not like the busy work they had experienced in middle school science class. However, they said "every little thing lines up perfectly" in biology. At the beginning of the program, Participant 3's confidence was very high in research skills and somewhat more moderate in science education and communication skills. In terms of belonging, at the beginning of the program Participant 3 felt they were a scientist but did not feel strongly connected to the scientific community. On their survey they rated themself an 8 of 9 for being a scientist, saying "That's anyone who wants to think that way. It's almost just a choice, if you choose to think that way." They rated themself a 6 for science education, noting "I have some amount of experience, just from tutoring other students." For science communication, Participant 3 shared, "I haven't done it and I can't say I am something that I've never done before," rating themself a 2 of 9. Participant 3 also felt disconnected from MOS and BU, rating their sense of belonging in these communities as a 3 and 1, respectively.

In the winter, Participant 3's interests in science remained high, with all survey ratings about interest staying the same, at either an 8 or 9 out of 9. They reported that the aspects of the program that were most interesting were doing scientific research ("I want to be a researcher when I'm older so that's always been an interest of mine"), being a part of the BU community ("not a lot of high schoolers get to say they've been part of research at a university"), and science communication ("We got to make a presentation slide. That was fun"). Participant 3 reported that they had gained confidence in science education and communication as they practiced those skills but felt less confident in statistics after trying it in the program. They shared, "I took a stats class last year so on paper I understand but there's a difference in an application and I learned the difference [in the TSRCP program]." Whereas Participant 3 had been less confident in many of their science communication and education skills in the fall (at the start of the program), by winter they rated every one of these skills as an 8 or 9 out of 9. Participant 3's sense of connection to MOS rose from a 2 to a 7, connection to BU rose from a 1 to a 5, and their

connection to science communication rose from a 1 to a 7. Their sense of self as a scientist remained high, as an 8 of 9.

When we connected with Participant 3 in the spring (end of the school year), their interests in science had changed little. They shared, "[My interests] pretty much stayed the same... high all the way through." Participant 3's sense of confidence in the spring showed a rebounding in research skills and remained high for science education and communication. They demonstrated an awareness of their likely overconfidence in research skills at the beginning of the program, saying, "[The survey data are] a good example of the effect of you don't know enough to know you don't know, [my initial ratings] should probably have been down at the beginning, [but I] didn't know what I didn't know." They continued by sharing how opportunities to use these skills during the program were contributing to their rising confidence: "Practicing skills and being exposed to them makes me be more confident in them." With this rising confidence, all of Participant 3's ratings for research, education, and communication skills were an 8 or 9 out of 9 (except making sense of data, which was a 6 out of 9). Participant 3's sense of belonging was also very high in the spring, with a particular rise in their sense of self as a science educator (which rose from a 3 in the winter to an 8 at the end of the school year, when teens began leading educational activities onsite in the Museum). Participant 3's sense of self as a scientist, science communicator, and member of the MOS community remained high (either 8 or 9), similar to the winter.

At the end of the program, we asked Participant 3 to look back at their meaning maps from the beginning of the year. In general, they thought the maps were still representative of who they were. They thought they had learned more about the scientific process, noting "I might add to each of those about it [science] has to be done in a controlled way that can be replicated" but, similar to their initial interview, they repeated, "Science is everything, as long as you did it right" and "I see myself as a science-y person...science is relevant to who I am and how I see the world." Participant 3's interests in science remained high through to the end of the program although they "might have narrowed down what aspects of science interested me…this program had a lot of focus in psychology, which I thought I really liked but over the course of the program realized was not for me – it wasn't bad, just not for me...not something I would want to do for a career." Participant 3's confidence in science education and communication remained very high whereas confidence in research skills was more mixed. On the final survey, they rated all education and communication skills as an 8 or 9 out of 9, even though these were the skills that Participant 3 had been least confident with at the beginning of the program. For the scientific research skills, Participant 3's survey responses declined slightly for most skills, but they shared, "Overall, in my head I think it went up." Participant 3 ended the year feeling very strongly connected to the Museum (9 out of 9), but not feeling connected to BU (1 out of 9). It seems that Participant 3 felt the research-based part of the program moved too slowly and contributed to them distancing themself from psychology and BU, as well as a slight decline in their sense of self as a scientist overall.

After reading their case study, Participant 3 had some additional comments about their science identity while reflecting on their time in the program. They reiterated that the program was helpful to refine their interest in science, specifically realizing that psychology was "not for me" but that other aspects of science were. Thinking about research-related skills, they "got better at everything" but also realized how much they did not know through the program. They described how this changed over the course of the program, saying, "[in the] fall I had falsely high

confidence, but no ability. [In the] winter, confidence went down and ability went up, then in the Spring, confidence went up and ability went up." Finally, in reflecting on their sense of belonging in scientific communities, they shared that being paid and recognized as staff was important to feeling like a scientist. As they explained, "having tangible proof of it, yeah I feel like a scientist but [now I] have a paycheck that shows, you can't doubt it, because it's a more formalized version of being a scientist." Also, small things like having a staff badge (rather than "intern") and being in staff spaces made them feel like part of the community.

Participant 4 case study summary

Participant 4 began the program with an interest in psychology and an intent to study psychiatry in college. Being a part of the program helped them solidify their interest and build research skills.

At the beginning of the program, Participant 4 described themself as a teacher, mentor, athlete, musician, student, and "not religious, but interested in spirituality." Relationships with their family and friends were a notable part of their meaning map, sharing that they were "supportive to [their] friends" and their "little brother is [their] best friend." They also shared that they were part of a single parent household and that their dad passed away years ago. They identified as Asian-American, as their mom had immigrated from China, and felt that this was an important aspect of their identity. Participant 4 felt science was a broad umbrella, and that they were not always excited about it because they were interested in some disciplines, such as psychology, biology, and "life-related things," and not in others, like physics. They felt like scientists "just come up with questions out of the blue," which seemed intimidating, because, although they were interested in research, they "just had no practice" and "wouldn't know where to start." Participant 4 talked about how science could be "hard to grasp but when you do it's very rewarding." They found classroom science and learning from textbooks "just really stressful." Outside of school they had interacted in a variety of science-related activities, including "reading books about bio and psych, watching videos, going to the occasional science competition, more multiple choice stuff, more quiz show things, I made a trebuchet once for a science fair." They also enjoyed reading about science, when they could choose topics they are interested in, and learning about real world applications of physics or psychology.

At the beginning of the program, Participant 4 indicated on their survey that they were very interested in science topics, reading about scientific issues, and pursuing a degree in a scientific field (9 out of 9 for all three areas). Thinking about what the program might entail, they shared that they were most interested in the aspects that they didn't have the most experience in, specifically doing scientific research. While their interest in science remained consistently high throughout the program, Participant 4 shared on their spring interview that their interest went up as they had "been exposed to more science topics, realized a lot [they] don't know but a lot [they] want to get involved in." By the end of the program, they indicated that they were a little less interested in reading about science (a sentiment that was shared by other participants), but. overall, they felt that their interest in science topics had stayed constant.

Initially, Participant 4 shared that they were not confident in most aspects of research, communication, and education. In the first interview, they shared that "most of the things on the list I didn't get what it was." Their confidence in these aspects increased over the course of the program, the rate of which varied by area. For instance, they started the program not at all confident in their ability to develop a research question (1 out of 9), describing their "concern

about coming up with new ideas." Their confidence steadily increased, however, and as they explained when reflecting on their survey answers in the spring "[I] had zero confidence and was nervous in the beginning, didn't know how to pull something out of thin air to be interesting" and explained that they worked on these skills over the course of the school year. At the end of the program, they were surprised by how highly they rated their confidence in this area (8 out of 9) and reflected that they now "know where to start, find something that inspires you from a past paper." Participant 4 also began the program not confident at all in using statistical software (rated as 1 out of 9), but by the end of the program they had some familiarity with using R and Excel and while their confidence was still moderate, they rated it a 4 out of 9.

At the beginning of the program, Participant 4 had a minimal sense of belonging in terms of being a scientist, science educator, or science communicator (all 2 out of 9). This was due to their lack of experience; they felt they were not a scientist because "[I] haven't done research yet except just learn about it, that's why I'd like to be, but I'm not yet." Similarly, they did not feel like a science communicator or educator because they "don't really teach science either or tell anyone about it, I just kind of learn about it." They continued to indicate that they did not feel like a scientist, saying the program "try to make us feel like that, but I feel like I'm just getting started and I couldn't call myself a scientist until I'm older and do my own research." However, from their experiences doing interpretations at the Museum, they felt more like a science communicator by the end of the program (5 out of 9).

Participant 4 had little connection to either the MOS or BU community at the beginning of the program. By the winter check-in, a few months into the program, their sense of belonging notably increased for both communities and feelings of belonging continued to grow throughout the program. For feeling they were part of the MOS community, they increased their rating from a 2 to a 7 (out of 9) and talked about how they were "integrated a lot with the Museum" and even though they were working remotely, it was "helping [them] connect to what's going on." By summer, they strongly felt like they were part of the MOS community (9 out of 9), saying that "everyone [was] very welcoming, [and] being in the office and working on the same projects with all of you was nice." For BU they went from a 1 to a 6 (out of 9) by winter, mentioning the work they were doing with the BU mentor. In the spring they reflected that they "felt more a member in the winter when [lab director] would come to our workshop sometimes and talk to us, but now it's just because we are on site and BU isn't, but [BU mentor] still makes us feel part of the community and we are part of the project."

When reflecting on their initial meaning map at the end of the program, Participant 4 felt their map was still mostly the same but would add "researcher" and that "science is more relevant to [their] life now." They refined their description of science, saying that they would now describe it as "very precise and specific" and would "get rid of broad" as a descriptor because while there are many fields in science "whatever field you are in you have to narrow it down something specific." They felt there was not much connection between their personal map and their science map, as they said "it's something I like to do and think about but it's not who I am."

Participant 4 was unavailable to meet to review their case study and reflect on the program.

Participant 5 case study summary

Participant 5 started the program feeling they had the potential to be a scientist and left feeling like they were a scientist. Through the program, they developed their research, communication, and education skills, while also recognizing there was a lot more to learn for some skills.

At the beginning of the program, when reflecting on their meaning map, Participant 5 first described themself as an athlete. They also talked about the way they interact with others, saying they were a "go with the flow type of person" who was empathetic as they "try to understand people and really see their side of things and sympathize with them." Participant 5 said that they were planning to pursue an engineering degree in college, like their parents and grandparents.

They described science as the "process of figuring out the truth so we know definitively" and understanding "how things work and discovering what's unknown." Despite describing school science as "stale" and "dull," Participant 5 had pursued science outside of school by immersing themself in nature, watching documentaries, and by fixing things—and they indicated on their survey that they were very interested in science (9 out of 9), as well as learning about science on their own and pursing a degree in a scientific field (both 8 out of 9).

When they were reflecting on their survey responses between the start of the program and the middle of the school year, Participant 5 noted that although their ratings fluctuated, they felt the same about being interested in science and reading about science, whereas they were now more interested in pursuing a STEM-related degree after getting to conduct research. By the end of the program, they rated their interest in scientific topics and reading about science lower (8 and 7 out of 9, respectively), and their interest in pursuing a scientific degree higher (9 out of 9). However, in reflecting on these survey responses, Participant 5 explained during the interview that they felt that their interest in all three areas had either increased or stayed the same, noting that "being able to really dig deep into different topics as a result of the work I have been doing has piqued my interest in a lot of things."

Over the course of the program, Participant 5's confidence in research, communication, and education skills fluctuated. In the beginning, they were least confident in writing up a study (3 out of 9) and writing a popular press piece about a scientific topic (4 out of 9), as they overall felt like writing was their weakest skill. By end of the program, they felt more confident (both 6 out of 9), noting after the winter check-in that those were areas they had done a lot of work with and their mentor "said we were pretty successful with those." Other areas where they indicated growth included critically thinking about research, such as reading papers written by scientists (going from a 6 to an 8 out of 9), considering the ethics of a research papers (going from a 6 to an 8 out of 9), and evaluating the strengths and weaknesses of scientific arguments (going from a 5 to a 7 out of 9). When reflecting on their survey responses, Participant 5 generally attributed increases in confidence to the program and getting opportunities to practice these skills. Participant 5 also indicated a couple areas where they decreased in confidence, specifically using statistical software and conducting statistical analyses (both going from a 6 to a 4 out of 9). They attributed the decrease to a phenomenon they had learned about during the program, saying "in general my confidence has gone up, but also had the Dunning-Kruger [effect], I've learned what really goes on so my confidence would have gone down because a lot more to this than I thought." They also reflected broadly on how their responses fluctuated in some areas, noting that some early increases in confidence followed by later decreases were "probably because we did [it] shallow[ly] and then dived deep, or out of practice with it."

For Participant 5, feeling like they were part of either the MOS or BU community largely fluctuated based on how often they were interacting or working with either group, saying "every day versus just sometimes, when [it was] everyday would become closer." They started the program feeling that they were somewhat part of the MOS community (5 out of 9), and by the middle of the school year reported an increase because they "got more comfortable with the people [they]'ve worked with." By the winter check-in they strongly agreed that they were part of the MOS community, which stayed highly rated for the duration of the program (8 out of 9). Participant 5's feeling of belonging fluctuated more with BU. They entered the program with minimal connection to BU (2 out of 9) but by winter strongly agreed that they were part of the BU community (8 out of 9). However, this declined to a 4 out of 9 in the spring which then rebounded to a 6 out of 9 at the end of the program. Reflecting on their survey responses, Participant 5 explained the fluctuations in feeling like part of the BU community were "probably just from interacting fairly often to not much at all in the spring, and back to fairly often in the summer."

From the beginning to the end of the program, Participant 5 indicated the most change in their feelings of belonging. At the beginning they disagreed that they were a science educator (2 out of 9), scientist (3 out of 9), or science communicator (4 out of 9). However, they emphasized they did not feel like any of these identities "yet!" As they went on to explain, "this is the first deep dive into those subjects that I've been able to do. My experience in those areas, comparing to people who do stuff like that, is minimal." By the winter check-in, Participant 5 was feeling most like a science communicator. Feeling like a science educator and a scientist increased steadily throughout the program. By the end, Participant 5 strongly agreed that they were a scientist (9 out of 9), a science educator (8 out of 9), and a science communicator (8 out of 9). In addition to agreeing on the survey, during the final check-in they also added "scientist" to their meaning map, explaining that they had heard repeatedly through the program "if you are doing science that makes you a scientist." Looking back at their initial meaning map, they reflected that their initial description of science focused on "a more physical explanation of it" and that they would add "attempting to define and explain things that are intangible." They described a connection with their personal meaning map to their definition of science, as "my definition of science comes down to how I am as a person." By approaching science as a process, it reflects their personal values of empathy and helping others. As they explain, "what it comes down to is why do we have science is there's a problem to be solved through logic and thinking, putting great minds to work and solving problems." Participant 5 felt the TSRCP program had been widely influential in supporting their changes in their science identity over the course of the year. As they explained, "[TSRCP] contributed to every single change there was. I don't think anything outside of this program contributed it to it much or at all. My relationship with science in school and stuff has generally been the same, I think it was entirely this program."

Participant 5 did not respond to requests to meet and review their case study.

Participant 6 case study summary

Participant 6 entered the program with existing interest in science and psychology specifically, having pursued these topics both in and out of school. Through the program they were able to build on previous experiences and skills, ultimately refining their understanding of themself in relation to science and a science-focused career. This participant built professional relationships with mentors that are ongoing at the time of this report.

At the beginning of the program, Participant 6 identified as a queer student who was passionate about social justice issues and interested in research, public speaking writing, and sci-fi/fantasy. They also shared that they had ADHD and "that affects how I do a lot of work." They saw science as something that was big, broad, and varied, but also "fundamental" because "there's aspects of science that underlie basically everything." They explained that science "could lead to people abusing it or manipulating findings or methods in order to have it do what they want." They also talked about how "there's a lot of different voices, different theories for everything, there's always ideas, people challenging [those ideas]." In addition to talking about how people use or see science, Participant 6 also saw science as something "robotic," because "a lot of fields have really high standards" and that doing extensive studies is needed for research to be meaningful. Previous experiences with science in school were mixed for Participant 6. Some experiences left them feeling lost, either due to lack of interest or teachers they did not connect with. Through science fair projects, which they both enjoyed and had embarrassing experiences with, they realized that they liked talking about science more than doing research.

As with other participants, Participant 6 began the program with high levels of confidence in their research skills, which then declined after learning more about what these skills entailed, followed by a rebounding of confidence as they engaged in the skills through the program. Education and communication skills were areas that they started out fairly confident in (6 or 7 out of 9 for all), becoming even more confident by the end of the program (8 or 9 out of 9 for all). This included skills like evaluating other research, writing or presenting about science, and connecting research to practice. They also talked about how getting to practice skills in the program supported their increased confidence; as they reflected on their survey responses in the spring, they explained that "as a general trend I feel a lot more confident in these areas now that we are in person and have had a chance to practice those, to see how that functions in the museum environment." Additionally, they shared that working on piloting with Museum visitors "has really affected my confidence and enjoyment in skills like that."

Initially, Participant 6 was most interested in learning "about things that other people might not already know, contributing to what everyone knows." They were also interested as they were considering it as a career and "makes it feel more real and possible and lets me know, basically what I decided to get into, which is exciting." Similarly, with their intent to pursue a psychology degree, they were interested in the mentorship aspect of the program. Participant 6 explained it as an "opportunity to meet STEM professionals and learn what they do and how they do it might be a better way to understand something I might want to do." Being part of the MOS community was an exciting aspect because, while they had enjoyed the Museum when they were younger, prior to the program they "didn't really see MOS as something that catered to me at this point in my life."

Despite Participant 6's *interest* in science, they were unsure whether they *were* a scientist (5 out of 9), a science educator (4 out of 9), or science communicator (6 out of 9). They explained, "I

feel like I know how to be a scientist, [but it's] not my job at the moment, not on the same level of people who do it professionally and have degrees." And when talking about feeling like a science educator or communicator, they felt some confidence in their abilities but also were aware of their weaknesses. For example, in talking about science communication, they explained that "in some circumstances I'm good, but not as adaptable as I would like to be." By winter, they strongly agreed that they were a scientist (8 of 9), which remained steady through the rest of the program. Some of the experiences that contributed to feeling like a scientist included "getting to publish and have my name in authorship in the ASTC proposal for Productive Struggle" as well as "getting to participate in data collection." And by the spring they reported that they also felt like a science educator and a science communicator (both 9 out of 9).

