Space and Earth Informal STEM Education (SEISE) Professional Learning Community Summative Evaluation

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NISE NATIONAL INFORMAL STEM EDUCATION NETWORK

March 2024

Professionals attending the 2022 NISE Network Earth & Space Project Based Professional Learning Community April Convening. (Screenshot by Catherine McCarthy)

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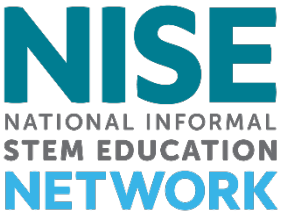

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Space and Earth Informal STEM Education Project

Summative Evaluations Executive Summary

NISE NATIONAL INFORMAL STEM EDUCATION NETWORK

The NISE Network Space and Earth Informal STEM Education (SEISE) project was funded through the National Aeronautics and Space Administration (NASA)'s Science Mission Directorate (SMD) Science Activation program.

The National Informal STEM Education Network (NISE Network) is a community of informal educators and scientists dedicated to supporting learning about science, technology, engineering, and math (STEM) across the United States. Over 500 NISE Network partner organizations participated in the SEISE project between 2015 and 2023.

Evaluating the impact of the project

Evaluations were focused on understanding the overall impacts of the SEISE project on professionals' Earth and space work, as well as the impacts of SEISE products on the public's interest, engagement, relevance, understanding of SMD content areas (Earth science, heliophysics, planetary science, astrophysics) and their societal implications. More information about the five summative evaluation studies and the methods they employed can be found in the accompanying reports on:

nisenet.org/evaluation/summative-evaluation-reports↗

Project Deliverables

For the Public

Explore Science: Earth & Space toolkits

included engaging, hands-on Earth and space science experiences with connections to science, technology, and society.

To learn more: https://www.nisenet.org/earthspacekit↗

Sun, Earth, Universe exhibition

offered activities, games, and graphics that allowed visitors to engage in fun interactive Earth and space science experiences, while using skills essential to STEM learning.

To learn more: https://www.nisenet.org/sunearthuniverse↗

Mission Future: Arizona 2045 exhibition

provided an immersive experience integrating authentic Earth and space science, imaginative storytelling, and hands-on activities to explore what Arizona might be like in the year 2045.

To learn more: https://www.nisenet.org/mission-future-exhibition↗

For Professionals

Professional development

included 66 Online Workshops, an in-person Earth & Space Partner Meeting, as well as training resources and materials to help professionals engage the public.

To learn more: https://nisenet.org/pd↗

Professional learning community

was a cohort of professionals from 99 informal education organizations, who met monthly to learn about and work together towards making Earth and space science more relevant and inclusive for their communities.

To learn more: https://www.nisenet.org/earthspaceprojects2021↗

Space and Earth Informal STEM Education Project

2021-2022 Professional Impacts Evaluation
Earth & Space Project-Based Professional Learning Community

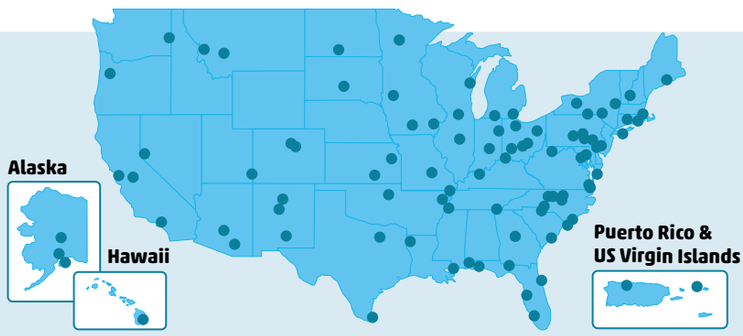
NISE NATIONAL INFORMAL STEM EDUCATION NETWORK

The Earth & Space Project-Based Professional Learning Community (PLC) met online monthly to learn and work together on local projects to make Earth and space science more relevant and inclusive for groups who are underserved or under-represented in STEM. The program culminated in a virtual convening where members presented their project work. The professional impacts evaluation was focused on PLC members' use and understanding of practices for engaging diverse public audiences in Earth and space science. This summary highlights the main findings from surveys and interviews.

Program reach

164 professionals

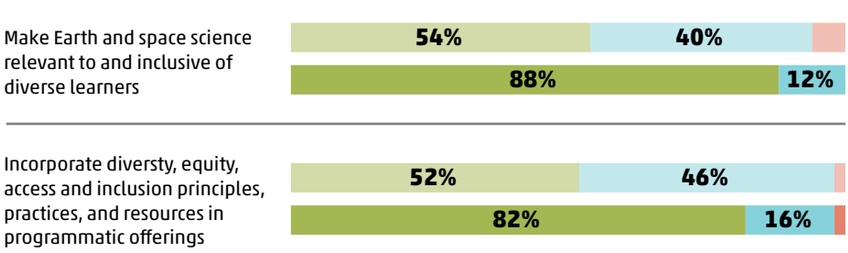
99 informal education organizations



Practices and partnerships to broaden participation

PLC members reported being significantly more confident using diversity, equity, access, and inclusion (DEAI) practices to engage audiences in Earth and space science after participating in the PLC. Through the program, they were also able to explore and implement partnership-related practices.

As part of my Earth and space science education efforts, I feel confident in my ability to...



> *"[The PLC] has given me tools to help me make better connections with our partner and more inclusive language to use in our communications.*
>
> *– a professional*

Value of interactive community

PLC members highly valued the interactive community aspects of the program, particularly being able to interact and learn from each other.

How valuable were the following aspects of the professional learning community?

Learning about the work my peers are doing	**92%**	**(very useful)**
Meet professionals outside my organization	**89%**	**(very useful)**
Receiving feedback from my peers	**88%**	**(very useful)**

> *"I think that the most valuable thing about participating in the PLC was the opportunity to network with other professionals and learn about their projects. All of the feedback and discussion I think strengthened each person's project and, at least for me personally, helped to spark some ideas for the future."*
>
> *- a professional*

Citation: Anderson, A., Atwood, A., Harvey-Justiniano, S., & Kollmann, E. K. (2024). *Space and Earth Informal STEM Education (SEISE) professional learning community summative evaluation.* Boston, MA: Museum of Science, Boston for the NISE Network.

To learn more about the PLC: https://www.nisenet.org/earthspaceprojects2021↗

1. Introduction

1.1 Project overview

The National Informal STEM Education Network (NISE Network) is a community of informal educators and scientists who are dedicated to supporting learning about science, technology, engineering, and math (STEM) across the United States, based out of Arizona State University. Through a variety of independent projects, the NISE Network aims to build the capacity of informal science education institutions and research organizations to work together to raise public awareness, understanding, and engagement with current topics in STEM. Starting in 2015, the Space and Earth Informal STEM Education (SEISE) project was awarded funding from the National Aeronautics and Space Administration (NASA) to create educational products and support informal educators' professional development in engaging the public with Earth and space content (through cooperative agreements NNX16AC67A and 80NSSC18M0061).