Participating in the program had an impact on their feeling of belonging, reinforcing their previous experiences they had in science. Over the course of the program, Participant 6 felt more strongly that they were part of both the MOS and BU communities. Participant 6 felt their connection to the Museum "increased dramatically." They shared elements that made them feel connected to the Museum, such as "getting to be on site and working with different groups on different projects and getting to represent the museum in certain activities and events, and participating in museum-wide meetings and programs." Participant 6 started with less of a connection to BU (4 out of 9 in the fall), and they noted early on that they felt that the program emphasized being integrated into the MOS community. However, by the winter and through the rest of the program, they indicated that they definitely felt like part of the BU community (9 out of 9). In the summer, they shared being part of the Structural Mindsets study and participating in data collection made them feel like they were doing "actual projects."

When reflecting at the end of the program, Participant 6 shared that they would not change anything to their identity on their meaning map but could better see how their identity existed in the context of their environment and in science. They talked about how they learned that there was "a lot of variety and internal politics in how you represent [science] and how you communicate it with people" and that "science is a very big thing and it's not the subject called science or the profession called scientists . . . it's a lot of different areas and subtypes." In addition to learning about and coming to see themself in relation to science research, education, and communication, they shared that they had also learned about working in an office and building skills (e.g., working with Excel) related to that. Overall, after the program they had "a clearer relationship between myself and my understanding of science and a professional environment and contributing to the field."

After reading their case study, Participant 6 thought it was interesting to see how their experience was described. They noted that at the end of the program, and reflecting back eight months later, that they felt that they were overconfident at the beginning, and later recognized what they did not know. Participant 6 also felt that their interest, confidence, and sense of belonging were intertwined, and that growth in one area ultimately impacted growth in another area. In addition to the areas discussed in the case study above, Participant 6 gained confidence in their ability to speak up, ask questions, and be part of the conversation in research settings. They felt that the area the program had the most impact on them was in their sense of belonging in scientific communities. While participating in the program, they "felt like part of decision-making processes" and that experience in turn made them "feel more qualified to engage with other opportunities." Through the connections and experience they built in the program, Participant 6 has been able to continue working on related research in college.

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

This section reviews the specific program activities the team felt would contribute to each of the intended program goals. In the interviews, the teens shared their perceptions of these program activities, including which activities contributed to each of the intended goals, and to what extent they engaged in the activities. As described in the introduction, the program set out to have youth participate in five core program elements:

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 educational handouts.
3. Engage in science education practices: Teens prototype and facilitate hands-on activities, help design exhibits, and work on the Museum floor as science educators.
4. Experience mentorship from STEM professionals: Teens have mentors both from the MOS and from BU.
5. Become a member of a science community: Teens are integrated into scientific communities as Museum staff and contributors to BU's Social Development and Learning Lab.

The findings for this section include:

3.2.1 Teens engaged in research practices throughout the program, primarily recognizing these practices in their contributions to the BU Structural Mindsets project and contributing to data collection efforts for both the Museum and BU.

3.2.2 Teens felt they primarily engaged in science communication practices through their contribution to writing a journal article, presenting findings to Museum staff, and writing Living Laboratory materials that describe research for caregivers.

3.2.3 Teens practiced science education skills primarily through on-the-floor interpretations with Museum visitors, which they also felt overlapped with practicing science communication.

3.2.4 Teens felt that the regular interactions with select staff from MOS and BU were the most noticeable elements of mentorship in the program.

3.2.5 Teens recognized that opportunities to feel like part of the MOS or BU communities were primarily through meaningfully contributing to projects and interacting with staff at either institution.

3.2.1 Teens engaged in research practices throughout the program, primarily recognizing these practices in their contributions to the BU Structural Mindsets project and contributing to data collection efforts for both the Museum and BU.

Table 2. Selected youth activities for Research Practices program element

Engage in research practices:
Youth Activities: - CITI ethics training - Pilot testing and refining research protocols - Data collection for BU's "Structural Mindsets" (in-person) study and the Museum's "Productive Struggle" (online) study - Quantitative and qualitative data analysis and statistics

The program team emphasized seven aspects of research practices for teens to learn about and practice through their work with BU and at the Museum: understanding research ethics, reading scientific literature, planning research, piloting, data collection, data analysis, and statistics. See Table 2. Activities from the program that addressed these research practices included completing human subjects research ethics training, attending workshops learning about the practices, testing and refining research protocols, collecting data, and conducting quantitative and qualitative data analysis and statistics. Specific projects that the teens worked on included the BU Structural Mindsets study; the Museum's Productive Struggle research and Imagination literature review; and the Museum's front-end (*Exploring A.I.*), remedial (*Engineering Design Workshop*), and summative (*Faces of Science*) exhibition evaluations. Throughout the interviews, the teens indicated which program elements they interacted with, to what extent, and in what ways. Overall, the teens most often associated practicing various research skills with the BU Structural Mindsets study, also recognizing how research skills fit into some of their Museum work.

Out of all the research practices, the teens most often talked about *data collection*, both broadly across many projects and for specific projects, recognizing this research practice as something integral to their TSRCP experience. Most of them specifically called out doing data collection for Living Laboratory (the BU Structural Mindset study). They also talked about data collection they did for Museum's Productive Struggle research, COVES (visitor exit survey), and exhibition development. The teens tied data collection to their ability to practice research skills, as well as to science communication or education practices.

Reading scientific literature was an area that the teens recognized they practiced a lot, with one teen explaining that "we have to do a lot of that, and they gave a lot of resources about how to do that." Teens talked broadly about the volume of reading that they had done, in addition to referencing more focused reading tasks, such as literature reviews for the Musuem's Imagination project or the BU Structural Mindsets project. Some of the teens also connected reading literature to other research practices, such as considering ethics in a project through discussions about articles.

The teens primarily felt engaged in *planning and piloting a study* through the BU Structural Mindsets project. They shared feeling actively involved in the study design process, with the help of their mentors. One teen explained that their contribution included "participating in designing the study, discussing the background information, brainstorming ways to create manipulations for various conditions." Once they had worked through the planning stage, the teens talked about piloting their methods and collecting data for the project. While the teens also

contributed to piloting for multiple Museum exhibition projects, these were rarely mentioned in their interviews when talking about planning or piloting.

For the remaining research practices--research ethics, data analysis, and statistics--the teens recognized that they learned about or practiced these skills but did not give many specific examples from their TSRCP experience. Most of the teens talked very generally about considering *research ethics*. When they did provide examples, they talked about reading and discussing case studies and talking about the consent process for the BU Structural Mindsets study. One shared they felt that ethics were "really thoroughly covered." For *data analysis*, the teens generally shared that they had opportunities to practice this skill, with specific mentions of working with the BU Structural Mindsets and Museum's Productive Struggle projects. They often talked about statistics as part of analysis, with the teens recognizing statistics as another tool for analysis. When the teens talked about *statistics,* they generally emphasized learning about statistics, and starting to get familiar with some of the software used for statistical analysis (Excel and R).

3.2.2 Teens felt they primarily engaged in science communication practices through their contribution to writing a journal article, presenting findings to Museum staff, and writing Living Laboratory materials that describe research for caregivers.

Table 3. Selected youth activities for Science Communication Practices program element

Engage in science communication practices:
Youth Activities: - Writing a methods description for a journal article - Developing text and visuals for a conference poster - Writing a handout about BU's Structural Mindsets study for museum visitors

The program team recognized the overlap between communication and education, grouping different practices and program activities under each area for the purpose of analysis, outlined in Table 3. Throughout this report, these skills are organized as the project team thought about them. They generally thought of *science communication* as skills related to developing and evaluating communication products for both academic and public audiences. This included thinking about writing for academic venues (articles or posters), meaningful data visualization, and effective social media. Specific opportunities for engaging in science communication practices primarily focused on work from the BU Structural Mindsets project and the MOS Productive Struggle project. This work included writing a handout that summarized and explained the Structural Mindsets study for Museum visitors, writing a methods description for a journal article, presenting research findings to Museum staff, and contributing to a conference poster for the Productive Struggle project. The program team generally conceptualized *science education* skills as related to directly conveying science to a broad public audience, through museum programming, exhibits, or similar experiences. The teens contributed to the prototyping experiences for an exhibition about artificial intelligence, along with leading hands-on interpretations in the Museum's *Engineering Design Workshop* and *Natural Mysteries* galleries.

The teens had many opportunities to practice both science communication and science education skills during TSRCP. However, the distinction the program team made between science communication and education practices seemed unclear or unimportant for many of the teens. In the interviews, the teens would talk about communication and education skills somewhat interchangeably. Some of the teens were unclear about what was in each category, and asked the interviewer to explain the distinction, who then prompted the teen to explain how they understood the two sets of skills. One teen described communication as "just transferring information" while education "is teaching concepts behind it." While the categorization of experiences or skills did not exactly match between the program team and the teens, it is apparent that teens recognized specific skills within each grouping that they had opportunities to practice and develop.

Most of the teens felt that they had opportunities to practice *communicating with scientific audiences* through writing and presenting. They talked about writing the methods section for a journal article about the BU Structural Mindsets project, which was discussed in the context of feeling confident in their skills or feeling like part of the BU community. Teens also highlighted the work they did with the Museum's Productive Struggle project, which included presenting findings to the Research and Evaluation department staff or to the broader Museum community in a division meeting and developing and presenting a poster at the Association of Science-Technology Centers conference. Beyond those two projects, teens identified other opportunities in the work they did, such as writing summaries of research to support the development of grant narratives, sharing outcomes internally with other staff, or generally talked about getting to practice "communicating with professionals in the field, and sharing our own experiences and how to phrase our own materials that would be usable and understandable in that context."

Communicating with public audiences was an area that the project team associated more with science communication than science education, primarily through summarizing papers for each other and writing educational materials related to Living Laboratory research. Many teens talked about written handouts and added the conversations they had when recruiting visitors for piloting Living Laboratory research. One teen explained that they were "educating the public about what is going on or how studies are run." Some of the teens also talked about how reading articles or debriefing from data collection contributed to skills related to science communication with public audiences.

3.2.3 Teens practiced science education skills primarily through on-the-floor interpretations with Museum visitors, which they also felt overlapped with practicing science communication.

Table 4. Selected youth activities for Science Education Practices program element

Engage in science education practices:
Youth Activities: - Leading hands-on interpretation activities in the Museum exhibit halls - Professional development focused on child development, facilitation, and pedagogy - Developing content and prototyping museum exhibit interactives

On-the-floor interpretations (hands-on activities) with visitors at the Museum was a primary method for the teens to practice *science education* skills, outlined in Table 4. As mentioned in the section above, teens did not see a clear difference between science communication and science education. How the teens defined science education was influenced by their in-school experiences, and their experiences with TSRCP seemed to expand their definition. One teen explained that they initially "considered education like lectures and talking about science in a formal setting like in schools" and by the end of the program they "extend[ed] that to interpretations and interacting with the public."

In preparation for their work with visitors, teens learned about child development and education practices, which came up when they talked about science education experiences. As one teen explained, they "talked a lot about principles of science education, how to design materials and what would be the most effective to communicate with visitors and others." Teens led interpretations in *Natural Mysteries*, helping visitors learn about sorting, classifying, and observing natural materials, like shells or eggs, or examining clues to match animal tracks to the animal that made them. They also supported visitors who were participating in Engineering Design Challenges. These interpretations were thought of as both science communication and science education by the teens. They connected interpretation activities to communication since they needed to learn how to share science content and tailor their conversations to each visitor. In addition to interpretations, some of the teens brought up the work they did with piloting and prototyping in connection with science education. They recognized their work contributing to the artificial intelligence exhibition and thinking about how to share information through an exhibit.

3.2.4 Teens felt that the regular interactions with select staff from MOS and BU were the most noticeable elements of mentorship in the program.

Table 5. Selected youth activities for Mentorship program element

Experience <u>mentorship</u> from STEM professionals:
Youth Activities: - Regular workshops and check-ins with primary mentors from BU and the MOS - Collaborative work with BU researchers and MOS researchers - Working meetings with exhibit project team members (designers, content developers, educators, evaluators)

Teens experienced mentorship from STEM professionals associated with both BU and MOS, see Table 5. Mentors supported teens' collaborative work with the BU and Museum researchers and regularly met with the teens. The teens also had regular onsite or virtual "job chats" with Museum, BU, and other STEM professionals. In addition, the teens were a part of regular meetings with exhibit project team members.

In the interviews, the teens shared about their interactions with program staff that made them feel like they were being mentored. They noted some differences in the work they did with mentors from the Museum versus mentors from BU, in both cases focusing on their interactions with the staff they spent the most time with. For the Museum, the teens talked about their primary mentor

and other MOS staff about equally. The experiences that stood out as mentorship included being trained on research protocols and interpretation plans, modeling and shadowing research practices, and providing guidance about research or working in an office setting. For BU, teens shared that their primary mentor generally provided guidance and support through being regularly present, and some felt that mentorship took the form of teaching them about research (e.g., experiment design and data collection). Other BU staff were mentioned by teens less frequently, and mentorship looked like learning about research through the workshops and meetings. They also noted that the primary mentors, other MOS and BU staff, and guest speakers provided mentorship through sharing career backgrounds, advice, and engaging with the teens on their work.

3.2.5 Teens recognized that opportunities to feel like part of the MOS or BU were primarily through meaningfully contributing to projects and interacting with staff at either institution.

Table 6. Selected youth activities for Science Community Membership program element

Become a member of a science community:
Youth Activities: - Working in the Museum exhibit halls alongside BU researchers, and MOS researchers and educators - Participating in meetings alongside MOS staff and BU students and faculty, including lab meetings and department meetings - Shared projects with museum staff and university staff at various scales - Sharing offices and physical workspaces with MOS staff - Sharing virtual workspaces with MOS and BU staff

Teens had opportunities to feel like they had become members of the BU science community through meetings with BU students and faculty and contributing to the research for the BU Social Development Learning Lab, see Table 6. In addition to all the program activities around research practices, this included participating in virtual lab meetings and networking with BU students. On the informal side, teens were integrated as MOS staff, shared project findings back with MOS colleagues, and participating in Department, Division, and Museum-wide meetings.

Across the MOS and BU communities, meaningfully contributing to project teams and being part of job chats were most often identified by teens as aspects of the program that built feelings of belonging. In addition to contributing to study design, data collection, article writing, and presentations as described in sections 3.2.1 through 3.2.3, above, teens identified other aspects that fostered belonging. They talked about being connected to current research, being involved in team meetings, being treated like peers, and doing tasks that would be expected of regular staff; this work felt like "doing actual projects that are a part of this" as one youth explained. Teens also identified ways that interacting with staff from MOS and BU was part of engaging with scientific communities, this included talking with professionals about their careers – what they did, their career path, how their work connected to the teens' work, and offering advice. This heavily overlapped with discussions about mentorship, as outlined in the section above. Getting

to know a variety of staff through these interactions also contributed to feeling like they engaged in those communities.

Teens talked about opportunities related to being part of the MOS community beyond the work related to the research they were working on. They noted that having visual cues as being members of the staff, such as having a badge and wearing the red Museum coats and being physically present in the building provided opportunities to feel connected to the Museum community. Attending all-staff meetings and doing regular office tasks, such as answering email or otherwise communicating with colleagues, provided additional opportunities to feel connected. For opportunities to feel like part of the BU community, teens primarily talked about doing research and being recognized as representatives of that community when collecting data in the Museum.

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

To evaluate the relationships between program activities and changes in science identities, evaluators coded participants' interview responses based on the five program elements as well as science identity factors (interest and affinity, skills and self-efficacy, and belonging and community) and assessed the co-occurrence of 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; science community; and engaging in science communication. Below, we describe these results in more detail, describing what the data say about how the specific program activities seemed to contribute to the science identities.

The findings for this section include:

3.3.1 Teens frequently connected their engagement in research practices to their high levels of interest in science.

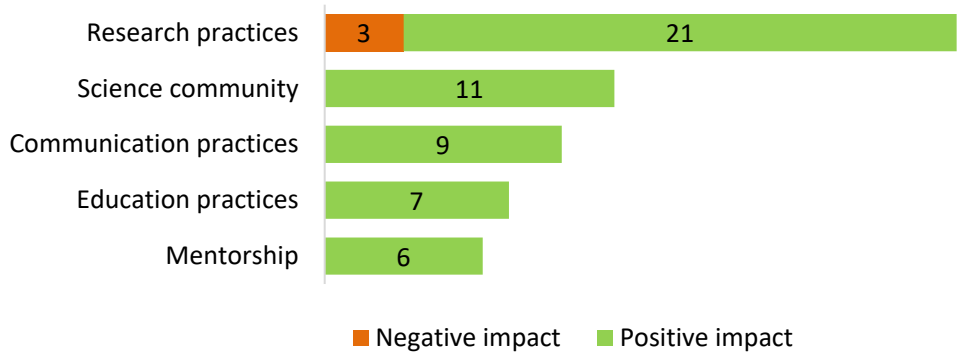
3.3.2 Teens most commonly attributed engaging in research, communication, and education practices to influencing their skills and confidence; in some cases, engagement in these practices initially led to declines in confidence.

3.3.3 The program's activities designed to immerse teens in science communities were effective in supporting teens' sense of community and belonging.

3.3.1 Teens frequently connected their engagement in research practices to their high levels of interest in science.

Overall, teens were most likely to talk about engaging in research practices as the strongest driver of changes in their interests regarding science (across the interviews, teens described this connection 24 times). The next most common program element that teens linked to interest was becoming a member of a science community (11 mentions), followed by communication practices (9 mentions), education practices (7 mentions), and mentorship (6 mentions). Teens almost universally described these program elements as supporting positive affinity and a growth in interest. Three of the 24 responses about research practices were the exception, where teens indicated that program elements made them less interested in specific types of research. For instance, Participant 3 talked about doing research in a balanced way, where being engaged made them more interested in research overall but also helped them discern what types of research were most compelling, after finding a negative affinity for psychology. Overall, Participant 3 said, "I think doing research is just really interesting to me, I plan to do that in college, hopefully make that a career. In high school you don't really get to do that." but as they continued, they shared, "The Structural Mindsets study showed me psychology might not be for me...not something I would want to do for a career." Figure 10, below, summarizes the frequency with which teens talked about each program element as contributing to changes in their interests and affinities towards science—both negative and positive. The sections below look more closely at individual activities within the categories of each program element.

Figure 10. Program elements contributing to changes in interest and affinity (n=57 co-occurring excerpts)



As described previously, engaging youth in research practices was a major focus of TSRCP and it was the most common program element that teens described when talking about their changes in interest and affinity. In general, when talking about the connection between research and interest and affinity, teens talked broadly about research, saying positive things about doing research in the program and how it was a valuable opportunity for high school students. For instance, one participant shared, "I think research has been interesting, haven't been able to engage much in research [outside of the program]" and another noted, "I really like participating in science research, especially in high school, having that experience."

Digging in more closely to the specific research activities that contributed to changes in interest, the most common thing that teens mentioned was reading and doing literature reviews (7 mentions). Teens shared things like, "a lot of research articles we read were really interesting" and connected reading to future goals, saying "I knew before that I wanted to go into science or a STEM field and I still am, and that involves reading a lot of stuff and reading about it. Reading a lot of articles." Two teens had negative affinities with reading, sharing, "[I'm] kinda burnt out from reading a lot" and noting that, once they were not reading as much, they lost interest: "Towards the spring we didn't read as many things, so I guess I lost interest in that because there were less things to look at." Other specific research activities that teens mentioned as impacting their interest and affinity for science were pilot testing, ethics, and planning. Regarding piloting, one teen said that they "love the parts" when they were piloting, one shared, "I enjoyed the ethics because we did a lot of case studies and I find those interesting, the story aspect of science" and one noted that the two major areas they enjoyed were "experimental design and understanding the work in the lab."

There were nine instances when teens talked about interest in relation to their engagement in communication practices. One of these mentioned a specific activity, when they presented their work to Museum staff: "We've more recently been focusing on that and we got to make a presentation slide. That was fun." Aside from that, teens spoke broadly about communication, saying things like "I loved doing [communication]," "Communicating science is something I enjoy a lot," "[communicating science] was a lot of fun and really interesting to do and learn about," and "I think it's very interesting and I feel proud to be able to learn about all this stuff, be able to explain it to other people."

Teens connected their engagement in education practices with their interest in science seven times. Most often this related to doing interpretations on the Museum floor. One participant shared, “I love the parts where we are on the floor doing interpretation.” Another added, “Interpreting was really fun.” Others talked more broadly about learning about education, saying things like, “I know why feelings of being a scientist would have increased, as I just said. I definitely know more about the theories of what someone does as an educator” while another commented, “Education, that part was a lot of fun and really interesting to do and learn about.”

Teens also felt mentorship contributed to their interest in science, mentioning this connection six times. All of these comments talked broadly about mentorship rather than pointing to specific aspects of the mentorship experience. One teen mentioned how valuable mentorship was in comparison to school: “Mentorship is a big resource. Not just being in class but being with someone in the field who has that specialization.” Another connected mentorship to career discernment, saying, “Being mentored by STEM professionals gives me a better idea [of what a career might be]...I’ve been really interested in psych as a topic for a while. That could transfer to being interested in psychology as a career, [but it’s] hard to think about what specific careers in psych entail, what you would be researching.” For one teen, mentorship was more informal and aspirational. They shared, “Sometimes [mentors] go on a tangent of a study they heard of and then talk about that for 10 min, and seem very interesting, and I want to make those connections in my life to make those connections to science. Just cool to know things.” Finally, others described mentorship as “cool,” “helpful,” and “insightful.”

Teens also frequently linked their interest in science to being part of a science community, mentioning this connection 11 times. Some of these were specific mentions about the MOS or BU communities. For instance, two teens talked about how they were interested in the program because they had existing relationships with the Museum. One noted, “I’ve been to the Museum a lot and I think it would be cool to feel like a part of the Museum,” and another added, “I looked for stuff at the MOS because I really like the MOS, went there a lot when I was little. Somewhere that’s familiar that I really enjoyed.” On the BU side, one participant described how becoming a part of that community had shifted their interest from being primarily about science communication to being more research-focused: “I was interested in doing science communication but over time the focus has shifted to research so that’s why that changed. Since October we’ve had more interactions with BU researchers and hearing more about their work so that’s my thought process.” Other teens spoke broadly about science community and its ability to prepare them for the future, saying things like, “The concept of being in scientific community is a really cool thing, feels very mature, this is what I want to do in my future, be in a science community” or “I think it’s really cool when we get to join meetings, feel like ‘oh wow, this is what being in a work place is like’ will be super valuable having these experience, and being more familiar with an office space and how it’s operated, super cool being able to join meetings and seeing how a company is run – will be less intimidated when searching for jobs 4 years from now.”

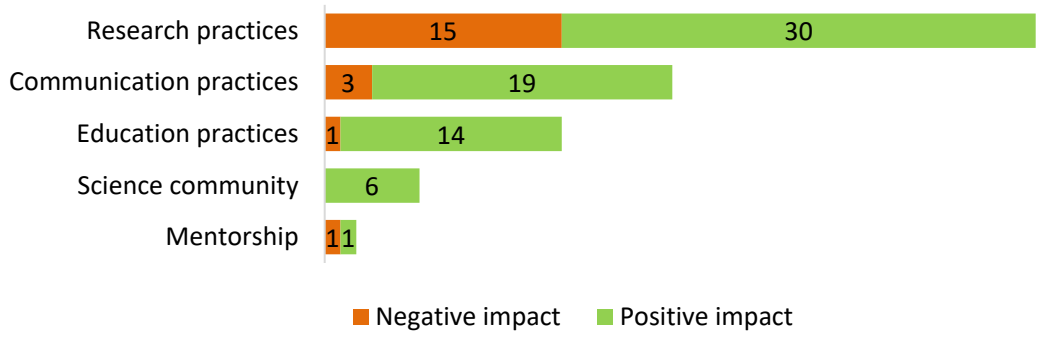
3.3.2 Teens most commonly attributed engaging in research, communication, and education practices to influencing their skills and confidence; in some cases, engagement in these practices initially led to declines in confidence.

As with interest, when teens drew connections between program activities and changes in their skills and self-efficacy, they most commonly spoke about engaging in research practices (45 mentions). Engaging in communication (22 mentions) and education (15 mentions) were also common. Teens less frequently connected mentorship (2 mentions) and being a part of a science community (6 mentions) to their skills and self-efficacy. In most cases, teens felt that being engaged in these activities built their skills and contributed to their sense of self-efficacy. However, especially for research practices, in some cases exposure to an activity led to declining confidence. Teens were highly metacognitive about these decreases—they often mentioned the Dunning-Kruger effect, which they learned about in the program, where people are initially overconfident in their abilities before learning about what a task entails; thus, in some cases, the decrease of confidence reflected a growing (and healthy) appreciation for how complex scientific research can be. One teen said:

> *Teen: In general my confidence has gone up, but also had the Dunning-Kruger, I've learned what really goes on so my confidence would have gone down because there's a lot more to this than I thought. But generally my skill and ability has increased.*
>
> *Researcher: Were there any particular areas where you feel your skill and ability increased?*
>
> *Teen: Mostly across everything, looking at collecting data – I was somewhat confident, so Dunning Kruger so [I] went down, and then I got more confident, then went down as [I] did more. The program contributes to all these changes. I got more confident while participating in the program.*

Figure 11, below, summarizes the frequency with which teens drew connections between the program elements and changes in their skills and self-efficacy. The paragraphs below describe these connections in more depth.

Figure 11. Program elements contributing to changes in skills and self-efficacy (n=90 co-occurring excerpts)



As shown in Figure 11, when talking about how the program contributed to changes in skills and self-efficacy, teens most often talked about their engagement in research practices. Several specific research practices came up often. Statistics was the most commonly discussed, and teens were highly mixed about whether their engagement with statistics contributed to increases or decreases in confidence (9 mentions were negative, 8 were positive). For example, one teen shared about how the software had been confusing, saying, "The one that moved down [in confidence] was the statistical software. I took a stats class last year so on paper I understand but there's a difference in an application and I learned the difference." Another mentioned that there was a lot of terminology involved but that they ultimately felt more confident: "Conducting statistical analyses I'm still not extremely confident in that but there have been discussions of different types of averages and errors and sources of statistical error and they're terms that, now that we've discussed them, I could use them with more confidence in conducting statistical analyses." One shared that the program's introduction to statistics was not enough to feel confident: "We've gone over using stats software to visualize data, [but it's] still not a subject I am very comfortable [with]" and another said, "Conducting statistical analysis something I can grasp at some point but not right now, need to learn more about what things mean in terms of statistical significance."

Data collection was another research activity that teens often talked about as contributing to their sense of confidence. More than half of the mentions of data collection were about how doing data collection supported confidence. Teens shared things like, "As we familiarized ourselves with more studies, it's becoming less and less daunting to perform such tasks" and "being able to collect a lot of data when came back in person, helped confidence." For others, data collection seemed high-stakes and led to a decline in confidence. One teen described:

> *We're going to start participating in studies by BU and Living Lab and it feels like collecting data has a fair amount of pressure to it. When we talked about the ethics, if there's not a level of integrity and competence of the people collecting data, the conclusions and interpretation and follow-up studies can be compromised, is what it's always felt like from what I understand it. And we've definitely covered a lot of the important aspects and I trust the mentors to help us in that aspect but it feels like the thing I might be most likely to mess up and it would be damaging if I messed it up.*

As mentioned in the quotation above and in other comments, ethics was another topic that came up frequently in relation to confidence. Aside from the quotation above, these comments indicated that the program's treatment of ethics led to a growth in confidence. For example, one teen shared, "We also learned about it as part of the BU ethics certification, so I feel very confident in what I've been taught about that." Another added, "Considering ethics, feel those have been really thoroughly covered, and feel a lot more confident in them." Similarly, reading academic papers was something teens tended to feel they got better at during the course of the program. One noted, "The program has helped me learn about phrasing and how to break down an article and how to look into sources and what you should be looking at." Several teens mentioned how they came in with experience reading from school, but that reading scientific papers was different. One shared:

> *We did some more specific things about reading papers by scientists including making discussion points and sharing them with each other, so I have a lot of experience applying the skills from the workshop in that area. I also feel that I had a background in that when I*

came into the program. The program reinforced those skills so I'm more equipped to apply that at a broader level.

Overall, as these quotations suggest, teens indicated that growth in confidence was a multi-faceted thing, and that the program made them feel more confident in some areas while they felt less comfortable in other areas when they got to know these tasks more closely. One teen articulated:

A lot of this made me aware how complicated these processes are now that I'm doing them, what I still don't know and what I knew before. Experience collecting data has made it more clear how it is done...Skills like ethics, iterating, developing research [questions], those are activities I have done through this program, and really brought to light the processes involved in that, what to consult and what the standards are with that.

Another teen reflected on how the program's work on some topics felt more comprehensive than others, saying, "All of these fall under the same thing about not realizing how much there was to collecting data and conducting statistical analysis...Reading papers written by scientists and considering ethics, feel those have been really thoroughly covered, and feel a lot more confident in them." Although teens recognized the complexity of these subjects, they felt that the program was contributing to their confidence in positive ways, and more so than school. One teen described, "I think I mostly gave high ratings when it's something we've done a lot in this program, more than school, it's when I've done it several times in the program, I understand how to do it."

After engaging in research practices, the program element that teens were most likely to relate to changes in their self-efficacy was their engagement in science communication. Several teens talked about how summarizing and presenting literature had boosted their confidence. Teens specifically mentioned the activities where they read a grant proposal and summarized literature (on intersections of imagination and STEM) in PowerPoint slides; presented findings of the Productive Struggle study (comparing a virtual and an in-person version of an exhibit) they had contributed to, and shared findings from piloting for an exhibition on artificial intelligence with internal Museum stakeholders. One teen mentioned writing inserts (handouts for museum visitors that describe Living Laboratory research) as an activity that boosted confidence. Teens tended to report that the program's exposure to science communication supported their overall confidence ("just doing that gained a lot of confidence") and teens also tended to be able to draw connections between what they had already done in the program and other skills they might do in the future. For instance, one mentioned, "I haven't written a popular press piece but I have talked to the public so I'm confident in my ability to get that on paper." For one teen, the program was supporting them to get through a discomfort with jargon: "I have been daunted by jargon and keeping track of variables with people I am working with or talking to, more aware of how hard that it is, but feel like it is a skill that is being taught as part of the program."

When describing how program activities contributed to science skills and confidence, teens mentioned engaging in science education fifteen times. When these comments mentioned specific project activities, it was most often interpretation on the Museum floor. One teen said, "Getting to do the interpretations...has really affected my confidence." Another described how the interpretations helped them gain confidence not just in broad science skills but in their confidence engaging in the Museum. They shared, "being trained in interpretations for eggs, feathers and EDW [*Engineering Design Workshop*], feel somewhat knowledgeable in science

and exhibits and where things are in the museum, and how to use things." One aspect of interpretations—and education more broadly—that teens valued was being in-person. A teen described that their confidence "Increased dramatically because we're onsite and in person, doing activities on the floor" and another added, "As a general trend I feel a lot more confident in these areas now that we are in person and have had a chance to practice those, to see how that functions in the museum environment. I have really enjoyed that and feel like we have covered a lot of skills in those areas." One teen described how the repetition of doing this work contributed to their sense of confidence: "Seeing how many people you engaged and your confidence with engaging, interact with kids a lot and before would not have said good with interacting with kids and now that I have, I have gotten much better at it."

Mentorship was the program element that teens least commonly connected to their skills and confidence, with just two teens drawing this connection. One described how the mentorship experience successfully scaffolded skill development. This teen shared, "[Mentor] was a really good mentor for these and did a good [job] showing us how, and watching her do it and then us doing it, listening to her was a really good way to gain confidence." The other teen shared how the mentorship had exposed them to the complexity of scientific research and made them feel more reliant on their mentor. They shared, "[I'm] not as confident as a scientist because I'm still very reliant on mentors, couldn't do it independently or without guidance" and added, "I think that initially I was pretty confident in a couple different things, but starting to go more in-depth and having more mentorship, I have realized how difficult some things were, a lot of things dipped."

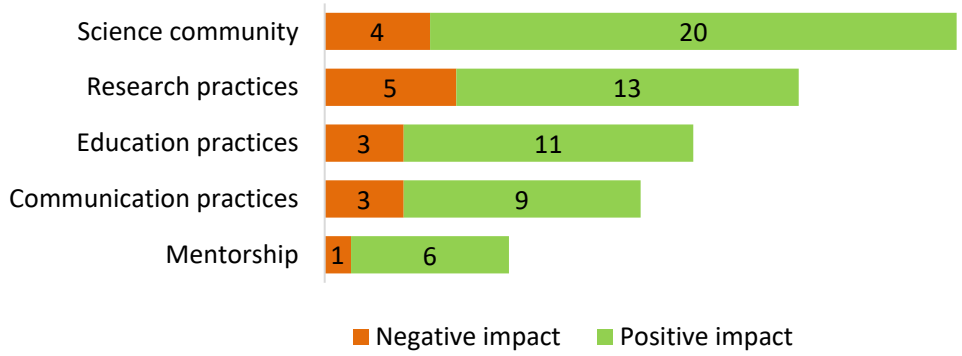
The fifth program element, becoming a member of a scientific community, seemed moderately related to skills and confidence for teens. There were two trends about which aspects of the program supported this sense of confidence. One was job chats and other opportunities to meet people in different STEM professions. A teen talked about how getting to know people helped them feel more confident in their ability to see themself in the people's roles. This teen said, "It was helpful to see the behind the scenes and I liked seeing there are people of all sorts of backgrounds – consider them all scientists, we did more psychology things, and also talked to the software engineer at the museum." Another teen spoke about how these connections helped them feel more confident in talking about how their work connected to other things. They shared, "We had a couple of people joining our select Saturday workshops and talk about developing exhibits or how they bring research into informal science learning environments, talks like those helped in being confident in how research connects to museum practice and design." The second program activity related to science community that seemed to contribute to a growing sense of confidence was embedding teens on project teams. One teen talked about the importance of feeling confident due to having people to work on things with you. They said, "Being in the office and working on the same projects with all of you, was nice." Another talked about how their confidence was, "Very strongly associated with communities and a lot of that has been working on projects."

3.3.3 The program's activities designed to immerse teens in science communities were effective in supporting teens' sense of community and belonging.

When teens talked about the ways their sense of community and belonging changed over the course of the program, they, unsurprisingly, most often talked about the program element of *becoming a member of a science community*, and the activities related to that program element

(24 excerpts made this connection). However, compared to the other identity factors, this topic was the one where teens were most balanced in talking about the contributions of many aspects of the program. This is perhaps summed up well by Participant 2, who shared, "I think everything involved [in the program] is helping becoming a member of a science community." Beyond the core program element of science community, the next most common program element that teens connected to their sense of community and belonging was the *research practices* (17 excerpts), followed by *education practices* (14 excerpts) and *communication practices* (12 excerpts). In all cases, teens most often associated the program elements with positive aspects of belonging and community, but also for each element there were instances where teens felt the activities hindered community and belonging. Figure 12, below, summarizes these findings, and the following paragraphs describe teens' comments in further detail.

Figure 12. Program elements contributing to changes in belonging and community (n=74 co-occurring excerpts)



Engaging in research practices frequently came up when teens talked about their sense of community and belonging with science. The most common theme within these responses was that teens were interested in science as a career, and doing research strengthened their sense that they were on that path. One shared, "scientific research is something I've really been considering as a career and makes it feel more real and possible and lets me know, basically what I decided to get into." Two teens talked about research skills as a credential that helped them better fit within their career goals, with one sharing, "I think the research one feels more important, because I am definitely going to be in the STEM field as my career. Having research skills is going to be important for me to use later in the future." Extending on this idea, one teen talked about the value of using research language as a factor that connects you to a science community: "When [you're] more familiar with things like research or psychology, can more easily become part of those communities because you share a common language or common knowledge so easier to talk to those people in the future."