During the first five years of the project, the SEISE project created numerous public-facing materials and professional development opportunities.[1] In 2021, the project was awarded additional funding to extend and enrich professional development opportunities offered by the Network. The second stage of funding (SEISE 2.0) supported a project-based professional learning community and online workshops that leveraged materials created in the first five years of the project. During this period the project also created a pilot exhibition, *Mission Future: Arizona 2024,* the evaluation for which is documented separately (Anderson et al., 2024).

In SEISE 2.0, the project focused on the Earth & Space Project-Based Professional Learning Community (PLC), as well as developing supporting guides and resources that would be useful for the entire Network. This report covers the summative evaluation for the PLC, focusing on professionals who were a part of that experience ("PLC members"). While not the focus of this evaluation, partners involved in the PLC and broader Network had access to additional resources through the NISE Network website (www.nisenet.org), such as online workshops, a monthly newsletter, professional development guides, that are included for context. They also had access to previously developed professional development resources that were created to support professionals' work with the pubic and their use of the public facing materials created during SEISE 1.0, such as the *Explore Science: Earth & Space* toolkits and *Sun, Earth, Universe* exhibition. Section 0 highlights some of these additional materials.

[1] Prior evaluation work has been documented in: King, Velázquez, & Robertson (2019), King, Velázquez, & Robertson (2020), and Beyer, Anderson, & Kollmann (2021). Reports can be found here: www.nisenet.org/catalog/SEISE-summative-evaluation-reports-2021

1.2 Earth & Space Project-Based Professional Learning Community (PLC)

1.2.1 PLC member description

Professionals from 99 NISE Network partner organizations were selected through a competitive award process.[2] Applicants were required to be employed at an eligible partner organization, defined as having received at least one *Explore Science: Earth and Space* toolkit (2017-2020), being located in the United States (including territories and freely associated states), and being a public informal science outreach or education institution (e.g., science museum, planetarium, NASA visitor center, etc.). Each organization had a primary contact and could include one additional colleague or project partner) in the PLC. Ultimately, 146 professionals participated in the PLC, representing a variety of roles such as educators, program managers, program coordinators, and directors. Additional details about the PLC can be found on the NISE Network website: www.nisenet.org/earthspaceprojects2021.

1.2.2 PLC member projects

As part of the application, professionals proposed a project to make Earth and space science more relevant and inclusive for their communities that they could make meaningful progress on over the course of the PLC. Projects that would broaden the organization's involvement in Earth and space science were given priority, these could either incorporate meaningful change into existing programs or build new, ongoing programs. Applicants were not required to incorporate NISE Network toolkits or exhibitions but were encouraged to make use of those and their supporting resources. Each organization received a $2,000 stipend towards costs associated with their project, such as staff time, educational materials, promotional materials, transportation, or honoraria. Example project summaries included:

- "Adapting our Earth & Space Science content to make it accessible, engaging, and relevant to preschool students (ages 3-6)."
- "Integrate and adapt NISE Net kits to enable presentation of heliophysics and astrophysics to blind/visually impaired and other underserved audiences."
- "Use NISE Net Earth and Space resources to expand our partnerships with local university researchers [and] train the researchers on science communication and work with them to develop demonstrations involving their own research."
- "Deliver an All About the Moon program. Using the NISE kits, students will learn about phases of the [Moon], eclipses, gravity/gravitational pull, space, and planets that can been seen with the naked eye."
- "The focus of our project will be to share the cultural heritage and natural history of the regions we serve by exploring the skies above us, past and present impact of neighboring

[2] Initially, 100 organizations were awarded spots in the PLC, however one site dropped out due to conflicting commitments.

planets on our land and peoples, and STEAM careers in our area that relate to Earth and Space."

- "Providing educators — approximately 50 teachers from both the public and private sector of our country — with training on topics like the Solar System and Heliophysics."

1.2.3 Program activities

PLC members attended **monthly online meetings** that were a combination of learning about content or best practices and working with each other on members' individual projects in small groups. Prior to the first session, the team hosted "tech checks" to help troubleshoot any technical challenges that might come up. Each month the session was offered four times, spread out to accommodate varied schedules. During these sessions, the NISE Network team also shared resources that PLC members could use with their projects or that might be useful in the future. PLC members attended one of the four sessions offered each month and often interacted with the same people each time. Between meetings, they filled out **project planning worksheets** and worked on making progress on their projects, to effectively make use of the time spent online together. They also were given homework in the form of reviewing resources or guides shared by the project team and giving colleagues feedback on their planning worksheets. The PLC made use of Google Classroom to share resources and provide a space for members to work collaboratively. All slides, materials, and resources are available on the NISE Network website: www.nisenet.org/making-relevant-inclusive.

The monthly meetings are described below:

- **Plenary Kickoff —** The initial meeting for the PLC was an orientation and overview of the program, including the goals for the community, anticipated outcomes for PLC members, orientation to the tools being used (primarily Google Classroom), and other expectations for professionals participating in the program. During this online session, the project team also shared a short introduction for each of the topics that would be covered in subsequent online sessions, along with some tools and resources.
- **Project Planning & Implementation –** During the first of the working meetings, PLC members started to get to know each other through ice-breaker activities and small breakout groups. Each PLC member created a slide briefly describing their project and started to fill out their individual project planning worksheet. In small groups, members shared their projects with others and start to utilize each other as resources by asking questions and providing peer feedback.
- **DEAI Practices and Tools –** This session was organized around the theme of incorporating DEAI practices in their PLC projects. PLC members learned about a NISE Network resource guide, worked through a series of reflection questions around intentionally planning for equity and inclusion, and participated in exercises they could use internally or with project partners.

- **Making Earth and Space Content Relevant –**The NISE Network team introduced and reviewed the Earth & Space Learning and Content Frameworks in this session, along with sharing how existing *Explore Science: Earth & Space* toolkit activities could be aligned with these frameworks. They also discussed how to make activities relevant to learners, and to think about invisible barriers for their audiences. In small groups, PLC members worked together to update their project planning worksheets and tackle challenges or questions together.
- **Community Collaborations and Working with Experts –** This working session was focused on strategies, tips, and resources for PLC members to use when working with community partners or experts to create Earth and space-related programming. In smaller breakout groups, PLC members shared and discussed previous experiences working with community partners or working with experts.
- **Planning Session** – During the last of the regular monthly meetings, PLC members addressed sustainability for their individual projects and next steps for their work, along with going over logistical information for the end of the PLC program and culminating April Convening.

Supporting materials for the monthly meetings included existing, updated, or new **NISE Network resources**. While many of the guides were initially developed through work on previous projects, the PLC project team felt that these resources were relevant and useful for the PLC members and their projects. Highlighted resources included:

- **Earth & Space Learning and Content Frameworks:** These frameworks describe content connections and expected science-process behaviors for learners engaged with NISE Network hands-on activities and exhibition components based on the research, discoveries, and missions from NASA's Science Mission Directorate (SMD). They also include a matrix identifying how the NISE Network Earth & Space products align with the frameworks. www.nisenet.org/earth-space-frameworks.
- **Diversity, Equity, Accessibility, and Inclusion (DEAI) Booklet:** The tools, practices, and project examples in this guide are designed to support efforts in making experiences more relevant and inclusive in order to promote a more equitable STEM future in our local communities. www.nisenet.org/DEAI-tools.
- **Museum & Community Partnerships: Collaboration Guide and additional resources:** This guide offers an introduction to collaborations between museums and youth-serving community organizations. Additional resources are included with the guide, such as a memorandum of understanding, tips sheet, and overview slide show. www.nisenet.org/collaboration-guide.
- **Working with STEM Experts: A Guide for Educators in Museums and Other Informal Learning Settings:** This guide is intended to be a practical resource for how to find, prepare, and work with STEM experts. Additional resources include tips sheets for planning guest presentations, guest speakers, and leading hands-on activities. www.nisenet.org/working-with-experts

The **April Convening** was held online over three half-day sessions on April 19-21, 2022. Originally, this event was planned to be in-person but ongoing pandemic concerns after a new variant surge prompted the switch to virtual. Since the convening was virtual, sessions were open to colleagues of the PLC members. The online convening included plenary sessions, concurrent sessions where projects presented their work, a showcase of NASA resources, and networking in SpatialChat.

Plenary sessions included keynote speakers primarily focused on efforts to make Earth and space science more inclusive and relevant, as well as current science topics. Each presentation was followed by a Q&A session. Plenary sessions included:

- Bringing the Perseverance Landing to the Deaf and Blind Community, Caitlin Ahrens, PhD, NASA Goddard.
- Improving Diversity, Equity, and Inclusion in Space Science, Derrick Pitts, HON.D, The Franklin Institute
- James Webb Space Telescope, Christine Chen, Space Telescope Science Institute
- Engaging Indigenous Youth and Adults in Community-Focused Efforts Around Climate Change, Elena Sparrow, PhD, University of Alaska Fairbanks

Concurrent sessions provided opportunities for many of the PLC members to report on their PLC project, as well as discuss related work they had done. Individual presentations reflected the main topics addressed during the monthly PLC meetings, such as "collaborating with Indigenous communities," "approachable ideas to address extreme weather," and "working well with experts."

Time was set aside for a **NASA resource showcase** and **networking**. For the showcase, a variety of NASA projects shared short videos about the programming, tools, or other resources for Earth and space science they offer. Examples included visualization tools like OpenSpace (www.openspaceproject.com), engagement efforts connecting people with experts like Solar System Ambassadors (solarsystem.nasa.gov/solar-system-ambassadors), online activities like NASA Space Place (spaceplace.nasa.gov), and other resources. The video showcase was accompanied by a virtual exhibition hall, where PLC members could chat with NASA project staff. The convening also time set aside for more informal networking, including a regional meeting where PLC members could get to know each other better in a somewhat facilitated setting, as well as minimally structured networking sessions where PLC members could virtually roam the SpatialChat space. A full list of NASA Showcase project, written descriptions, and short videos is available on the NISE Network website at www.nisenet.org/nasa-resources-showcase.

1.3 Additional professional development resources

Online workshops are regularly offered through the NISE Network to bring together professional partners and experts to share their expertise and experiences. All workshops are recorded and archived on the NISE Network website (www.nisenet.org/online-workshop-recordings). Workshops related to the SEISE project cover a wide range of topics, including

special event programming related to Earth and space, the science behind the SEISE *Explore Science: Earth & Space* toolkits, and innovative ways to use SEISE materials with various audiences and partners. The Network held four online workshops related to Earth and space science or the SEISE project that overlapped with the PLC:

- Kick-Start Your Planning for 2023 and 2024 Solar Eclipse Events;
- Increasing Community Resilience to Extreme Weather and Environmental Hazards — The Citizen Science, Civics, and Resilient Communities (CSCRC) Project;
- Communicating Climate Change to Diverse Audiences; and
- Working with STEM Experts — If Only There Was A Guide… Now There Is!

The NISE Network offered two workshops after completion of the program that shared resources from the PLC with the wider informal science education community:

- Earth and Space Resource Roundup — An Overview of All the NISE Network Has to Offer
- Tools for Engaging Communities and Incorporating Diversity, Equity, Accessibility, and Inclusion (DEAI) Practices

The NISE Network sent out monthly **newsletters** that shared partner highlights, upcoming opportunities and events, and relevant news articles. Many of these included information related to Earth and space science, both during the PLC and beyond. Regional hub leaders also communicated and shared resources directly with informal education organization partners, including those who participated in the PLC. Monthly newsletters are available on the NISE Network website: www.nisenet.org/newsletter.

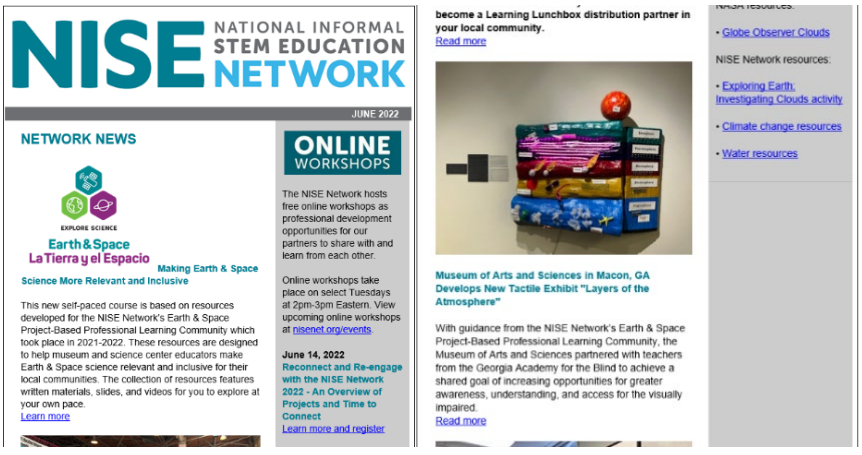


Image: Excerpts from the June 2022 NISE Network Newsletter.

In the first five years of the SEISE project, the team created four ***Explore Science: Earth & Space* toolkits**, which contained a suite of hands-on activities, along with resources that supported professionals' use of the activities with public audiences. The supporting resources included planning and collaboration guides, promotional materials, facilitations guides, training

videos and slides, educational posters and media, and more. Additional details about the toolkits and their contents can be found at www.nisenet.org/earthspacekit.