Another theme among teens' comments about how research activities supported their sense of community was around doing authentic research rather than simply learning about science. Teens mentioned things like "actually [being] able to conduct some research" and "[I] feel like [I'm] doing actual projects." A third theme was feeling included in project teams. One teen described the importance of collaboration, saying, "Collaboration is important for a lot of stuff, can do more with more people. In science, knowing what other people are researching so you can build off of that. True for a lot of things like group projects." Another mentioned that it was

useful to feel like a member of the research team, sharing, "we were pretty heavily engaged in research stuff, we piloted thinking about the study, did the script, and actually ran it and did data collection. Also Productive Struggle, it was multiple things. Felt pretty involved in that process." While most of the discussion of science research focused on how this work made teens feel more connected to science, there were four comments about how it made them feel less connected. These comments were connected to interest and confidence, as described in the previous sections: one teen felt less connected to science because they realized they did not actually like psychology research (in one case) and teens felt less connected when they felt they were not good at aspects of scientific research, which they abstracted to thinking meant they were less interested in being part of the science community in the future. For instance, one teen shared, "Wow, there's a lot I still don't know or I haven't known before so that made me less confident in [my potential for] being a researcher."

There were fourteen mentions when teens described how engaging in education practices contributed to their sense of community and belonging. Numerous teens talked about the importance of physically being in the Museum doing education, sharing things like describing how their sense of community, "increased dramatically because we're onsite and in person, doing activities on the floor." One teen talked about how it made them feel connected to science when they were familiar enough about topics to explain them to visitors on the floor. They shared, "I would say that I was able to communicate with other people about science, I was able to sort of learn about science and be educated about it and educate others." In one case, a teen found science education to be more difficult during the program than their past experiences. This participant described, "it has been more difficult for me to interact with the public, especially for AI prototyping... finding it more difficult than I used to."

Although not the most common program element that teens talked about in relation to their sense of belonging, engaging in science communication came up twelve times across our interviews. One trend among these comments was that it helped teens feel like they belonged when they felt that they were able to explain the work they were doing. One teen explained that the opportunity to practice this with visitors in the Museum was useful: "Definitely now that we are on site and communicating and seeing people, definitely feel more of a science communicator...explaining what we are doing, and that has had a lot of experience with that recently." For some other teens, the emphasis was less on communicating to visitors and more about communicating with STEM professionals. Numerous teens mentioned giving presentations to MOS staff and one teen described how they felt connected "with other researchers as a whole through the ASTC [Association of Science and Technology Centers] conference" when they shared a poster of their findings from one of their projects. Again, mentioning the ASTC conference, another teen mentioned that doing science communication things like scientists—such as being named on publications—was important for their sense of community. They mentioned that it made them feel like a scientist "to publish and have my name in authorship in the ASTC proposal for Productive Struggle project and for the Structural Mindsets study for Living Lab." Although less common, three comments about communication indicated that teens felt they had not done enough science communication for it to lead to any change. One noted, "I don't think that my way of communicating about science changed at all."

Mentorship was the core program element that teens were least likely to connect to their sense of community and belonging. Mostly, when teens did make this link, they felt the mentorship helped them feel connected to the MOS and BU communities. For instance, they talked about

how meeting with the BU mentor, especially through the winter, made them feel connected. One teen explained why they felt like a scientist, explaining, "I am a scientist that has gone way up, as I said earlier, through the course of the program. At first, they weren't very high due to the lack of experience, but now all substantially higher. Maybe because we did quite a few Zoom calls with BU in the winter made it feel high." Another mentioned that their sense of belonging was associated with their career goals, and that mentorship was supporting that: "The mentorship is something I've found enjoyable because it gives me a better perspective on what a career in science might look like and sort of, who the people in that community are and what they actually do." One teen highlighted how both BU and MOS mentors made them feel "like we're part of the team that's trying to accomplish something, feeling like we're members of science community." The regularity of contact with mentors was important for one teen, who mentioned that they valued, "Talking with [mentor] every day and being involved with [their] study."

The project's efforts to foster science community were widely recognized by the teens as contributing to their sense of belonging, with teens mentioning this connection 24 times across their interviews. A main trend among these comments was that, although some teens were complementary of the project's virtual activities, being physically in the Museum contributed to their sense of belonging. One shared, "In a virtual setting you don't feel as connected," one talked about how much it helped to "work in an office and we have a desk and we know people" and another talked about how "over the course of the program [my sense of belonging] improved a lot, getting to be on site." Another reflected on how the physical proximity made them feel closer to the Museum than BU: "For the BU community, I felt more a member in the winter when [researcher] would come to our workshop sometimes and talk to us, but now it's [lower] just because we are on site [at the Museum] and BU isn't [as much]." This thinking was echoed by another teen who reflected on their connectedness with BU, suggesting ways they could feel more connected but recognizing the functionality of being primarily at the Museum:

> *We had a few meetings in the past with [researcher] who headed the lab, and they talked more about BU. Just meeting with them more [would help me feel more connected]. And way back at the beginning when COVID was still an unknown, we were talking about actually being on the BU campus. It's not necessary but would make me feel more a part of the community. I don't feel like I'm missing out much, though, because we're working on the study and the Museum is best place to do that.*

Other teens felt like the program design successfully made them feel connected to BU and the Museum because their work had them representing the organizations with physical demonstrations of their connections (badges, shirts, signs, etc.). One teen shared, "having a public image [that] I am working with the BU community reinforced that identity" and another described, "I get asked a lot if I'm a student at BU, and I say not really, I'm with the museum, but feels like I am a part of that community as well because I'm collecting data for their lab." Two teens mentioned that they felt like part of the community because they had badges. For instance, one shared, "It feels cool walking around with a badge, sometimes people ask questions because I have a badge and I know where everything is, it feels cool and feels like I am an actual employee." Being included in meetings was another trend that came up in four of the mentions of how the program supported teen's sense of belonging, which helped make teens "familiar with what is happening." In four comments, teens described how project activities made them feel less connected. Three of these related to the limits of the virtual space, as noted above. One teen described the trajectory of their relationship with BU and how it ended on a sour note because

they felt the researchers underestimated their knowledge and capabilities: "[my sense of community with BU] started low because I didn't know that community at all. It went up because we started to interact with people there, and then went down again because we were not being treated as part of that community and we were treated like we are very young." This person further explained that there was a gap between what they felt they knew and what the BU researchers thought the teens knew. Another teen talked about a similar disconnect between themself and the BU researchers, though this teen reported that they overall felt like part of the BU community. This second teen described how they had made suggestions and felt like their feedback was not taken seriously, which led to them being less interested in giving future feedback. These comments highlight ways that power dynamics between adults and youth can have impacts on young people's sense of community and illustrate the importance of active listening and transparent communication about why decisions are made, especially when they are not in line with youth input. The comments also highlight the importance of flexible pacing of the program and the ways pacing can affect community—with people for whom the material seems to be going too slowly feeling like they are being disrespected and people for whom the material is going too quickly feeling negative effects on their self-efficacy.

IV. Discussion and conclusion

This evaluation report describes outcomes for Cohort 2 of the TSRCP piloting effort. Overall, it shows that the program offered a valuable experience for the six teens who participated. 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 changes in science identities and program elements to evaluate which elements were effective in supporting the development of science identities. Fourth, we reflect on some of the similarities and differences between the two cohorts that participated in the TSRCP piloting effort. Finally, we reflect on the findings' implications for future work.

4.1 Science identities

Teens entered the program with a high interest and affinity for science, which was sustained throughout the program. Through the program's activities, teens refined their understanding of their own interests in specific aspects of and fields of science, and thoughts about what they want to do in the future. Cohort 2 was provided a highly varied program, with the youth being involved in many different projects. As a result, through the program, the teens developed a greater awareness of what goes into science research, communication, and education, and learned they were drawn to different aspects of these processes.

Teens also gained a better understanding of their own knowledge and felt that they developed greater confidence in their research, communication, and education skills. In some areas, such as data collection, teens' confidence would drop as they learned more about a topic (recognizing they had even more to learn) and then rebound or increase as they had opportunities to practice those skills. For the areas where they had less confidence, such as conducting statistical analyses, teens expressed that they felt capable of learning new skills, even if they were currently less confident in that area.

Developing research, communication, and education skills contributed to the teens feeling more like science communicators and educators than they did before the program. Being onsite at the Museum seemed particularly important to developing these identities, for both increasing and sustaining alignment with these identities. Youth attributed changes to being able to practice research, communication, and education skills, with the confident application of these skills impacting their identity. Cohort 2 also developed a greater sense of belonging in both the MOS and BU communities over the course of the program. Even while working fully remotely in the beginning of the program, teens reported substantial increases in feelings of belonging with both MOS and BU in the first few months. The summer intensive period further strengthened teens' connections to these science communities, ending the program on a high note. Interacting regularly with mentors from each institution, interacting with a variety of STEM professionals, and actively contributing to projects for both organizations contributed to these feelings of belonging.

4.2 Engagement in core program elements

Teens engaged in the core program elements through a variety of activities, recognizing how their project work could be connected to multiple elements. In general, the youth understood where the various activities fit into the program, with specific activities being more strongly or memorably associated with a particular element. Some activities, such as the workshops, were rarely mentioned by youth, whereas they called out how the work they were doing with the BU Structural Mindsets study and MOS Productive Struggle project related to all five core elements to some degree.

Teens primarily recognized opportunities to practice research skills through their varied contributions to the BU Structural Mindsets project and contributing to data collection efforts for other BU and Museum projects. Teens felt that the primary examples of practicing science communication were through their work contributing to a journal article, writing Living Laboratory caregiver handouts for the Structural Mindsets study, and presenting Productive Struggle findings to MOS staff were the. The project team's differentiation of science communication from science education skills did not seem to be meaningful or relevant for teens. Teens' perceptions of the difference between these aspects of practicing science were influenced by experiences they had prior to the program, with youth often talking about education as happening primarily through formal school experiences and associating science communication with out-of-school experiences. This led some teens to describe activities such as on-the-floor interpretations, at times, both as science education and science communication.

When describing core elements related to mentorship and community, teens talked about making interpersonal connections with MOS and BU staff, as well as feeling like they meaningfully contributed to projects. Teens had regular interactions with a primary mentor for each organization and recognized the mentorship provided by these two individuals. Teens referenced how mentors supported them in practicing and developing research, communication, and education skills. The mentors were also important for helping teens to feel connected to the MOS and BU communities. Making meaningful contributions to two major research projects also built a sense of community, and teens felt like they were doing real work. Physical cues helped teens feel particularly like they were part of the MOS community, such as having a dedicated office space, badges, and wearing the red coats (MOS front-line staff uniform). While teens indicated they felt moderately like part of the BU community and did not indicate they felt like they were missing something substantial. The lack of opportunities to be physically present on BU campus (i.e., due to constraints related to the COVID-19 pandemic) may have hampered greater feelings of belonging.

4.3 Connecting program activities to science identities

The opportunity to meaningfully engage in the "real" work of the Structural Mindsets study, the Productive Struggle project, and other Museum projects was the primary driver impacting teens' science identities. Teens were most likely to talk about their engagement in research practices as part of the program—particularly reading scientific material and doing literature reviews--as the strongest driver for their interest in science. The four other core elements were more evenly distributed as factors that contributed to interest and affinity.

Teens tended to feel that engaging in research, communication, and education practices influenced their **skills** and **confidence**. They indicated that changes in confidence were multifaceted: for some of the research skills, such as *data collection*, the program helped teens feel more confident as they were able to practice these skills; in other areas, such as *statistical analysis,* they felt less confident as they learned more about what specific research skills involved. Teens were highly self-aware about these decreases, mentioning the Dunning-Kruger effect, which they had learned about in the program. In some cases, by recognizing what they still needed to learn, teens felt like they had laid the groundwork for becoming more confident in the future. Practicing communication skills was also a driver of confidence, particularly related to activities that teens engaged with frequently from the beginning of the program, such as *summarizing and presenting literature*. Due to their experience developing these summaries, some teens felt they could become even more confident in their own writing in the future. For science education, *working on-site with the public* was particularly impactful for teens' confidence in their skills.

Intentional efforts to create community and immerse teens in the BU and MOS communities were effective in supporting teens' feelings of belonging. All the youth in this cohort started the program with high interest and intentions to pursue a scientific field as a career, and the program reinforced or refined their decisions. Engaging in research, communication, and education practices through projects made teens feel like they were doing real work and having an opportunity to try out a path they were interested in pursuing. Although teens felt that the program did a good job at making the virtual aspects of the program effective, they felt that having an in-person presence was particularly important to feeling like part of a community. The physical space (e.g., having an office space and working on the Museum floor) was particularly important, as were in-person social connections with peers and others.

4.4 Emergent Findings: Virtual programs can create foundations for building science identity, including feeling connected to a scientific community.

Two cohorts of teens participated in the piloting effort, allowing the project team to refine their approach and improve the program. The biggest differences between the two cohorts were due to the COVID-19 pandemic, which affected the teens' schedules and how they interacted with the program, and the professionals and public audiences who could be involved. First, while the pandemic shortened the intended program period for Cohort 1 (which began with a summer intensive in 2019, continued through the following school year, and was held entirely on-site until pandemic onset), it led the team to flip the overall schedule for Cohort 2 (which began with an entirely virtual experience during the academic year, followed by summer intensive on-site at the Museum).

In terms of their science interest or affinity and confidence in research skills, teens in both cohorts experienced similar outcomes. Both cohorts of students entered with and maintained high levels of interest in science, felt that the program helped them better articulate which aspects of science they liked most and least, and showed increased interest in science communication. The level of confidence teens felt in terms of their research skills remained relatively consistent across the year among both cohorts, with confidence in specific skills fluctuating as teens gained experience applying them, and teens in both cohorts felt least confident (overall) in the skill of conducting statistical analyses.

However, the two cohorts had differing impacts in terms of their confidence with science communication and education skills, as well as their sense of belonging with scientific communities. Cohort 1 teens tended to report relatively consistently high levels of confidence in education and communication skills, with confidence in specific skills fluctuating as the program's explicit focus on those skills ebbed and flowed. Overall, they shared that their confidence had decreased around writing for a scientific audience toward the end of their experience. These teens had prior experience volunteering as Museum educators and started their program with the intensive summer schedule, where they spent much of their time practicing education and communication skills with public audiences. They had just begun activities related to writing for academic audiences when the pandemic hit. Finally, for Cohort 1, the summer intensive had been especially effective in supporting a sense of community as teens worked on-site at the Museum; but when the program went virtual for a brief period, before eventually ending early, it had trouble sustaining that sense of community. In contrast, Cohort 2 teens' confidence in their communication and education skills increased consistently over time. They started the program focused on building foundational knowledge and activities that could be completed remotely, with an intensive summer of working on-site at the Museum at the end of their program. While the teens in Cohort 2 started the program with less frequent contact, they reported substantial growth in their feelings of community during this virtual period, which continued to increase throughout the course of the program. This demonstrates that engaging in the foundational work virtually was an effective strategy that supported the later, in-person activities. Although teens valued having in-person time, the program also effectively leveraged virtual technologies to contribute to their positive development of science identities. This shows that while working in-person can quickly build a sense of community among teens, thoughtfully designed virtual programming can *also* work to foster feelings of community.

4.6. Implications for future work

Data from two cohorts of teens who participated in the pilot and feasibility study provide insight into how program elements supported intended outcomes for teens and variations in program implementation illustrate ways the model could be adjusted to meet varying organizational conditions (e.g., many aspects of the program implementation were successful in both in-person and virtual formats), suggesting that the model has potential to be flexible and therefore potentially more replicable by others. While the pandemic put restrictions on how Cohort 2 experienced the program and participating virtually presented some challenges, including a lack of opportunities to gain direct experience with public audiences early on, the capstone summer intensive was successful for engaging teens in work that they felt was meaningful, with teens finding authenticity in being physically present with mentors, peers, publics, and on the Museum campus.

Additionally, this pilot and feasibility study included just two cohorts of six teens. We recognize the limitations of a small sample size but feel that the lessons learned are promising for future work. The following paragraphs summarize key questions for future iterations of TSRCP.

How can future research and practice support young people through dips in confidence to encourage their long-term involvement with STEM?

In numerous contexts, evidence demonstrates that people initially over-estimate their skills in various domains, their confidence subsequently declines when they come to understand the

complexity of that area, and they then regain confidence as they build new skills. For STEM participation, known "drop-off" points occur (such as middle school and Freshman year in college) when many young people experience a decline in confidence and decide to turn away from STEM rather than persisting through this dip until they rebound their skills and confidence. How might future work support this resilience with an identity lens? This project suggests that, rather than simply focusing on skills and self-efficacy, strengthening other parts of our framework (interest and affinity and sense of community) may buffer some of the effects of the fluctuation in confidence. Future work could build off this notion to design and study focused programming that encourages resilient STEM identities.

How can TSRCP be adapted to meet the evolving needs and practical constraints of involving youth in the work of museums and universities?

The TSRCP model was effective at positively impacting teens' science identity, whether by sustaining, refining, or building on that identity. Conducting real research and being authentically included in project teams were meaningful elements for supporting youths' science identities. However, incorporating teen collaborators while navigating research or other project timelines and priorities may be a challenge for many museum-university partnerships. Expansion or replication of the TSRCP program could adapt the year-long program through more discrete learning modules, perhaps focusing each on a specific sub-set of science skills from among the three aspects of science practice. Future work could also explore varying strategies for youth to meaningfully contribute to a study at different stages of a research project, and what level and form of contributions at each stage might best support youth's science identity formation and feelings of belonging as a valued member of the team.

How can the TSRCP model be modified to better meet the needs of youth audiences (e.g., those whose ability to participate may be transient, or who come to the program with more varied backgrounds and prior experiences), while acknowledging potentially limiting factors (e.g., availability of mentors, or competing timelines for on-going research projects)?