1.4 Evaluation questions

The SEISE Project Professional Impacts Summative Evaluation was a longitudinal study focused on professionals taking part in SEISE 2.0. Because the primary professional goals of SEISE were to increase the use of best practices by informal science educators (ISE) related to Earth and space content and to foster relationships and collaborations between different organizations, the evaluation aimed to understand how professionals were impacted in these areas. Evaluation questions guiding this study included:

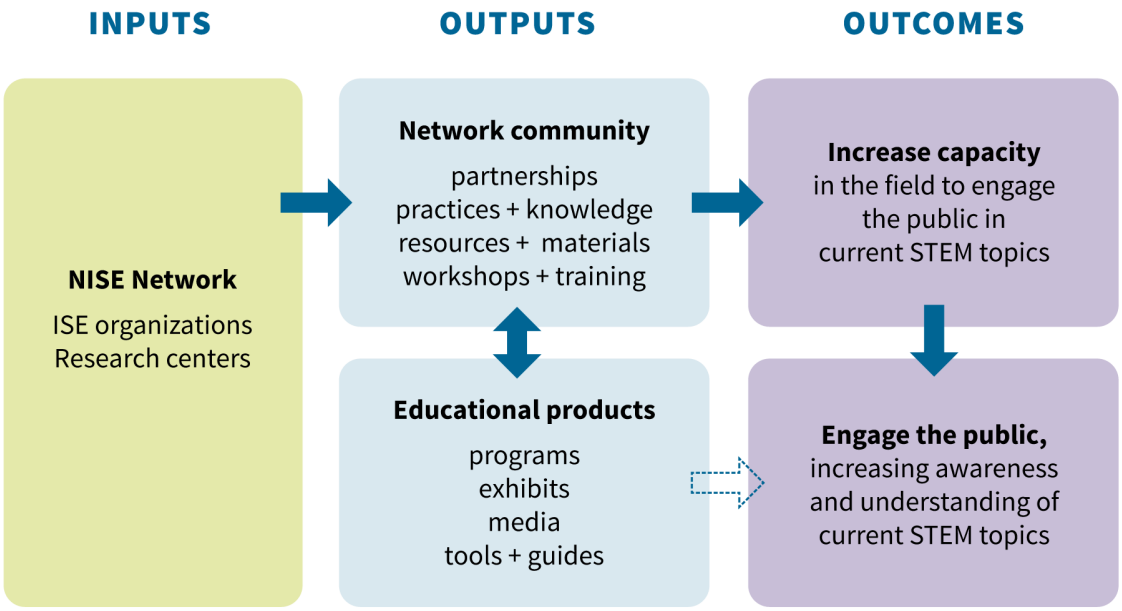
- Who and how many professionals does SEISE and the Professional Learning Community reach?
- How does participating in the Professional Learning Community impact professionals':
    - knowledge and understandings of practices for engaging the public in Earth and space topics?
    - use of NASA-related products and practices for engaging the public in Earth and space topics?
    - sense of community within the NISE Network and/or informal science education?

The evaluation also included some formative evaluation around the structure and content of the PLC. Data collected in this area were meant to both support the project team during the program as well as inform future NISE Network professional development opportunities. The primary formative question was:

- How can professional development deliverables be improved to better achieve goals for professional audiences?

This evaluation study was grounded in the NISE Network's logic model, which is depicted in Figure 1. Overall, the Network's theory of action emphasizes how the community and educational products created by the Network can lead to professional and public impacts. Specifically, by increasing the capacity of informal science education institutions and professionals to deliver Earth and space programming, the Network can help achieve the public outcomes of the SEISE project. As can be seen in the logic model, the Network advances professionals' knowledge and practices through professional development opportunities and supports created for the public-facing activities and exhibits produced by the Network.

Figure 1. The NISE Network's simplified logic model



2. Methods

The evaluation was focused on members of Earth & Space Project-Based Professional Learning Community and outcomes from participating in the program. Data consisted of online surveys and interviews, which were collected before (October 2021) and after the program (April, August-September 2022). Together, the paired data allowed for evaluators to look for change over time, to understand the impacts of participating in the PLC. Evaluators also had access to program artifacts, such as project description slides and project planning worksheets. The artifacts themselves were not analyzed but were used to provide context for analysis of survey and interview data. Further details about the evaluation methods and the data analysis are described below.

2.1 Data collection

2.1.1 Surveys and interviews

The evaluation collected data through a pre-survey (October 2021), a post-survey (April 2022), and interviews (August – September 2022). Each survey took approximately 15-20 minutes, and the interview took approximately one hour. Respondents were informed about the evaluation during online meetings and were recruited through email. All data collection was conducted online: surveys through the online platform Alchemer and interviews through recorded video calls on Zoom. No incentives were offered for the survey, and interview participants were offered a digital gift card to compensate them for the longer time commitment.

Both surveys contained questions to understand where PLC members were prior to and after the program, focusing on change over time of their:

- Confidence to engage general and diverse public audiences with Earth & space science;
- Confidence integrating relevancy and inclusive practices into project planning and implementation;
- Characteristics of their Earth and space project-related partnership(s);
- Use of SEISE and/or NISE Network resources; and
- Use of NASA resources.

In addition to covering the topic areas above, the post-survey also asked participants to reflect on their experience with the PLC, in terms of:

- How useful the PLC / NISE Network resources were;
- What was valuable about participating in the PLC;
- Their sense of community in the NISE Network; and
- What did or did not work well in the program.

Interviews were conducted with a small sub-set of PLC members, focused on contextualizing the survey and following up on participants' individual survey responses. Questions focused on understanding how, if at all, being part of the PLC may have impacted changes in their responses between the pre- and post-surveys, and which specific elements of the PLC contributed to those changes. To test assumptions about public reach after the pandemic began, additional questions were included for respondents at organizations that had used their *Explore Science: Earth & Space* toolkits for cart activities, public events, or long-term displays. These are discussed in the public reach memo (Anderson, 2024).

2.1.2 Sampling

Professionals recruited for this evaluation were all PLC members, who were at organizations that had received at least one *Explore Science: Earth & Space* toolkit and thus were expected to have at least some familiarity with the NISE Network prior to the PLC. All PLC members were invited to take the pre- and post-survey. In a few instances, professionals dropped out or were replaced by colleagues over the course of the PLC, in both cases they were not asked to complete the survey they missed. In total, 164 individuals from 99 partner organizations were invited to participate in the evaluation. A total of 108 individuals from 87 organizations responded to at least one survey (response rate: 66% individuals, 88% organizations). Ultimately, 50 individuals from 49 organizations completed both the pre- and post-surveys, making up the paired data set, see Table 1. The paired sample is the primary focus of this report and included in Sections 4-6. The post-survey data set is comprised of 74 individuals who responded to the post-survey and are the focus of Section 7.

Table 1. Data sets analyzed and referred to in this report.

Data Source	Sample Size (N=)
Paired pre-/post-survey	50
Interviews	9
Post-survey	74

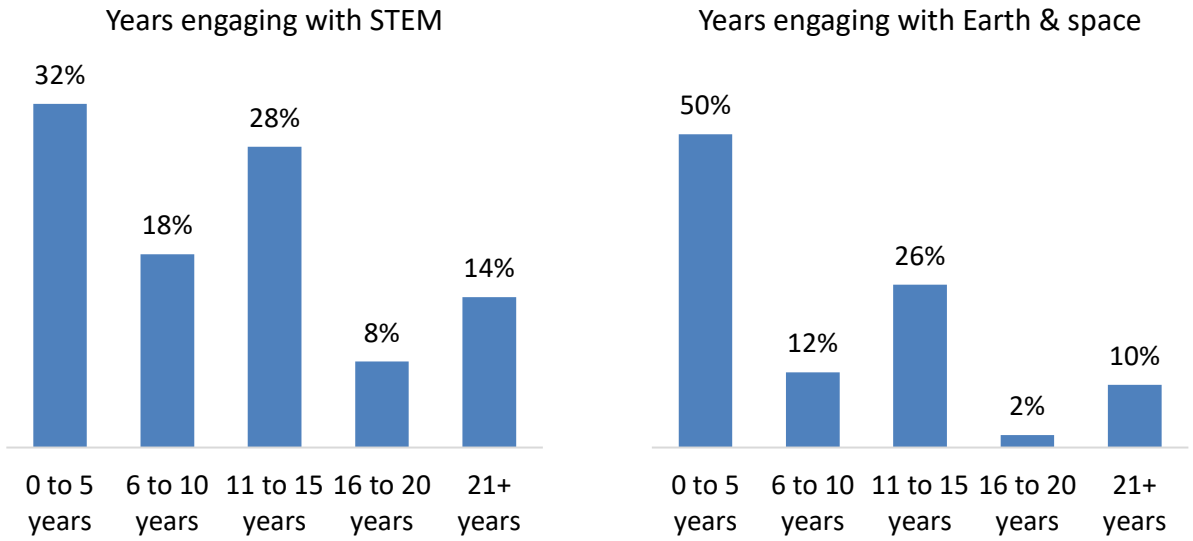
PLC members were primarily eligible to be recruited to participate in an interview if they had completed both surveys. To reduce evaluation burden for NISE Network partners, PLC members that had been recently interviewed for another project were not eligible for participation in the PLC interviews. To help answer questions about public reach, one third of the interview invitations were randomly selected from eligible PLC members at organizations that had also reported using an *Explore Science: Earth & Space* toolkit for long-term display. All other participants were randomly recruited from the 45 eligible PLC members, of which nine professionals participated in an interview (Table 1).

2.1.3 Survey respondent description

PLC members who responded to the survey represented a diversity of individual roles, ranging from educator-level staff to museum directors. They came from a variety of informal education organizations, such as children's, science, and university museums, located across 44 US states and two territories. These organizations represented a variety of sizes, budgets, and geographic settings. Most respondents were situated in urban settings, ranging from small cities of under 100,000 residents to larger cities over 250,000. Most of the organizations were small to medium in terms of their attendance, serving under 200,000 visitors per year. Respondent organizations were more evenly distributed in terms of their annual budget, with about half operating with an annual budget under $1 million per year. Additional details about the respondents' organizational context are available in Appendix A.

Respondents also varied in their prior experience engaging audiences with STEM or Earth and space science. The sample skewed towards less experience engaging audiences with STEM or Earth and space science, so PLC members may not have had deeply established practices for engaging audiences. About a third of paired survey respondents had five or fewer years' experience engaging audiences with STEM, see Figure 2. A greater percentage of PLC members in the paired sample were relatively new to engaging audiences with Earth and space science specifically, with about half of them reporting they had five or fewer years' experience. Survey respondents from the post-survey sample were similarly distributed, though were slightly more likely to have 6-10 years instead of 11-15 years' experience than the paired sample, see Appendix A for additional data.

Figure 2. Years experience engaging audiences with STEM or Earth & space content for PLC members. (Paired, N=50)



2.2 Data Analysis

The PLC summative evaluation utilized mixed methods, drawing on both quantitative and qualitative analyses. Findings in this report are drawn from three data sets (paired pre/post survey responses; post-survey responses; and interviews, see **Error! Reference source not found.**), with tables and figures labeled accordingly. Analysis of the paired sample (N=50) focused on changes over time using inferential statistics, comparing data from PLC members who completed both the pre- and post-surveys. Interview responses (N=9) provided a qualitative understanding of the quantitative data and offered a rich description of professionals' experience with the program. These data were first coded deductively around major themes and then sub-coded inductively. Responses from only the post-survey (N=74) were used as formative data to understand how to improve professional development materials, with a focus on format and content. The quantitative data from these data were analyzed through descriptive frequencies, while qualitative data were analyzed through inductive coding.

2.2.1 Quantitative analysis

Comparisons were made between PLC members' pre- and post-survey responses using inferential statistical tests. Since the data were negatively skewed, non-parametric tests were used. Throughout the report, statistically significant data ($p<0.05$) are marked with asterisks (*), additional supporting data such as significance ($p=$) or effect size ($r=$) can be found in the footnotes.

Some questions included in the paired analysis asked participants to rate their agreement on a 10-point scale, from "completely disagree" (1) to "completely agree" (10) or from "not at all" (1) to "a great deal" (10). To support clear visualizations, ratings are grouped into high (8-10),

medium (5-7), and low (1-4) categories for charts and discussion in this report. These ordinal data (and other Likert-type questions) were analyzed using the Wilcoxon signed ranks test. Additionally, effect sizes were calculated to determine the magnitude of change, or strength of the finding, for statistically significant results. The calculation $r=Z/\sqrt{n}$ was used to evaluate the effect size as small (<0.3), medium (0.3-0.5), or large (>0.5) (Rosenthal, 1991). Other questions included in the paired analysis were dichotomous (i.e., "yes" or "no" questions) for which the McNemar's test was used. Although participants usually had a "not applicable "or "I don't know" option available, these responses were removed for analysis as they would not allow for clear conclusions about whether any change had occurred (e.g., if someone changed from "I don't know" to "yes").

In addition to the statistical analysis of the paired sample, questions that were only asked on the post-survey were analyzed descriptively. This included questions asking respondents to what extent the PLC contributed to their confidence and about specific aspects of the program such as resources shared, topics discussed, or learning formats. These data are presented as descriptive frequencies only.

2.2.2 Qualitative analysis

Survey responses were analyzed through inductive coding methods. Inductive coding involves "immersion in the details and specifics of data to discover important patterns, themes, and interrelationships" (Patton, 2002). For all qualitative analyses, two evaluators reviewed any coded data, discussing discrepancies and refining categories. Findings from these qualitative analyses were used to either support, explain, or describe the quantitative survey results.

The post-survey included qualitative questions to explore PLC members' perceptions of what about the program impacted their practices, along with what was successful about the program and what could be improved. The interviews also provided rich qualitative data contextualizing and elaborating on survey responses.