Challenges in replicating this model revolve primarily around time commitments (for mentors and teens), as well as research timelines. Program planning and implementation required a substantial investment of staff time to support teen experiences. Likewise, committing to the program part-time for a full year was a significant ask of teen participants. Paired with the nature of research studies, which often occur over extended periods of time, TSRCP may need to be adapted in ways that allow project teams to support more regular turnover among youth collaborators and/or that condense the period of commitment expected for each youth. Further developing and testing TSRCP as a modular program is a promising strategy, as it could support bringing youth collaborators into projects at varying points within a research trajectory, allowing teens to meaningfully contribute to whatever phase of work a research team may be at.

The collaborative mentorship approach that was piloted, which involved having primary mentors at each institution as well as engaging other staff and external collaborators as mentors for specific projects or areas of work, is promising for managing overall commitments of staff time required to support implementation, by embedding youth's experiences in the projects that staff are already working on. This approach also enabled teens to experience targeted mentorship from key staff while also feeling like authentic contributors within a larger science community.

Another area to explore in future work is replication of TSRCP outcomes with teens who have different experiences with science, more varied pre-existing levels of science capital, or lower existing self-efficacy with research, communication, or education skills. Recruiting youth with diverse backgrounds and providing equitable pay are important considerations in expanding this program. In the year-long model, teens were able to learn and practice skills across three aspects of science: research, communication, and education; this variety appears to be highly beneficial for youths' science identify formation and should be considered a key element in any future implementation of the model.

How can future programs balance youths' suggestions for improvement with practical limitations?

Teens in Cohort 2 shared suggestions to improve the TSRCP program, which ranged from devoting more time to science education and spending more time working in-person, to providing more context or background on why they were doing the specific work they were doing and allowing more opportunities for contributing throughout the entire life of a research project. In addition, the Cohort 2 implementation received conflicting feedback on one aspect: while teens most often reflected that they felt treated like authentic contributors by mentors, one participant expressed feeling like they were treated "like we are very young" and another shared they felt their suggestions related to research procedures were not taken seriously. At the group level, youth responded differently to the pacing of the program at different points in the year (reflecting their prior experience, or lack thereof, with different aspects of science); this, at points when some youth felt the program was moving too slow, other youth were suggesting a preference to slow the pace. These tensions suggest mentors should continually monitor and make adjustments to implementation plans in order to offer an appropriate level of challenge that is responsive to youth's individual and collective needs.

Some of this feedback could easily be incorporated in future iterations; some may be more challenging to address. Further, we acknowledge that it does not always make sense to act upon every suggestion that youth offer, knowing that practical limitations can be a barrier to responding to youth's desires. However, youth's reflections offer an important perspective on disciplinary culture – the culture of science itself – that could productively disrupt the norms of science research. Their concerns may reflect shifting tides on authority, autonomy, and knowledge ownership across generations – changes that must be acknowledged if we wish to welcome more diverse perspectives into scientific activities and encourage youth to pursue science careers. As the practice of science continues to evolve, any program team that works with youth on STEM topics, including the TSRCP project team in future collaborative work, should be open to listening to and responding to youth voices, committed to sharing clear rationale for decisions that impact youth who are part of our organizational communities, and reflecting on our own personal and organizational attitudes and behaviors toward science and toward young people who have chosen to engage with it.

Another consideration is about how to make future programming adaptable to different learners' needs. For instance, some teens thought the program moved too slowly—and projected this onto a sense that the adults saw them as less capable than they were. Yet, other teens in the program reported that the program seemed to move too quickly at points—which could influence a sense that their own capacities were limited. Designing programming that can flex and adapt to

students' varied needs could make participation more accessible for a broader range of youth and could strengthen youth's development of science identities.

How can future iterations of TSRCP explore the role of evaluation and measurement for science identities (interest and affinity, skills and confidence, belonging and community)?

Evaluation of the pilot program relied on rich qualitative data to support survey data at multiple points in the feasibility study. These qualitative data were valuable for understanding how teens' identity and feelings changed over the course of the program, particularly as teens shared nuanced changes in areas like interest and affinity that were not well captured through quantitative questions. However, while important for understanding nuance, this level of qualitative analysis is time consuming and resources for this level of work may not be available. Therefore, adjustments to the methods used should be explored in the future: this may include investigating additional ways to measure or track nuanced changes in science identities, identifying the most important measures for understanding science identities, or how to pair smaller samples of specific measures with specific program modules.

Engaging the youth in the evaluation of the program they are participating in may provide opportunities to support their self-reflection and research skill development, as well as provide useful information for project teams to make improvements. The interview protocol could be adapted as a youth-led focus group, where the youth collaboratively report on what they feel is effective and generate recommendations for the implementation team. Through the TSRCP pilot, participating in the evaluation seemed to provide valuable space for teens' self-reflection, particularly through the meaning map exercises and member-checking reflections on the case studies. These activities would be valuable to adapt or integrate into the programmatic offerings, regardless of whether they are used evaluatively. Surveys could be administered at regular intervals throughout the program, and youth could use their own survey data, along with documentation from the integrated program activities, to write their own case studies.

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Appendix A: TSRCP Survey

As discussed in the Methods section, teens completed four surveys while participating in the program. This included a pre-survey, two mid-surveys, and a post-survey. In general, teens were asked the same questions throughout the evaluation, with some questions only appearing on the pre and/or post survey. Notations indicate questions that were asked for specific check-in points (Pre, Mid 1, Mid 2 and/or Post). When no notation is included, the question appeared on all four surveys.

1. **[Pre]** What is your gender?
   - ☐ Female
   - ☐ Male
   - ☐ Another category: _____
   - ☐ Prefer not to say

2. **[Pre]** As of June 30, 2020, what year of high school will you have you most recently completed?
   - ☐ Freshman
   - ☐ Sophomore
   - ☐ Junior
   - ☐ Senior

3. **[Pre]** How long have you been with the Museum of Science?
   - ☐ 0-2 months
   - ☐ 2-6 months
   - ☐ 6 months-1 year
   - ☐ 1-2 years
   - ☐ More than 2 years

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

☐ Doing scientific research	☐ Being mentored by STEM professionals
☐ Doing science communication	☐ Being a part of the museum community
☐ Doing science education	☐ Being a part of the university community

5. Please indicate how much you disagree or agree with the following statements.

	Strongly Disagree (1) to Strongly Agree (9)								
	1	2	3	4	5	6	7	8	9
Scientific topics interest me.	□	□	□	□	□	□	□	□	□
I am interested in reading websites, articles, or books about scientific issues.	□	□	□	□	□	□	□	□	□
I am interested in pursuing a degree in a scientific field in college or graduate school.	□	□	□	□	□	□	□	□	□
I know a lot about science.	□	□	□	□	□	□	□	□	□
Science is relevant to my daily life.	□	□	□	□	□	□	□	□	□

6. 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	

7. **[Pre & Post]** What scientific skills do you most want to develop as a part of TSRCP? (select up to 3)

- ☐ Reading papers written by scientists
- ☐ Developing a research question
- ☐ Considering the ethics of a research study
- ☐ Collecting data
- ☐ Writing up a study for a scientific audience
- ☐ Using statistical software to visualize data
- ☐ Talking about scientific methods with the public
- ☐ Presenting and discussing my research with academic audiences
- ☐ Making sense of data
- ☐ Writing a popular press piece about a scientific topic
- ☐ Evaluating the strengths and weaknesses of scientific arguments
- ☐ Evaluating the effectiveness of science communication
- ☐ Connecting research to museum practice and design
- ☐ Iterating on the research questions and methods of prior research studies
- ☐ Conducting statistical analyses
- ☐ Other (please describe)

8. How confident are you in your ability to do the following science research skills?

	Not confident at all (1) to Extremely confident (9)								
	1	2	3	4	5	6	7	8	9
Reading papers written by scientists	□	□	□	□	□	□	□	□	□
Considering the ethics of a research study	□	□	□	□	□	□	□	□	□
Iterating on the research questions and methods of prior research studies	□	□	□	□	□	□	□	□	□
Developing a research question	□	□	□	□	□	□	□	□	□
Using statistical software to visualize data	□	□	□	□	□	□	□	□	□
Collecting data	□	□	□	□	□	□	□	□	□
Conducting statistical analyses	□	□	□	□	□	□	□	□	□
Making sense of data	□	□	□	□	□	□	□	□	□
Other: _____	□	□	□	□	□	□	□	□	□

9. How confident are you in your ability to do the following science education and science communication skills?

	Not confident at all (1) to Extremely confident (9)								
	1	2	3	4	5	6	7	8	9
Evaluating the strengths and weaknesses of scientific arguments	□	□	□	□	□	□	□	□	□
Writing up a study for a scientific audience	□	□	□	□	□	□	□	□	□
Talking about scientific methods with the public	□	□	□	□	□	□	□	□	□
Presenting and discussing my research with academic audiences	□	□	□	□	□	□	□	□	□
Connecting research to museum practice and design	□	□	□	□	□	□	□	□	□
Writing a popular press piece about a scientific topic	□	□	□	□	□	□	□	□	□
Evaluating the effectiveness of science communication	□	□	□	□	□	□	□	□	□
Other: _____	□	□	□	□	□	□	□	□	□

10. Please indicate how much you disagree or agree with the following statements.

	Strongly Disagree (1) to Strongly Agree (9)								
	1	2	3	4	5	6	7	8	9
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	□	□	□	□	□	□	□	□	□

11. **[Pre & Post]** Please indicate how much you disagree or agree with the following statements.

	Strongly Disagree (1) to Strongly Agree (9)								
	1	2	3	4	5	6	7	8	9
I have experience working with children in professional and/or educational contexts.	□	□	□	□	□	□	□	□	□
I am familiar with psychology or psychology research.	□	□	□	□	□	□	□	□	□
I would like to have a job that uses science.	□	□	□	□	□	□	□	□	□
People who are like me, work in science.	□	□	□	□	□	□	□	□	□
My parent(s)/guardian(s) know a lot about science.	□	□	□	□	□	□	□	□	□

12. **[Pre & Post]** How often do you do the following things?

	Rarely or never	Occasionally (a few times a year)	Sometimes (once per month)	Regularly (once per week)	Always (every day or every other day)
Watch science programs (e.g. TV program, YouTube clips, science documentaries)	□	□	□	□	□
Read books, blogs or articles (print or digital) about science	□	□	□	□	□
Participate in online science activities (e.g. play science games, create or share science social media posts)	□	□	□	□	□
Go to a science center, science museum, zoo, aquarium or planetarium (as a visitor, NOT to work)	□	□	□	□	□
Do experiments or use science kits (e.g. growing crystals, chemistry set, microscope)	□	□	□	□	□
Program computers (e.g. writing apps, building websites)	□	□	□	□	□

Appendix B: TSRCP Interview

As discussed in the Methods section, teens completed four interviews while participating in the program. These occurred after each survey and included a pre-interview, two mid-interviews, and a post-interview. The interview followed a similar structure at each check-in point, organized by topic areas, with some grammatical differences so that wording made sense at the time of each check-in (e.g. what are most interesting vs. what were most interesting). Some questions were only asked on some of the check-in points, while other questions were asked on all four interviews. Rather than presenting the four overlapping interviews separately, they have been merged together to limit redundancy. The bracketed notes at the beginning of each question indicates whether they were on all interviews, or some combination of interviews (Pre, Mid 1, Mid 2, or Post).

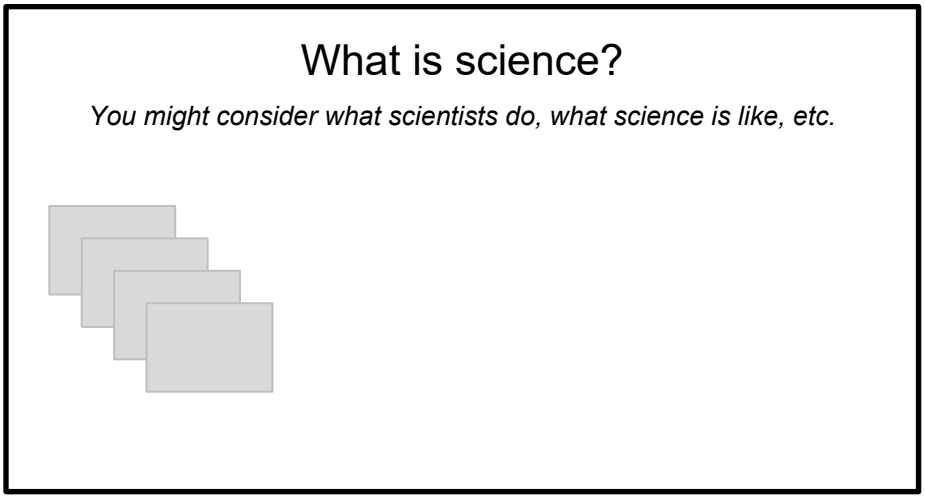
Meaning Mapping

1. **[Pre]** To start off today, we're going to do a meaning mapping activity. We used to do this on paper but now we'll do it online. So I'm going to put a link in the chat if you can just click on that:

   Ok, so you saw these meaning maps at the orientation. This is the one I showed during the orientation just to give an example, but it can look however you want. We have some text boxes on the left side if you want to type into those and move them around, but you can make other shapes and lines and text boxes or copy in pictures – whatever you like.

   I'll give you about four 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.

2. **[Pre]** Ok, it's been four minutes so we can stop. Now you can go ahead to the next slide. This time, you'll take four minutes to **describe science**. Ready? Ok, go ahead.



3. **[Pre]** Ok, time is up. Thanks for doing that. **How, if at all, do you think the two maps relate to one another?**

1. **[Post]** At the beginning of the program we talked about who you are in relationship to science, and now we'd like to circle back to that. This is going to feel a little different from past interviews because we're not just going to ask you questions but we'd like to analyze some of your data together and talk about what it tells us.

   So to start off, I'm going to show you the meaning maps you made at the beginning of the program. Here's your map for you. Looking at it now, what would you change to reflect where you are now?

2. **[Post]** Here's your map for science. What would you change to this map to reflect your current understandings of science?

3. **[Post]** How would you describe the relationships, if any, between these revised maps?

Introduction Questions

4. **[Pre]** What has science been like for you in your classroom education to date?

5. **[Pre]** 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?

6. **[Pre]** What types of science-related things have you done outside of classrooms, if any?

7. **[Pre]** What have you found particularly interesting or disinteresting about those out-of-school science experiences?
    a. Do other people think you're good at science outside of the classroom? Why do you think so?
    b. You said on your survey [the participant agreed highly on the statement, "My parent(s)/guardian(s) know a lot about science."] that your parent/guardian knew a lot about science. Could you explain that?

Interest

8. **[Pre]** When you talk to a friend or family member, what do you tell them about TSRCP?

9. **[Pre]** On the most recent survey that you completed, you said [in response to the question, "Which aspects of TSRCP are most interesting to you?"] that ["Doing scientific research, Being mentored by STEM professionals", "Being a part of the Museum of Science community"] were the most interesting aspects of the program for you. Can you tell me what you find interesting about them?

    [Mid 1] On the most recent survey that you completed, you said that [response to the question, "Which aspects of TSRCP are most interesting to you?"] were the most interesting aspects of the program for you. Can you tell me what you find interesting about them?

10. **[Mid 1]** In the past you said that [response in first interview/first survey to, "Which aspects of TSRCP are most interesting to you?"] were the most interesting aspects--why might that have changed/stayed in the same?
    a. Probe: Is there anything surprising about this?

11. **[Pre & Mid 1]** On your survey you said you tend to feel [responses to the question, "When I think about science, I tend to feel…"] when you do science. Why do you feel that way?

12. **[Mid 2 & Post]** Now we're going to do some member-checking about how your interests, confidence, and sense of community may have changed over time. On this slide [show slide with graph], we have your survey responses about how interested you are in various topics from the beginning of the year, the winter, the beginning of the summer, and now. Looking at these data and drawing on your own perceptions, how would you describe your interests in science topics over the course of this program?
    a. Probe about anything notable, if anything is surprising, what about the program contributed to those changes, etc.

Self-efficacy

13. **[Pre & Mid 1]** On your survey, you said that you were [most confident] in [highly rated responses in the question, "How confident are you in your ability to do the following science research skills?"]. Why did you give that rating?

14. **[Pre & Mid 1]** You said you were [least confident] in [lowly rated responses in the question, "How confident are you in your ability to do the following science research skills?"]. Could you explain why you felt that way?

15. **[Mid 1]** On your first survey this fall, you said that you were [more/less] confident in [responses that indicated change "How confident are you in your ability to do the following science research skills?"] Can you talk about why things might have changed or stayed the same?
    a. Probe: Is there anything surprising about this?

16. **[Mid 2 & Post]** Now here's some of your survey data about your confidence in different skills over time. How would you describe your confidence over the course of the program?
    a. Probe about anything notable; if anything is surprising, what about the program contributed to those changes, etc.

Belonging and Recognition

17. **[Pre & Mid 1]** On your survey you indicated [level of agreement] that you were a ["scientist", "science educator", and "science communicator"]. Could you describe your identity in relation to science, science education, and science communication?

18. **[Pre]** On your survey you [level of agreement] that you would like to have a job that uses science. What, if any, are your plans for after high school?

19. **[Mid 1]** On your first survey this Fall, in the question, you [level of agreement] that you [are, are not] a [scientist, science educator, and science communicator]. Can you talk about why things might have changed or stayed the same?
    a. Probe: Is there anything surprising about this?

20. **[Mid 2 & Post]** Alright and our last slide here is data about your sense of belonging in scientific communities. How would you describe your sense of belonging in these groups over time?
    a. Probe about anything notable, if anything is surprising, what about the program contributed to those changes, etc.

Evaluation

21. **[Pre]** In future interviews if you choose to participate, we will ask questions about how the program is going. We know things just started, but so far, how would you say things are going?

22. **[Mid 1, Mid 2, & Post]** How are things going with the program?

The core elements of the program are:

- Research practices
- Science communication practices
- Science education practices
- Mentorship from STEM professionals
- Become a member of a science community

23. **[Mid 2 & Post]** What, if anything, have you done in the program so far that has involved
    a. Research practices

    b. Science communication practices

    c. Science education practices

    d. Mentorship from STEM professionals

    e. Becoming a member of a science community

24. **[Mid 1, Mid 2, & Post]** Which of these do you think the program [is doing/did] the best? Why?