Interviews were analyzed using both inductive and deductive coding methods. Deductive coding involves looking for themes related to the evaluation questions (Fereday & Muir-Cochrane, 2006), for the interviews this involved an initial round of coding around areas of interest such as "partnerships" and "DEAI practices." These deductive categories were then further refined through inductive coding, with evaluators looking for emergent patterns within the responses.

3. Introduction to findings

This report brings together the summative evaluation for the SEISE Professional Learning Community (PLC) to understand the impacts of the program with formative assessment to understand how to design future professional development opportunities. Each findings section addresses one of the areas of interest for the study:

Section 4: Earth and Space Content Knowledge

Section 5: DEAI Practices & Partnerships

Section 6: Use of NISE Network & NASA products

Section 7: Professional Learning Community Feedback

Each section includes an overview of aspects of the PLC that provided opportunities for PLC members to engage with the topics of interest for that section of the report (e.g., online sessions, guides, etc.) as well as other contextual information important for understanding the findings. For example, Section 4.1 describes how the PLC provided opportunities for members to learn about or enhance their knowledge of Earth and space topics.

Data were drawn from surveys and interviews with members of the PLC. Survey data presented through charts represent an overarching view of PLC members' experiences in the project, while direct quotes offer insight into individual's experiences. Summative findings, Sections 4-6, are drawn from the paired data set (N=50) and interviews (N=9). Formative data, Section 7, are drawn from the post-survey data set (N=74). In Section 8 findings are synthesized and impacts of the program discussed.

4. Findings: Earth and space content knowledge

The evaluation question related to impacts on professionals' content knowledge was:

- How does SEISE impact partner professionals' knowledge and understandings of SMD-related practices and content areas?

To understand how the PLC affected professionals' content knowledge, participants were asked to rate their agreement to a series of statements on a 10-point scale. These included statements about their confidence in planning and facilitating Earth and space science content with public audiences on both a pre-survey and post-survey; paired responses were used to measure changes in professionals' ratings. The broader SEISE project aims to engage multiple and diverse audiences in STEM learning, which informed the emphasis on including PLC members with projects working to broaden participation. On the survey, professionals were asked to rate their confidence in engaging both general audiences and diverse audiences. A subset of survey respondents were interviewed to understand in greater detail what aspects of the PLC contributed to changes in their content knowledge.

Findings are discussed in detail in the following sections, the key takeaways are:

- Professionals were significantly more confident facilitating Earth & space content with general audiences, with the most members indicating increased confidence for Living with the Sun.
- Professionals were initially less confident facilitating content with diverse audiences than with general audiences and indicated greater increases after participating in the PLC.

4.1 Opportunities for professionals to learn Earth and space content

The PLC provided multiple opportunities for professionals to engage with and learn Earth and space content as well as about ways to engage public audiences around these topics. These included monthly online meetings of the PLC; access to NISE Network resources; connecting members to Earth and space subject matter experts; plenary sessions and the NASA showcase at the April Convening; and additional content resources from the *Explore Science: Earth and Space* toolkit support materials. Some examples of these opportunities were:

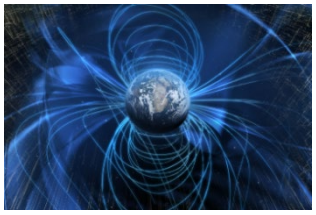
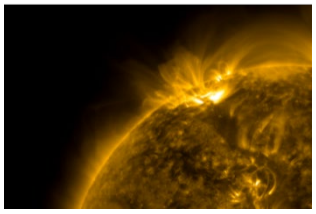
- The fourth online meeting **Making Earth and Space Content Relevant** (page 4) was centered around the NISE Network **Earth & Space Learning and Content Frameworks** (page 15). This framework describes content connections for learners engaged with NISE Network hands-on activities and exhibition components and makes connections to accompanying resources related to the research, discoveries, and missions from NASA's SMD.
- The April Convening **plenary sessions** (page 15) included presentations on current science topics, such as Christine Chen's talk around the James Webb Space Telescope.

- The April Convening also included a **showcase of NASA resources** (page 5). For the showcase, a variety of NASA projects shared resources for Earth and space science, many of which offer content-focused resources, such as visualization tools or online activities.
- The NISE Network's monthly **newsletters** shared partner highlights, opportunities, and events as well as relevant news articles—many of which included information related to Earth and space science.
- The SEISE project previously created four ***Explore Science: Earth & Space*** **toolkits** with hands-on activities and associated resources supporting professionals' use of the activities with public audiences, generally include related Earth and space content for facilitators.

4.1.1 Alignment between SMD topic, survey definitions, and project focus

For the surveys in this evaluation, and in previous Annual Partner Surveys in the SEISE project, the four SMD topics (astrophysics, Earth science, heliophysics, and planetary science) were translated into five content areas, with astrophysics being covered by two categories: "galaxies and beyond" and "forces and energy of the universe." Table 2 displays how the SMD content areas and the survey categories relate to each other. Beyond the SMD topics, the survey also asked about an additional cross-cutting area "connections between Earth and space research and our society," a specific emphasis of the NISE Network. Professionals were asked a series of questions about each of these areas including their confidence in facilitating these topics for general and diverse audiences, along with how participating in the PLC may have impacted their confidence.

Table 2. NASA Science Mission Directorate (SMD) content area and survey categories with definitions

SMD content areas	Survey categories with definitions	
Astrophysics	**Galaxies and beyond** (e.g., stars, birth of the universe, black holes, sizes and distances in space)	
	Forces and energy of the universe (e.g., gravity, electromagnetic spectrum, magnetism)	
Earth science	**The changing Earth** (e.g., climate change, plants and animals, ocean, atmosphere, geology)	
Heliophysics	**Living with the Sun** (e.g., energy from the Sun, eclipses, shadows, solar flares)	
Planetary science	**Our solar system and planets around other stars** (e.g., orbits, icy moons, the search for life, exoplanets)	
NISE Network focus	**Connections between Earth and space research and our society** (e.g., our values influence Earth and space science questions; Earth and space research can inspire us and result in new technologies; studying Earth and space helps us make better decisions about our home in the universe; we address challenges in Earth and space)	

PLC members were asked to identify which Earth and space content area their project addressed, with many indicating their project covered multiple content areas. Most commonly, projects were focused on "the changing Earth" and "Connections between Earth and space research in our society." Table 3 shows the proportion of paired survey respondents that focused on each of the content areas.