25. **[Mid 1, Mid 2, & Post]** Which ones could we be doing better? Why?

26. **[Mid 1, Mid 2, & Post]** How could the program do a better job with these core elements?

27. **[All]** What, if anything, could the program change at this point to make it more valuable for [you/future teens]?

28. **[Mid 2 & Post]** Alright. Earlier we talked about your feedback about the program, but now we'd love your insights about how we could improve the evaluation for next year. What suggestions do you have about how we could improve the evaluation?
    a. Probe: We did meaning maps, interviews, surveys, some observations, and we reviewed materials you created as part of the program. Which of those methods do you think best reflected your experiences? Why?

Debrief

29. **[Post]** Ok, so all of these questions are trying to get at the bigger construct of science identities. We focused on your interests, skills and confidence, and relationships. When you think about those three areas, do any feel more or less important to your sense of who you are in relationship to science?

30. **[Post]** When you think about your science identities more broadly, what might be missing when we focus on interests, skills and confidence, and relationships?

31. **[Post]** Is there anything else you'd like to say about how you would describe your science identities over the course of this program?

32. **[Post]** So we've talked about your science identities over the last year. How, if at all, do you think the TSRCP program contributed to those identities?

33. **[Post]** What else might have contributed to those identities?

Conclusion

34. **[Pre & Mid 1]** Is there anything else you'd like to ask or share?

35. **[Mid 2 & Post]** Do you have any other comments or questions about the program and/or how it could be improved?

Appendix C: Case studies

The research team wrote a detailed case study for each of the six teens in Cohort 2. Each narrative combined that teen's surveys and interviews, exploring the overall experience they had with TSRCP and the impacts of the program on the individual. Four teens reviewed their narrative as a member check during which time they talked about additional impacts of the program; two were unavailable to participate. The following six case studies provide an in-depth look at each teen's experience over the course of the program, highlighting both growth and change where applicable.

Participant 1 Case Study

The program helped Participant 1 gain confidence in research, education, and communication skills. They left the program seeing themself more as a science educator and communicator than at the beginning of the program, and now consider "museums" an aspect of their identity.

At the beginning of the program, Participant 1 primarily identified as an artist because they liked to draw and create things through drawing and coding. Being a student and being collaborative were also important pieces of Participant 1's identity. They said, "collaborative is a huge part for my school, since I've realized how helpful it is, I try to be even more collaborative." Participant 1 also identified with the biomedical field "because that's the main field I'm interested in right now," and described themself as "curious," "motivated," and "ambitious." They also added, "I also put mixed race, but also like how I get the best of both worlds, also bilingual." Looking to their future, Participant 1 shared, "[I have] no idea what I want to be when I grow up, I just know I'm interested in a biomedical field, biotechnology, something in that area. Also I like business I guess, how these companies do research and develop either treatments or things. I'll probably try to major in something biology related. Maybe business and technology."

Prior to joining the program, Participant 1 had been attending a STEM school where "they really prioritize science." Participant 1 had taken classes in biology, chemistry, earth science, and physics. Additionally, as part of school they were required to work on a science fair project. Participant 1 noted "they offered a lot of [science] opportunities" and "they allow us to explore a lot of things." Overall, they described science in school as "really interesting" although "sometimes it is tedious to memorize some of the things in science." Aside from school, Participant 1 had also done extracurricular STEM activities about anatomy, physiology, neuroscience, and computer science. They were drawn to the out-of-school programs' project-based approach, stating, "when you're working on a project you learn more because [you are] putting knowledge to use."

These experiences led Participant 1 to have a positive view of science at the beginning of the program. In describing their meaning map for science, Participant 1 shared that it is, "Fascinating because lots of things are still unknown, lots to learn about." Drawing a connection to their own identity, they shared, "[science is] collaborative because, in order to progress and make new inventions, it is way better to work together." Participant 1 described science as "innovative," "creative," "broad because [there are] lots of fields: chemistry, biology, astronomy," and "beneficial to [do] work about and solve problems, think of research and inventions." They also mentioned being "not afraid to take risks because a lot of times it's looking into unknown things" and "inclusive," further describing, "people can do science from all ages, there's science fairs for

kids in high school, then for people with way more expertise as well." In talking about connections between their own identity and science, Participant 1 identified how they put "collaborative" on both maps and noted that "I'm very interested in the science field." On their survey, they strongly agreed that they were a scientist but were less sure about science communication and education, saying, "I've never taught someone specifically about science."

When we met with Participant 1 in the winter, several months after starting the program, their interests in science remained strong. They described science research saying it is like being "on the frontiers and discovering things is meaningful, which relates to proud, you could help other people." As in their pre-survey, the parts of the program that were most interesting to Participant 1 in the winter were doing research, being a part of the Museum community, and being mentored by STEM professionals. Reflecting on this consistency, Participant 1 shared, "I gave the same answers but it's not that surprising. My interests haven't changed that much. Maybe I've expanded my interests but the same things that drew me [to the program] are still relevant now."

In terms of skills and self-efficacy, Participant 1 shared how the research skill they were most confident with in the winter was reading papers written by scientists. They shared, "We have to do a lot of that and [the mentors] gave a lot of resources about how to do that" but overall, they said they thought their confidence in reading was primarily because of a project at school where they summarized 25 research articles. Although they were less confident in considering research ethics than reading, this was an area Participant 1 felt the program had helped them improve. They said, "We're thinking through a fake study and what we would do in setting it up. I've definitely become more confident, but also back to humble, I realize how many aspects there are." Doing statistics was an area that Participant 1 wanted to grow in: "I've realized I need to work on that."

With regards to community and belonging, Participant 1 indicated on their winter survey that they had come to see themself more as a science educator, communicator, and member of both the MOS and BU communities, but that they still did not fully see themself in those roles. This had to do with defining these roles in professional terms. Participant 1 shared that a scientist was "anyone in a STEM field" and an educator was "more of a teacher role." Although Participant 1's sense of self as a scientist did not change from fall to spring, it was the identity that they rated most highly, rating themself as a 7 out of 9.

In the spring, Participant 1's interest remained strong except for a dip in interest in reading. They shared that the program "solidifies that my interest, that I want to go into a science field, and solidifies how I see that it is relevant in daily life." However, they did note "I've been reading so many [things about science] recently I'm a bit sick of [reading]." In terms of confidence, by spring Participant 1 felt their skills were increasing. Whereas at the beginning of the program they had said, "I wouldn't say I'm super confident in [research skills] but I am interested and hopefully getting better," by the winter, they said, "I think I have definitely gained more confidence…having more experience and practice with that has increased my confidence." They added that it was "not as intimidating as I thought." Yet, as in the winter, they also saw room for continued growth in statistics. They shared, "I'm still not able to do it independently, but being able to see examples and see that helps."

Participant 1's sense of self as a science educator, communicator, and member of science communities continued to rise in the spring, as well. Whereas their sense of self as a scientist remained steady at a 7 out of 9, in the spring Participant 1 rated themself higher as a science

communicator (9 of 9), science educator, and member of the Museum community (both 8 of 9). They shared, "Definitely now that we are on site and communicating and seeing people, [I] definitely feel more of a science communicator" and "[I'm] definitely part of the museum community. When we put on the red coats is pretty cool—you look like you have authority in the Museum and are a part of the Museum with the other interpreters." Although their sense of self in relation to the BU community was lower than the others (5 of 9), Participant 1 spoke positively about it, saying, "It's a smaller community but we're a group and we're just focusing on one study…everyone in that group is excited about it and that makes it a community." They added that they, "Don't know how much involved we're supposed to be…don't feel like I'm missing out much, because we're working on the study and the Museum is the best place to do that." After reviewing this case study, Participant 1 clarified that they understood that they were not visiting the BU campus because of COVID, and that they "associated a feeling of connected with the community being physically connected." They also felt that they "didn't feel like it mattered at much that [they were] not as connected with BU" in that way.

By the end of the program, Participant 1 was appreciative of their involvement in the program and having "experiences that you wouldn't normally have in high school." Looking back at their initial meaning maps, they had nothing to change about their definitions of science and they felt that the things that mattered to them at the beginning of the program—like creativity, collaboration, curiosity, motivation, ambition, and being mixed race and bilingual—were still major parts of who they were. Drawing connections between science and self, Participant 1 shared, "I think of myself as an artist, and in science you have to be creative. A lot of research articles we read were really interesting or creative studies." One thing that had changed was that they had shifted their career goals; no longer interested in the biomedical field, Participant 1 now wanted to pursue computer science. Additionally, Participant 1 said they wanted to add something to their map: museums. They shared, "Museums, always liked that and mattered to me. [I] want to continue here so I might add that here."

Participant 1's interests in science remained high throughout the program, with every item on our survey at its highest point at the end of the year (9 out of 9). They shared, "It's pretty consistent. I knew before that I wanted to go into science or a STEM field and I still am." Confidence and skills showed increases or sustained confidence at the end of the year as well, except for statistics, which showed a decrease in confidence toward the end of the programing, from a 6 at the beginning of the summer to a 4 at the end of the program. They shared, "We learned a lot more about research" and felt they had learned about many topics, "everything besides statistical software, because we're still collecting data." Doing these things helped Participant 1 gain confidence, and they shared, "[I'm] definitely feeling more confident being involved in piloting or conducting a study." With regards to science communication and education, they shared, "[I] have grown, because every day [I was] interacting with a lot of people. Interpreting, even with COVES [visitor exit survey], learning how to share information and talk to anyone."

At the end of the program, Participant 1 felt more like a scientist, science educator, science communicator, and member of the BU and MOS communities than they had at the beginning of the program. Whereas their identity as a scientist remained relatively consistent throughout the program (they rated themself a 7 of 9 in the fall, winter, and spring; and an 8 at the end of the program), others showed greater rises. They rated themself as a 3 for science educator and science communicator at the beginning of the year and an 8 by the end. As was the case throughout the program, at the end Participant 1 felt less connected to BU than the other

identities, but did not see this as a problem. They said they felt "close to" the BU mentor and knew "a couple other people" but the fact that they never went to BU made them feel less connected to the University as a whole. Reflecting on the program overall, Participant 1 said the program "definitely gave me more research skills and communication skills, and becoming part of the MOS community was helpful to see behind the sciences and I liked seeing there are people of all sorts of backgrounds – I consider them all scientists."

During a check-in approximately eight months after the end of the program, Participant 1 reflected on the ways that the program affected their science identity. Participating helped them refine their interests in science, because "it helped me discover what I want to pursue now and what I don't want to pursue; [I] realized how tedious some of the research things are, don't like the stats part, but I'm fine with script writing" and this helped them think about where they fit into STEM. In addition to what they revealed during the evaluation, they added that the program helped increase their confidence in research skills because "practice makes you more familiar with it." They also talked about other skills that they developed through the program that might not necessarily be "science skills." Scheduling, for example, might not be a "science skill" but can be "applied everywhere," including for science work. They also added that just participating in the program strengthened their sense of belonging in scientific communities by giving them something concrete to reference in their day-to-day life, and being able to talk about working at the Museum or the research they were working on.

Participant 2 Case Study

The program helped Participant 2 build confidence in research skills, helped them see science research as more collaborative, and expanded their sense of belonging in scientific communities. Participant 2 entered the program feeling like a member of the MOS community and was able to build a broader professional network through program activities.

Participant 2 had previously volunteered and done an internship with the Museum. They had heard about TSRCP from the Cohort 1 participants, which had made them excited about the opportunity to do their own research as part of the program. At the beginning of the year, Participant 2 described themself as having two cultures, being bilingual, and being involved in activities such as sports and a religious community since about age 5 or 6. They talked about loving learning in general, hobbies like sewing and playing the ukulele, but also learning in school. They said, "I'm very science-centered. I really enjoy Biology, Chemistry, also Psych and also the Humanities, ethics studies, studying Greek or Roman history. I am just, like, very curious about a ton of different things." In their initial meaning map, they also reflected on their prior experiences at the Museum and shared, "I would identify myself as being a part of the MOS community...that's a big portion of myself as well."

Participant 2 also had numerous other experiences with science prior to joining the program. In school, they had gone on field trips and done lab work that they described as, "interesting and engaging and gives insight into science today more than reading textbooks and listening to lectures." Participant 2 had also taken "a couple" college science courses, did an engineering and science fair, and taught "quite a bit of science" including serving as a helper in elementary school classes and teaching a biology course for middle school students.

At the beginning of the program, based on these experiences, Participant 2 thought about science as an "interdisciplinary subject" that "involves a ton of different skills." They described science as "flexible and changing." and saw it as, "a way to help people, make our lives easier, give perspective on the world. Helps us live and understand what's around us. Personally, it's an insight into why things happen in your life." They also saw a tension in science between flexibility and structure. On one hand, they shared, "I imagine science as a playground, to experiment, play, and learn things. It requires creativity to test hypotheses, have crazy ideas to make progress and expand your knowledge." On the other hand, they mentioned, "It's also very structured. It's strict and critical in its methods." Ultimately, when Participant 2 joined the program they said, "I personally love learning new things, which is what science is all about." However, they did not see themself as a scientist because they saw a scientist was someone who was employed full time in the field. They said, "I wouldn't say I was a scientist because I haven't made it a career or I don't work full time in it." However, they did identify as a science educator and communicator, even though they had not been formally employed in those areas, because they had prior experience at the Museum: "I would say that I was able to communicate with other people about science. I was able to sort of learn about science and be educated about it and educate others."

After several months of participating in the program, Participant 2's interest in science remained high. The program activities seemed effective in building interest, as Participant 2 noted that they were most interested in scientific research, which they felt was "the focus of what we've been doing." Participant 2 reflected on how they had started the program thinking science communication was more interesting, but as they engaged with science research, that aspect

became more interesting than communication. They said, “Earlier I was interested in science communication but over time the focus has shifted to research so that's why that changed. Since October we’ve had more interactions with BU researchers and hearing more about their work.” The interest was strong enough that Participant 2 noted they shared about it with others: “My overall feelings [about science] are just very positive. Just doing this work is making me more appreciative of science in general and the efforts that you take into account when doing research. The more I’m involved, the more I’m more excited to share with other people. I talk about my work a lot with my friends. Some of the things we learn and discover are really interesting and I want to pass that along.”

While participating in research was making the research more interesting, it also made Participant 2 less confident in a number of research skills. They were aware of this trend and reflected, “The more we talked about the kinds of things that go into developing a research question, the less confident I was about it. I forget the name of the phenomenon, but the less you know, the more confident you are. That happened over the course of this period.” These decreases in confidence were strongest around developing a research question (they rated their confidence as a 9 out of 9 in the fall and a 4 in the winter), conducting statistical analyses (6 in fall, 3 in winter), and connecting research to museum practice and design (also a 6 in the fall and a 3 in the winter). Although Participant 2 was cognizant of their initial overconfidence and adjustment in research skills, they also indicated that, for some science communication and education, being involved in project activities tended to increase their confidence. Notable increases were around writing up a study for a scientific audience (which rose from a 3 to a 7), evaluating the strengths and weaknesses of scientific arguments (which grew from a 5 to an 8), evaluating the effectiveness of science communication (which moved from 4 to 7).

In the winter, Participant 2 felt their sense of belonging with science communities and science identity was tied to their sense of confidence. When they were describing their identity, they felt their connection to science communication and education “stayed around the same,” which matched their survey responses. While their survey indicated a slight increase in identifying as a scientist, in describing their data they shared, “Wow, there’s a lot I still don’t know or I haven’t known before so that made me less confident in being a researcher.” Participant 2 felt most strongly connected to the MOS community, which they ranked as a 9 out of 9. Although their connection with BU was lower, it increased between fall and winter (from 2 to 3), and they shared that mentorship from BU was the highlight of the program to date, saying, “For the most part we’ve been getting a lot of, I guess lessons from [BU mentor] and talking to [another researcher] and I think that is kind of like the majority of what’s going on during our shifts is hearing what’s important in their research and different aspects of that study.”

At the end of the school year, Participant 2’s family situation dictated that they participate remotely while the other participants were transitioning to being in-person. Participant 2 was grateful for the program’s flexibility to accommodate their circumstances and found that, “Even not being there in person, I was able to do a lot and feel like I am a part of the program and still doing things.” As in the winter, Participant 2’s interests in science remained high and their confidence in scientific skills fluctuated. They reported that their confidence collecting data, developing a research question, using statistical software, and connecting research to museum practice and design all grew over the course of the spring. On the other hand, their confidence declined in reading papers written by scientists, considering the ethics of a research study, making sense of data, conducting statistical analyses, writing for both scientific and popular

press audiences, and presenting and discussing research with academic audiences. Describing these changes, Participant 2 demonstrated nuanced understanding of how trajectories of comfort with these skills are all different. For instance, in the case of data collection and research planning, Participant 2 felt that doing these skills made them more confident: "as we have learned more about research and putting those into practice more, that has helped raise a couple things in terms of confidence." Yet with writing, practice had made Participant 2 less confident: "I think that as we had more opportunities to write things, that decreased my confidence because we are actually doing it, talking about it is easier said than done. Had a little more confidence in talking about how it's done but actually doing it is more difficult." In terms of overall sense of belonging in scientific communities, Participant 2's survey data showed slight declines as compared to the winter, but in reflecting on the data, Participant 2 felt the changes were not strongly felt trends: "Looking at this data is weird, I thought I would be more connected, I feel more connected to science communities."

At the end of the program, Participant 2 reviewed the meaning maps they made at the beginning and overall they thought the maps still reflected who they were. They still felt that science was a part of who they are, noting, "[I] probably said this in the beginning, but I think science is a part of who I am as a person, especially towards the MOS side." Thinking about their concept of science overall, Participant 2 felt they had come to see science as more collaborative. Looking at their meaning map about science, Participant 2 shared, "I would add another box saying how for each individual scientist there is a very minimal contribution, a small portion that as a whole, collectively, helps expand whatever field or study that they are part of. Also needs to be a lot of communication between different people, and collaboration."

Participant 2's interest in science continued to be strong through the end of the program, and they noted that they were able to better articulate specific aspects of science that were particularly interesting or less interesting. They felt the program had helped them build interest in cognitive science and child development, the topics they focused on in TSRCP. Looking at their survey data over time, they shared, "I would say [my interest] was kept pretty constant, I think that really depends on which science topic it is. I think I've grown in interest more in cognitive science and child development, but overall don't think there was much change in science topics in general." Aside from interest in scientific fields, Participant 2 found the program influenced their interest in certain scientific topics. In this case, more exposure was not necessarily indicative of increased interest. They noted, "We did a lot of reading articles and different websites, had to do a little research about guest speakers and illuminating AI, I'm kind of burnt out from reading a lot."

Between spring and summer, Participant 2 reported strong increases in confidence for almost all of the project's focal research skills and more modest changes (both increases and decreases) for the project's education and communication skills. For example, after rating their confidence in making sense of data as a 1 at the end of the school year, this rose to a 7 at the end of the summer and considering the ethics of a research study rose from a 3 to an 8 in this period. They shared, that they thought overall their research skills "increased in general" and, with regards to ethics and making sense of data, "I had to consider what is really happening more in depth that helped me gaining confidence in these areas." The only research skill where Participant 2's confidence did not increase was collecting data, which remained at an 8 for both the spring and summer surveys. They noted, "[we] have only being doing that fairly recently to do that in practice." For skills in science education and communication, presenting and discussing research with

academic audiences rose from 3 (in the spring) to 6 (at the end of the summer). All other education and communication skills stayed the same or fluctuated up or down by one point. They thought overall, “For science communication, I feel like it stayed the same, but education was a bit decreased.” Reflecting further on this, Participant 2 shared how their definitions of education and communication had shifted over the course of the program. They said, “I considered education like lectures and talking about science in a formal setting like in schools, and I’ve considered that, nowadays I extend that to interpretations and interacting with the public. Used to think the interpretations part of science communication, but now communication is talking to other researchers and in the museum about what you are doing.” Thus, Participant 2’s prior experiences in formal education had influenced their initial confidence in what they considered science education skills. Through the program they developed a broader definition of science education to include informal aspects, as practiced in the museum setting, which made Participant 2 feel somewhat less comfortable in their abilities ("I’m finding it more difficult than I used to”).

Overall, Participant 2 found that the program effectively connected them to scientific communities. Although their affinity with the MOS was particularly strong throughout the year, they felt their network of scientific communities grew over the course of the year. Participant 2 noted, “I think [my sense of community] extends beyond the Museum at this point, I made a lot more relationships with other people that would extend beyond the museum but would be a part of science.” Their connection to the Museum expanded, as well. Participant 2 shared, “It definitely helped in feeling like I’m a member of scientific communities, being connected through the museum, through BU, through the research and evaluation department, and with other researchers as a whole through the ASTC conference. That has helped sense of community. Research too, actually [being] able to conduct some research.” At the beginning of the program, Participant 2 identified very strongly as a member of the MOS community (9 of 9), strongly as a science educator and communicator (8 of 9), and less strongly as a scientist (4 of 9) and member of the BU community (2 of 9). By the end of the year, there was less differentiation between these identities. They remained a 9 of 9 as a member of the MOS community, and now their connection to the BU community rose to a 6. Their connection to being a scientist also rose to a 5, while their sense of self as a science educator and communicator dropped to a 6. Ultimately, Participant 2 valued the program and found that it helped them articulate what aspects of science were most interesting to them, built confidence in research skills, and helped them see themself more as a scientist and member of multiple scientific communities.

Participant 2 did not have many thoughts to add to their case study when reflecting eight months after the program ended, feeling that what they initially reported well represented their experience. They did note that the experiences in the program, particularly those around research skills, were beneficial to what they were currently doing in college. Particularly, the program "helped me have a better frame of reference for things I encountered [in college classes].”

Participant 3 Case Study

Participant 3 came into the program with a strong interest in science and psychology. Although the program actually turned them off to psychology research, it helped them realize their interests and build their skills in science education and communication.

When Participant 3 began the program, they described themself first by their academic interests in molecular biology and bioengineering, noting that they would major in these fields with a minor in psychology ("My ideal career would be to be a professor in either Molecular Biology or Bio Engineering. Two fold. I love to teach and doing research"). They described loving learning and working with kids as well as being a dancer. Participant 3 thought science was "everything," sharing, "Anything that you look at through a scientific angle, anything is science." They added that they saw science as a mindset and they thought they had that mindset, saying, "I'm inquisitive, I like to understand how the world works, understand these things." This approach helped them see science in their other interests, as well: "The way I go through life, things like dance that aren't a science, but thinking of it in the right way, understanding what you can do, asking questions, becomes the physics of how you turn, it all meshes together." Participant 3 had pursued numerous other informal science opportunities prior to the program, including a bioengineering program, a neuroscience program, and a program at Harvard Medical School.

Participant 3 had clearly articulated interests and disinterests in science from the beginning of the program. While they were strongly drawn to the process and mindset of science, saying "I really like anything with a critical thinking aspect, inquisitiveness, being able to think of a question, but also use your head to find a solution and think further." On the other hand, they also shared that they "could not care less about the topic" of geology and that they did not like the busy work they had experienced in middle school science class. However, they said "every little thing lines up perfectly" in biology. Participant 3 was particularly drawn to the program because of their interest in research. Despite having pursued numerous informal science opportunities previously, they found that these were mostly learning *about* science rather than *doing* research.

At the beginning of the program, Participant 3's confidence was very high in research skills and somewhat more moderate in science education and communication skills. For example, they rated their confidence in making sense of data and collecting data as 9 of 9, and conducting statistical analyses and developing research questions as 8 out of 9. In contrast, Participant 3 rated their confidence in writing up a study for a scientific audience as a 4, presenting and discussing research with academic audiences as a 5, and talking about scientific methods with the public as a 6.

In terms of belonging, at the beginning of the program Participant 3 felt they were a scientist but did not feel strongly connected to the scientific community. On their survey they rated themself an 8 of 9 for being a scientist, saying "That's anyone who wants to think that way. It's almost just a choice, if you choose to think that way." They rated themself a 6 for science education, noting "I have some amount of experience, just from tutoring other students." For science communication, Participant 3 shared, "I haven't done it and I can't say I am something that I've never done before," rating themself a 2 of 9. Participant 3 also felt disconnected from MOS and BU, rating their sense of belonging in these communities as a 3 and 1, respectively.

In the winter, Participant 3's interests in science remained high, with all survey ratings about interest staying the same, at either an 8 or 9 out of 9. They reported that the aspects of the

program that were most interesting were doing scientific research ("I want to be a researcher when I'm older so that's always been an interest of mine"), being a part of the BU community ("not a lot of high schoolers get to say they've been part of research at a university"), and science communication ("We got to make a presentation slide. That was fun").

Looking at confidence, Participant 3's exposure to research skills led to a decline in confidence in some areas, whereas they gained confidence in science education and communication as they practiced those skills. Participant 3's remained confident in the research skills of making sense of data, considering the ethics of a research study, and developing a research question (9 of 9) and they gained confidence in iterating on the research questions and methods of prior studies (rising from 6 in the fall to 8 in the winter). They noted that the program had a strong influence on this confidence, saying, "I think I mostly gave high ratings when it's something we've done a lot in this program, more than school, it's when I've done it several times in the program I understand how to do it." However, Participant 3 became less confident in conducting statistical analyses (dipping slightly from 8 to 7), collecting data (dropping from 9 to 5) and using statistical software to visualize data (going from 7 to 3). They felt that this was because the program exposed them to what these skills meant in more detail, sharing, "I took a stats class last year so on paper I understand but there's a difference in an application and I learned the difference [in the program]." Whereas Participant 3 had been less confident in many of their science communication and education skills in the fall, by winter they rated every one as an 8 or 9 out of 9. They described, "We worked on it and learned how to do it in the program."

In the winter, Participant 3 felt more connected to the MOS and BU communities and saw themself more as a science communicator. Their sense of connection to MOS rose from a 2 to a 7, connection to BU rose from a 1 to a 5, and their connection to science communication rose from a 1 to a 7. Participant 3's sense of self as a scientist remained high, as an 8 of 8. However, Participant 3 noted that their definition of science education changed to be more Museum-focused, leaving them feeling less of a sense of self as an educator. They shared, "I used to tutor in Bio so I used to think that counted." In contrast, in the winter they were "thinking of [education] in terms of this program."

When we connected with Participant 3 at the end of the spring, their interests in science had changed little. Although there were some minor fluctuations in the survey data, in the interview Participant 3 shared, "[My interests] Pretty much stayed the same...it isn't that anything truly changed overall but how I was interpreting the question and the aspect of the question at that time." They added, though, that their overall interest was staying high, saying, "For interest in pursuing a degree, [it] would relate high all the way through."

Participant 3's sense of confidence in the spring showed a rebounding in research skills and remained high for science education and communication. They demonstrated an awareness of their likely overconfidence in research skills at the beginning of the program, saying, "[The survey data are] a good example of the effect of you don't know enough to know you don't know, [my initial ratings] should probably have been down at the beginning, [but I] didn't know what I didn't know." They continued by sharing how opportunities to use these skills during the program were contributing to their rising confidence: "Practicing skills and being exposed to them makes me be more confident in them." With this rising confidence, all of Participant 3's ratings of confidence for research, education, and communication skills were an 8 or 9 out of 9 except making sense of data, which was a 6 of 9.

Participant 3's sense of belonging was also very high in the spring, with a particular rise in their sense of self as a science educator (which rose from a 3 in the winter to an 8 in the spring). This corresponded with the teens being able to start coming on site to lead educational activities in the Museum for the first time in the spring. Participant 3's sense of self as a scientist, science communicator, and member of the MOS community remained high (either 8 or 9), similar to the winter.

At the end of the program, we asked Participant 3 to look back at their meaning maps from the beginning of the year. In general, they thought the maps were still representative of who they were. They thought they had learned more about the scientific process, noting "I might add to each of those about it [science] has to be done in a controlled way that can be replicated" but, similar to their initial interview, they repeated, "Science is everything, as long as you did it right" and "I see myself as a science-y person...science is relevant to who I am and how I see the world." One change was that the program had made Participant 3's interest in psychology decline. They shared, "Psychology went away. I'm not interested in that anymore."

Participant 3's interests in science remained high through to the end of the program. Their survey ratings fluctuated slightly but their overall impression was that they "stayed very interested in the whole thing" although they "might have narrowed down what aspects of science interested me." Expanding on their declining interest in psychology, Participant 3 described, "This program had a lot of focus in psychology, which I thought I really liked but over the course of the program realized was not for me – it wasn't bad, just not for me...not something I would want to do for a career." They noted that the Structural Mindsets study was really the turning point that showed them Psychology was not the direction they wanted to head professionally.

By the end of the program, Participant 3's confidence in science education and communication remained very high whereas confidence in research skills was more mixed. On the final survey, they rated all education and communication skills as an 8 or 9 of 9, even these were the skills that Participant 3 had been least confident with at the beginning of the program. They shared that they "liked every part" of the education and communication and that "Just doing that gained a lot of confidence." They also felt the program's mentorship supported this growth, saying, "The program definitely contributed to all of the changes on here, [mentor] was a really good mentor for these and did a good job showing us how, and watching [them] do it and then us doing it, listening to [them] was a really good way to gain confidence." For the scientific research skills, Participant 3's survey responses declined slightly for most skills, but they shared, "Overall, in my head I think it went up." They reflected on ethics, describing how they had thought something was unethical, but it passed IRB, and that this had shaken their confidence. For the other skills, though, they felt that their confidence went along with how recently they had been doing a certain skill; that the confidence did not necessarily last but that it rose when it was fresh. This was particularly the case with statistics, which dropped on the survey from an 8 to a 4.

Participant 3 ended the year feeling very strongly connected to the Museum (9 of 9 on the survey), having a sense of self as a scientist (6 of 9), educator (8 of 9), and communicator (7 of 9), but not feeling connected to BU (1 of 9). This marks a sharp rise in connection to the Museum, education, and science communication as compared to the beginning of the program. It seems that Participant 3's sense that the research-based part of the program and the BU mentorship were too slow paced contributed to them distancing themself from psychology and BU as well as a slight decline in their sense of self as a scientist overall. Summing things up,

they shared, “My sense of belonging in most communities grew a lot...everyone except BU went up. As I touched on, it didn’t seem like we were a part of their community.”

After reading their case study, Participant 3 had some additional comments about their science identity while reflecting on their time in the program. They reiterated that the program was helpful to refine their interest in science, specifically realizing that psychology was “not for me” but that other aspects of science were. Thinking about research-related skills, they “got better at everything” but realized how much they did not know through the program. They described how this changed over the course of the program, saying “[in the] fall I had falsely high confidence, but no ability. . .. [in the] winter confidence went down and ability went up, then in the Spring confidence went up and ability went up.” Finally, in reflecting on their sense of belonging in scientific communities, being paid and recognized as staff was important to feeling like a scientist. As they explained, “having tangible proof of it, yeah I feel like a scientist but have a paycheck that shows, you can’t doubt it, because it’s a more formalized version of being a scientist.” Also, small things like having a staff badge (rather than “intern”) and being in staff spaces made them feel like part of the community.

Participant 4 Case Study

Participant 4 began the program with an interest in psychology and an intent to study psychiatry in college. Being a part of the program helped them solidify their interest and build research skills.

At the beginning of the program, Participant 4 described themself as "not religious, but interested in spirituality," explaining that they came from a varied religious background and were "interested in reading about it." They also identified as a teacher and mentor, sharing a variety of ways they tutor, mentor, and otherwise teach others both in and out of school. Part of their identity included being an athlete, sharing that they "play competitive tennis, jiu-jitsu, and boxing" and are a coach and teacher for the sports they are involved in. They identified as a student, noting that they hadn't "really made it to real student land – college," and were looking forward to getting more into psychology. They also shared that they were a musician and had been "playing piano their whole life." Relationships with their family and friends were a notable part of their meaning map, sharing that they were "supportive to [their] friends" and their "little brother is [their] best friend." They also shared that they were part of a single parent household and that their dad passed away years ago. They identified as Asian-American, as their mom had immigrated from China, and felt that this was an important aspect of their identity.

In talking about science, Participant 4 felt that was a broad umbrella, and that they do not always get excited about it because they are interested in some disciplines, such as psychology, biology, and "life-related things," and not in others like physics. They also described different areas of science as seeming like it has "two different sides," described both as "the stuff you can't see... and stuff that's big and actually related to [their] life" and as "personal, impersonal." Another way they described science was in term of research, saying it was "original thought," and felt like scientists "just come up with questions out of the blue." This perception informed their feeling that research is intimidating, because although they were interested in research they "just had no practice" and "wouldn't know where to start." Participant 4 talked about how science could be "hard to grasp but when you do it's very rewarding," and explained that based on their experiences in science classes and reading articles. In reflecting on the two maps, there were things about science they liked but did not see it as part of their identity.

Prior to the program, Participant 4 primarily had experiences with science through school and occasionally doing science-related activities outside of school. They have found classroom science "just really stressful" learning from textbooks, and notes that they find videos, lab experiments, and lectures interesting. In particular "when teachers are excited about something, you can kind of feel it and excitement transfers." Outside of school they have interacted in a variety of science-related activities, including "reading books about bio and psych, watching videos, going to the occasional science competition, more multiple-choice stuff, more quiz show things, I made a trebuchet once for a science fair." They also enjoy reading about science when they can choose the topics they are interested in or learning about real world applications of physics or psychology.

At the beginning of the program, Participant 4 indicated on their survey that they were very interested in science topics, reading about scientific issues, and pursing a degree in a scientific field (9 out of 9 for all three areas). Through their initial interview, they shared nuance around the specific scientific topics that interested them, they enjoyed learning about psychology and biology, but were generally less interested in physics. They also brought up the differences they

saw in these topic areas when reflecting on their meaning maps. While their survey responses throughout the program remained consistently high, Participant 4 shared in their spring interview that their interest went up as they had "been exposed to more science topics, realized a lot [they] don't know but a lot [they] want to get involved in." At the end of the program, they indicated on the survey that they were a little less interested in reading about science, but overall they felt that their interest in science topics had stayed constant.

Thinking about what the program might entail, they shared that they were most interested in the aspects that they didn't have as much experience in, specifically doing scientific research. Over the course of the program they continued to be interested in research practices, as they explained "because there's so much I don't know and when I get to university I'm going to have to do a lot of that" and that they wanted to be prepared.

Initially, Participant 4 shared on the survey that they were not very confident in most aspects of research, communication, or education. In the first interview, they shared that "most of the things on the list I didn't get what it was." Overall they indicated increased confidence over the course of the program, the rate of which varied by area. In some areas they were not confident at the beginning, such as using statistical software or writing up a study for scientific or general audiences (all rated as 1 out of 9). For working with statistical software, they explained that they were not familiar at all with the software, but by the end of the summer they were a little familiar with using R and Excel (rating that as 4 out of 9). For writing up research, they worried about how long it took them to write and get their thoughts out. By the winter they were a little more confident in writing a popular press piece (4 out of 9), explaining "we did insert work for the living lab for a minute in the winter" but that their confidence dropped a little in the spring (3 out of 4) because they were not doing that kind of writing anymore. In the summer they were more confident with writing up a study for a scientific audience (4 out of 9), but "wish[ed] we did more writing."

For a couple areas, Participant 4 indicated dramatic increase in their confidence. In particular, they started the program not at all confident in their ability to develop a research question (1 out of 9). They explained that this was due to their "concern about coming up with new ideas." During the program, their confidence steadily increased, and as they explained when reflecting on their survey answers at the end of the school year, "[I] had zero confidence and was nervous in the beginning, didn't know how to pull something out of thin air to be interesting and we worked [on those skills] over the winter and in the spring." At the end of the program, they were surprised by how highly they rated their confidence in this area (8 out of 9), but then reflected that although "we didn't develop a question, we used other peoples' questions" but they now "know where to start, find something that inspires you from a past paper." Likewise, they started the program feeling not at all confident in presenting and discussing research with academic audiences (1 out of 9), but by the end of the program feeling very confident. At the end of the program, they attributed this confidence to working on the Structural Mindsets project, including learning how to explain the work during the consent process. For some aspects of research, Participant 4 started the program feeling moderately confident in their abilities. As they explained during their first interview, these were practices that were similar to what they had done in psychology class, such as considering the ethics of a study (7 out of 9), reading papers written by scientists (6 out of 9), and iterating on questions and methods or prior studies (6 out of 9). During the winter check-in, these continued to be the areas that they were most confident in, citing prior experiences in school. By summer they were more confident in more of these areas,

and attributed this growth to specific program elements. For reading papers written by scientists they were more confident at the end of the summer (8 out of 9). Teens attributed this growth to the literature review for the Museum's Imagination project, along with reading for the Museum's project on artificial intelligence (Exploring AI) and BU's Structural Mindsets study as the reasons for their growth. Their confidence in considering the ethics of a research study "went up and down, [because] the more you know the less you know." Their rating went down to 6 before moving up to 8 out of 9, "fall I thought I was better and in winter [mentor] picked us apart, but now we can tell or debate whether something is ethical or not."