Table 3. Earth and space content focus for paired survey respondents' projects. (N=50)

PLC project focus area	Percent
The changing Earth	48%
Connections between Earth and space research and our society	46%
Living with the Sun	30%
Forces and energy of the universe	26%
Galaxies and beyond	22%
Our solar system and planets around other stars	22%

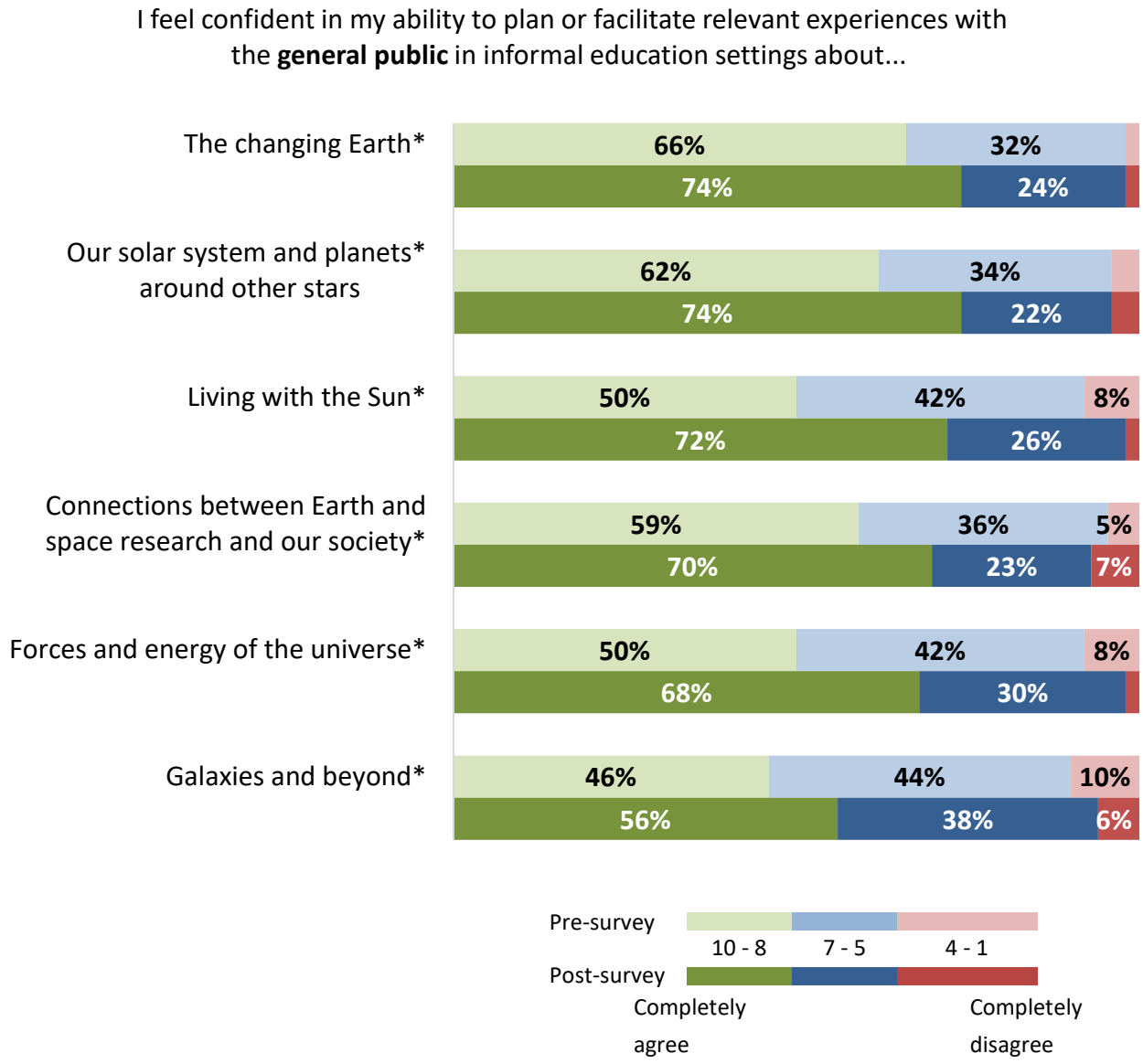
4.2 Professionals were significantly more confident facilitating Earth & space content with general audiences, with the most members indicating increased confidence for Living with the Sun.

After participating in the program, PLC members were significantly more confident facilitating Earth and space content with general audiences, see Figure 3**Error! Reference source not found.**. At the beginning of the program, between 46% and 66% of professionals strongly agreed that they were confident facilitating learning in the various Earth and space content areas as shown in the light green bars (ratings of 8-10 on a 10-point scale). At the end of the PLC, professionals' confidence had increased to between 56% and 74% strongly agreeing that they were confident as shown in the dark green bars. The content area "Living with the Sun" had the largest change in confidence overall, with 50% of respondents indicating they were very confidence (strongly agreeing) on the pre-survey and this rising to 72% on the post-survey.

The project team questioned whether PLC members indicated increased confidence in the various content areas due to the topics of their individual projects, so the survey results were compared to the focal content areas of PLC members' projects. Looking at "Living with the Sun," which was the content area which saw the biggest change in confidence ratings in the surveys, however "Living with the Sun" was the third most frequently named project content area with 30% of PLC projects addressing it (Table 3), suggesting that overall increases in professionals' confidence in addressing content were not necessarily connected to what their project focused on. Individual professionals may have experienced an increase in confidence around the focal

content area of their individual project through their project work as they planned and facilitated learning experiences around those topics.

Figure 3. Professionals' agreement ratings for their confidence facilitating Earth and space science content with general audiences (N=50) [3]