Overall, at the beginning of the program, Participant 4 had a very minimal sense of belonging in terms of being a scientist, science educator, or science communicator (all 2 out of 9). This was due to their lack of experience, they were not a scientist "haven't done research yet except just learn about it, that's why I'd like to be, but I'm not yet." Similarly, they did not feel like a science communicator or educator because they "don't really teach science either or tell anyone about it, I just kind of learn about it." They continued to indicate that they did not feel like a scientist, saying the program "try to make us feel like that, but I feel like I'm just getting started and I couldn't call myself a scientist until I'm older and do my own research." However, from their experiences doing interpretations at the Museum, they felt more like a science communicator by the end of the program (5 out of 9).

Participant 4 had little connection to either the MOS or BU community at the beginning of the program. By the winter check-in, a few months into the program, their sense of belonging notably increased for both communities and feelings of belonging continued to grow throughout the program. For MOS they increased their rating from a 2 to a 7 (out of 9) and talked about how they were "integrated a lot with the Museum" and even though they were working remotely, it was "helping [them] connect to what's going on." By summer, they strongly felt like they were part of the MOS community (9 out of 9), saying that "everyone [was] very welcoming, [and] being in the office and working on the same projects with all of you was nice." For BU they went from a 1 to a 6 (out of 9) by winter, and hinted at some of the work they were doing with [BU mentor], though did not go into detail. In the spring they reflected that they "felt more a member in the winter when [lab director] would come to our workshop sometimes and talk to us, but now it's just because we are on site and BU isn't, but [BU mentor] still makes us feel part of the community and we are part of the project."

When reflecting on their meaning map at the end of the program, Participant 4 felt their map was still mostly the same but would add "researcher" and that "science is more relevant to [their] life now." They refined their description of science, saying that they would now describe it as "very precise and specific" and would "get rid of broad" as a descriptor because while there are many fields in science "whatever field you are in you have to narrow it down something specific." They felt there was not much connection between their personal map and their science map, as they said "it's something I like to do and think about but it's not who I am."

Participant 4 was unavailable to meet to review their case study and reflect on the program.

Participant 5 Case Study

Participant 5 started the program feeling they had the potential to be a scientist and left feeling like they were a scientist. Through the program, they developed their research, communication, and education skills, while also recognizing there was a lot more to learn for some skills.

When reflecting on their meaning map at the beginning of the program, Participant 5 first described themself as an athlete. They explained that they enjoy how they feel when they engage in physical activities such as wrestling, jiu-jitsu, MMA, and working out. Another example was hiking, which bridges being an athlete and their love of nature, sharing that they had done "some 5-day section hikes of the Appalachian Trail." They also talked about the way they interact with others, saying they were a "go with the flow type of person" who was empathetic as they "try to understand people and really see their side of things and sympathize with them." Their values also include volunteerism, as "every interaction you have with society should be voluntary." In terms of their future, Participant 5 said that they were planning to pursue an engineering degree in college, like their parents and grandparents.

Participant 5 primarily described science as the "process of figuring out the truth so we know definitively" and understanding "how things work and discovering what's unknown." By the end of the program, they reflected that their initial description focused on "a more physical explanation of it" and that they would add "attempting to define and explain things that are intangible." They described a connection with their personal meaning map to their definition of science, as "my definition of science comes down to how I am as a person". By approaching science as a process, it reflects their personal values of empathy and helping others. As they explain, "what it comes down to is why do we have science is there's a problem to be solved through logic and thinking, putting great minds to work and solving problems."

In-school experiences with science were described by Participate 5 as "stale" and "dull", expressing a desire to learn how it is applied. They had pursued science outside of school in a few ways, by immersing themself in nature, watching documentaries, and by fixing things. One anecdote they shared described how they fixed their Airsoft gun with their dad's help, explaining that it was important to know the science of "how these connections work and how I can take this piece of lithium and get it to turn a motor which compresses a piston that creates a puff of air."

At the beginning of the program, Participant 5 indicated on their survey that they were already very interested in science (9 out of 9), as well as learning about science on their own and pursuing a degree in a scientific field (both 8 out of 9). When they were reflecting on their survey responses at the end of the school year in the spring, Participant 5 noted that although their ratings fluctuated they felt the same about being interested in science and reading about science, whereas they were now more interested in pursuing a STEM related degree after getting to conduct research. By the end of the program, they rated their interest in scientific topics and reading about science lower (8 and 7 out of 9, respectively), and their interest in pursuing a scientific degree higher (9 out of 9). However, in reflecting on these survey responses Participant 5 explained during the interview that they felt that their interest in all three areas had either increased or stayed the same, noting that "being able to really dig deep into different topics as a result of the work I have been doing has piqued my interest in a lot of things."

Participant 5 indicated on the initial survey that the program elements they were most interested in were doing scientific research, doing science education, and being mentored by STEM professionals. However, they noted in their interview that they thought all the elements were interesting and they were "disappointed to just have to choose three." They also tied these three areas to previous experiences with science, like that they had learned a lot about engineering from their parents and grandparents and they learn "from people who know what they're talking about."

Over the course of the program, Participant 5's confidence in research, communication, and education skills fluctuated. In the beginning, they were least confident in writing up a study (3 out of 9) and writing a popular press piece about a scientific topic (4 out of 9), as they overall felt like writing was their weakest skill. By end of the program, they felt more confident (both 6 out of 9), noting after the winter check-in that those were areas they had done a lot of work with and their mentor "said we were pretty successful with those." Other areas where they indicated growth included critically thinking about research, such as reading papers written by scientists (going from 6 to 8 out of 9), considering the ethics of a research papers (going from 6 to 8 out of 9), and evaluating the strengths and weaknesses of scientific arguments (going from 5 to 7 out of 9). When reflecting on their survey responses, Participant 5 generally broadly attributed increases in confidence to the program and getting opportunities to practice these skills.

Participant 5 indicated a couple areas where they decreased in confidence, specifically using statistical software and conducting statistical analyses (both going from 6 to 4 out of 9). They attributed the decrease to a phenomenon they had learned about during the program, saying "in general my confidence has gone up, but also had the Dunning-Kruger [effect], I've learned what really goes on so my confidence would have gone down because a lot more to this than I thought." They also reflected broadly on how their responses fluctuated in some areas, noting that some early increases in confidence followed by later decreases were "probably because we did [it] shallow[ly] and then dived deep, or out of practice with it."

Over the course of the program, Participant 5 indicated the most change in their feelings of belonging. At the beginning they disagreed that they were a science educator (2 out of 9), scientist (3 out of 9), or science communicator (4 out of 9). However, they emphasized they did not feel like any of these identities "yet!" As they went on to explain, "this is the first deep dive into those subjects that I've been able to do. My experience in those areas, comparing to people who do stuff like that, is minimal." By the winter check-in, Participant 5 was feeling most like a science communicator, and feeling like a science educator and a scientist increased steadily throughout the program. The progression seemed to reflect what they were doing at the time. By the end, Participant 5 strongly agreed that they were a scientist (9 out of 9), a science educator (8 out of 9), and a science communicator (8 out of 9). In addition to agreeing on the survey, during the final check-in they also added "scientist" to their meaning map, explaining that they had heard repeatedly through the program "if you are doing science that makes you a scientist."

For Participant 5, feeling like they were part of either the MOS or BU community largely fluctuated based on how often they were interacting or working with either group, saying "every day versus just sometimes, when [it was] everyday would become closer." They started the program somewhat feeling like part of the MOS community (5 out of 9), and initially increased because they "got more comfortable with the people [they]'ve worked with." By the winter check-in, they strongly agreed that they were part of the MOS community, which stayed highly

rated for the duration of the program (8 out of 9). Participant 5's feeling of belonging fluctuated more with BU. At the beginning they didn't feel very connected to BU (2 out of 9) but, by the winter check-in, strongly agreed that they were part of the BU community (8 out of 9). This continued to fluctuate, feeling less connected in the spring (4 out of 9) and more connected in the summer (6 out of 9). Reflecting on their survey responses, Participant 5 explained the fluctuations in feeling like part of the BU community were "probably just from interacting fairly often to not much at all in the spring, and back to fairly often in the summer."

Participant 5 started and ended the program with high interest in science, while other aspects of their science identity reflected more changes. They had gone from seeing themself as someone who could be a scientist, to seeing themself as a scientist. Opportunities to practice skills made them more confident in writing about science, as well as thinking critically about research. Participant 5 attributed many of the changes in their science identity to the program. As they explained, "[TSRCP] contributed to every single change there was. I don't think anything outside of this program contributed it to it much or at all. My relationship with science in school and stuff has generally been the same, I think it was entirely this program."

Participant 5 did not respond to requests to meet and review their case study.

Participant 6 Case Study

Participant 6 entered the program with existing interest in science and psychology specifically, having pursued these topics both in and out of school. Through the program they were able to build on previous experiences and skills, ultimately refining their understanding of themself in relation to science and a science-focused career. This participant built professional relationships with mentors that are ongoing at the time of this report.

Participant 6 started describing their meaning map by talking about how the example was identity focused and how that prompted them to include the things they care about. They talked about identifying as queer, went on to describe themself as a student, and shared that they were passionate about things like social justice issues. They also shared their interests, including research, public speaking through debate and mock trails, writing, and sci-fi/fantasy. Another aspect they shared was that they had ADHD and how "that affects how I do a lot of work." Across their reflection on their meaning map, Participant 6 related various aspects of their identity back to how they care about social justice issues. In particular, that "research can contribute to [social justice] causes, reveal more detail about them" and debate and mock trial "informs what I know about social justice."

Shifting to how they described science, Participant 6 approached it from multiple perspectives. They saw science as something that was big, broad, and varied, but also described it as "fundamental" because "there's aspects of science that underlie basically everything." Science was something that they felt could be a concept, or tool, or knowledge in a specific area, and that the outcomes can vary based on how other people see it. For example, they explained that science as a concept "could lead to people abusing it or manipulating findings or methods in order to have it do what they want." They also talked about how "there's a lot of different voices, different theories for everything, there's always ideas, people challenging [those ideas]." In addition to talking about how people use or see science, Participant 6 also saw science as something "robotic," because "a lot of fields have really high standards" and that doing extensive studies is needed for research to be meaningful. At the end of the program, they refined their view of science. They talked about how they learned that there was "a lot of variety and internal politics in how you represent that and how you communicate it with people" and that "science is a very big thing and it's not the subject called science or the profession called scientists . . . it's a lot of different areas and subtypes."

Previous experiences with science in school were mixed for Participant 6. Some experiences left them feeling lost, either due to lack of interest or teachers that did not work for them. Through science fair projects, which they both enjoyed and had embarrassing experiences with, they realized that they liked talking about science more than doing research. Participant 6 also had some more positive experiences with science in school, around psychology, understanding ecological systems, and macro-biology systems. They felt that their out-of-school experiences with science were more limited, and that they had not "done a lot of very structured science things outside of school." Some of their experiences included Audubon camps, particularly enjoying swamp explorations, researching science topics for writing science fiction, or self-guided reading.

Initially, Participant 6 felt that the most interesting aspects of the program were doing scientific research, being mentored by STEM professionals, and being part of the MOS community. For research, they were most interested in learning "about things that other people might not already

know, contributing to what everyone knows." They were also interested as they had considering it as a career and "makes it feel more real and possible and lets me know, basically what I decided to get into, which is exciting." Similarly, with their intent to pursue a psychology degree, they were interested in the mentorship aspect of the program. Participant 6 explained it as an "opportunity to meet STEM professionals and learn what they do and how they do it might be a better way to understand something I might want to do." And being part of the MOS community was an exciting aspect because, while they had enjoyed the Museum when they were younger, prior to the program they "didn't really see MOS as something that catered to me at this point in my life."

These continued to be areas of the program that Participant 6 found interesting. During the winter, they felt that being part of the MOS community was "very exciting because it's a very different context for participation in science than the educational contexts I'm used to." They also felt that being mentored was interesting and enjoyable as "it gives me a better perspective on what a career in science might look like and sort of, who the people in that community are and what they actually do." These aspects supported a path towards a career in science that they were already interested in, giving them an opportunity to learn more about the field and what their place in it might be.

Participant 6 was already highly interested in science (8 out of 9), reading about science (8 out of 9), and pursuing a degree in a scientific field (7 out of 9). In the spring, they noted that they were already interested in science, but that "this program did reinforce my interest in pursuing psychology and confidence that is a subject I can understand and enjoy learning about." In the end, while their ratings only slightly increased, now rating reading about science and pursuing a degree in a scientific field as a 9 out of 9. Their interview at the end of the program revealed that the program "reinforce[d] my interest in pursuing psychology and confidence that is a subject I can understand and enjoy learning about." They also felt that the "number of different topics that interest me have broadened."

Participant 6 started the program most confident in considering the ethics of a research study, iterating on research questions, and developing a research question (all 8 out of 9). These were areas they had previous experience with, through school or science fairs. In particular they had covered research ethics in AP Psychology and covering that in one of the first workshops reinforced what they already knew, and "seeing how they overlapped conceptually made it easy to understand." Their ratings in these areas fluctuated a little on the survey, and they pointed out during their winter interview that they felt the Dunning-Kruger effect applied, explaining "I know more about iterating and questions and methods and that's making me realize I didn't come into the program knowing as much as I thought I did. I still have a lot to learn to meet the levels of confidence that I started out with." In the end, they rated their confidence as the same they had in the beginning.

Initially they felt less confident in reading papers by scientists (6 out of 9), saying that "most of the time I feel [research papers] need more attention and experience than I am able to bring at certain points." By the winter this was an area they were more confident in (up to 8 out of 9), and they felt that work they had done in the program reinforced some of the skills they started the program with, so they were "more equipped to apply that at a broader level." Participant 6 also started the program feeling that they were moderately confident in conducting statistical analysis (6 out of 9), but by summer felt more confident in interpreting those analyses, rating their

confidence in conducting analyses lower (4 out of 9) and saying they felt capable of learning statistical analysis but recognized that they had a lot more to learn.

Education and communication skills were areas that they started out fairly confident in (6 or 7 out of 9 for all), becoming even more confident by the end of the program (8 or 9 out of 9 for all). This included skills like evaluating others' research, writing or presenting about science, and connecting research to practice. While they did not reflect on these skills individually, they talked in the interview about how getting to practice skills in the program supported their increased confidence. As they reflected on their survey responses in the spring, they explained that "as a general trend I feel a lot more confident in these areas now that we are in person and have had a chance to practice those, to see how that functions in the museum environment." Additionally, they shared that working on piloting with Museums visitors "has really affected my confidence and enjoyment in skills like that."

Initially, Participant 6 moderately agreed they were a scientist (5 out of 9), a science educator (4 out of 9), or science communicator (6 out of 9). They explained during the interview "I feel like I know how to be a scientist, [its] not my job at the moment, not on the same level of people who do it professionally and have degrees." And when talking about feeling like a science educator or communicator, they felt some confidence in their abilities but also were aware of their weaknesses. For example, in talking about science communication, they explained that "in some circumstances I'm good, but not as adaptable as I would like to be." By winter they already strongly agreed that they were a scientist (8 of 9), which remained steady through the rest of the program. Some of the experiences that contributed to feeling like a scientist included "getting to publish and have my name in authorship in the ASTC proposal for Productive Struggle" as well as "getting to participate in data collection." And by the spring they felt like a science educator and a science communicator (both 9 out of 9). Participating in the program had an impact on their feeling of belonging, reinforcing their previous experiences they had in science.

Over the course of the program, Participant 6 felt more strongly that they were part of the MOS and BU communities. By participating in Museum projects and BU Structural Mindsets study, they felt more connected to these two communities. In the fall they felt fairly connected to the Museum (7 out of 9), which increased to feeling strongly connected by the spring (9 out of 9). Once they were on-site (rather than participating virtually) that "increased dramatically." They shared elements that made them feel connected to the Museum, such as "getting to be on site and working with different groups on different projects and getting to represent the museum in certain activities and events, and participating in museum-wide meetings and programs." Participant 6 started with less of a connection to BU (4 out of 9 in the fall), and they noted early on that they felt that the program emphasized being integrated into the MOS community. However, by the winter and through the rest of the program, they definitely felt like part of the BU community (9 out of 9). In the summer they shared being part of the Structural Mindsets study and participating in data collection made them feel like they were doing "actual projects."

When reflecting at the end of the program, Participant 6 shared that they would not change anything on their identity meaning map but could better see how their identity existed in the context of their environment and in science. In addition to learning about science education and communication, they shared that they had also learned about working in an office and building skills (like working with Excel) related to that. Overall, after the program they had "a clearer

relationship between myself and my understanding of science and a professional environment and contributing to the field."

After reading their case study, Participant 6 thought it was interesting to see how their experience was described. They noted both at the end of the program and reflecting eight months later, that they felt that they were overconfident at the beginning, and later recognized what they did not know. Participant 6 also felt that their interest, confidence, and sense of belonging were intertwined, and that growth in one area ultimately impacted growth in another area. In addition to the areas discussed in the case study above, Participant 6 gained confidence in their ability to speak up, ask questions, and be part of the conversation in research settings. The area they felt the program had the most impact was in their sense of belonging in scientific communities. Through the connections and experience they built in the program, Participant 6 has been able to continue working on related research in college. While participating in the program, they "felt like part of decision-making processes" and that experience in turn made them "feel more qualified to engage with other opportunities in a more professional context."