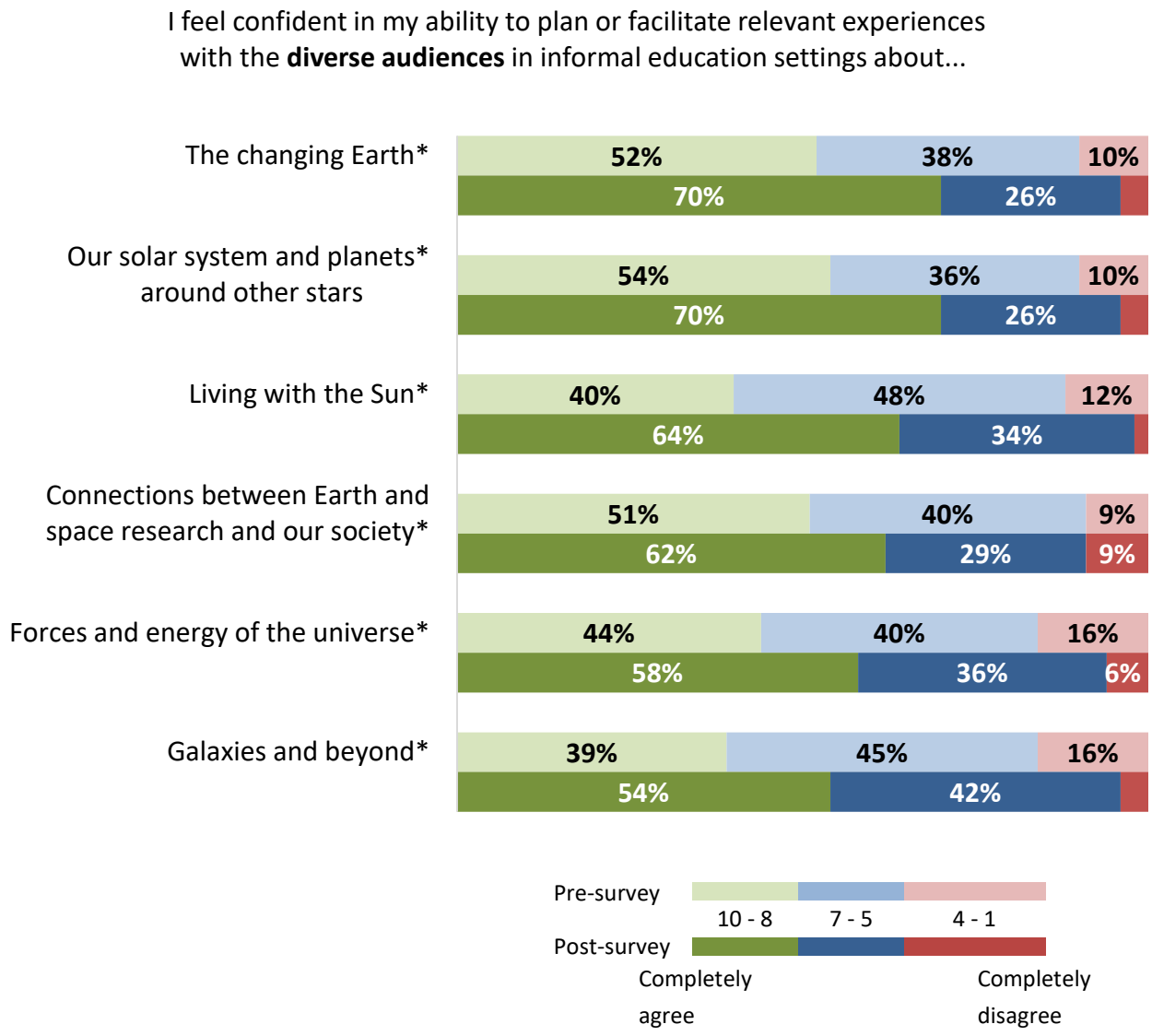
[3] The changing Earth (p=0.047, Z=-1.990, r=0.28, N=50); Our solar system and planets around other stars (p=0.006, Z=-2.746, r=0.39, N=50); Living with the Sun (p<0.001; Z=-3.561, r=0.50, N=50); Connections between Earth and space research and our society (p=0.018, Z=-2.373, r=0.34, N=50); Forces and energy of the universe (p=0.004, Z=-2.881, r=0.41, N=50); Galaxies and beyond (p=0.008, Z=-2.654, r=0.38, N=50)

4.3 Professionals were initially less confident facilitating content with diverse audiences than with general audiences and indicated greater increases after participating in the PLC.

Overall, professionals initially rated their confidence facilitating Earth and space content with diverse audiences lower than they did with general audiences, indicating they thought differently about audiences and tailoring their approach for specific audiences. At the end of the program, while not quite as confident as they were in working with general audiences, they indicated greater growth in their confidence facilitating Earth and space content with diverse audiences, see Figure 4.

At the beginning of the PLC, between 39% and 54% of professionals strongly agreed that they were confident facilitating content with diverse audiences, as shown in the light green bars in Figure 4. By the end of the PLC, professionals' ratings had significantly increased in each content area to between 54% and 70% indicating strong agreement with the statements, as shown in the dark green bars. The two areas that saw the highest degree of change for individual participants between their ratings were: "Living with the Sun" (with at least one participant reporting an increase of 9 points out of 10) and "Galaxies and beyond" (with at least one participant reporting an increase of 8 points out of 10).

Figure 4. Professionals' ratings of statements about their confidence facilitating Earth and space science content with diverse audiences (N=50) [4]



In the interviews, PLC members who indicated a positive change in their confidence generally attributed it to learning how to communicate content areas with audiences. Some respondents talked about learning new Earth and space content from the presentations, such as learning about research related to the James Webb telescope, but then emphasized that what impacted their confidence was understanding how to share that learning with others. They talked about

[4] The changing Earth (p=0.027, Z=-*2.212*, r=0.31, N=50); Our solar system and planets around other stars (p=0.001, Z=-3.254, r=0.46, N=50); Living with the Sun (p=0.001; Z=-3.286, r=0.46, N=50); Connections between Earth and space research and our society (p=0.007, Z=-2.716, r=0.38, N=50); Forces and energy of the universe (p=0.003, Z=-2.973, r=0.42, N=50); Galaxies and beyond (p<0.001, Z=-3.764, r=0.53, n=50)

being introduced to (or reminded of) resources and how to use them with audiences, that gave them confidence to dig in deeper later. Professionals also talked about being able to hear about what other PLC members were doing when sharing Earth and space content, as one person explained *"what they've seen is successful - using the content, using the experiences, and how they adapted it for specific audiences - I think that was key for us."* Hearing what others were doing sparked new ideas on how to share content with their project and beyond. Interviewees did not make a clear distinction between changes in confidence for working with general and diverse audiences, and they talked about changes to their confidence in general terms.

Making Earth and space science relevant and inclusive for local communities was an overall focus for the PLC. Successful applicants to the program proposed individual projects that aligned with this goal. The PLC program provided resources to support organizations' work with diverse audiences throughout the program, including a DEAI guide and one of the monthly meetings focused on DEAI (page 3). Considering the focus and available resources, it makes sense that PLC members would report increased confidence particularly around engaging diverse audiences in Earth and space science.

5. Findings: DEAI Practices & Partnerships

The evaluation question related to impacts on professionals' self-efficacy around DEAI practices and fostering partnerships to engage the public in Earth and space science was:

- How does SEISE impact partner professionals' knowledge and understandings of SMD-related practices and content areas?

Collaborations between organizations has been shown to be one way to broaden participation in informal STEM education; therefore, we have clustered the findings around the PLC's impact on professionals' confidence using DEAI practices with the program's impacts on partnerships and professionals' confidence in working with various types of partners.

Findings are discussed in detail in the following sections, key takeaways are that:

- Professionals were significantly more confident using DEAI practices to engage audiences in Earth and space science after participating in the PLC.
- Professionals were significantly more confident in their ability to collaborate with each type of partner.
- Professionals had opportunities to explore and implement partnership-related practices through working on their PLC projects.

5.1 Opportunities for professionals to learn or refine knowledge of DEAI and partnership practices.

The PLC program was a project-based community of practice in which members proposed and worked on individual projects to make Earth and space science more relevant and inclusive for their communities, so opportunities for members to engage with DEAI and partnership practices were core to the program. These opportunities included monthly online meeting topics, highlighted NISE Network resources, sessions at the April Convening, and interactions with the PLC project team. PLC members also were applying and refining their knowledge of these practices through working on their individual projects and through interacting with each other as they learned about other members' projects and provided peer feedback.

Some examples of opportunities to learn and refine their understanding and use of DEAI and partnership practices included:

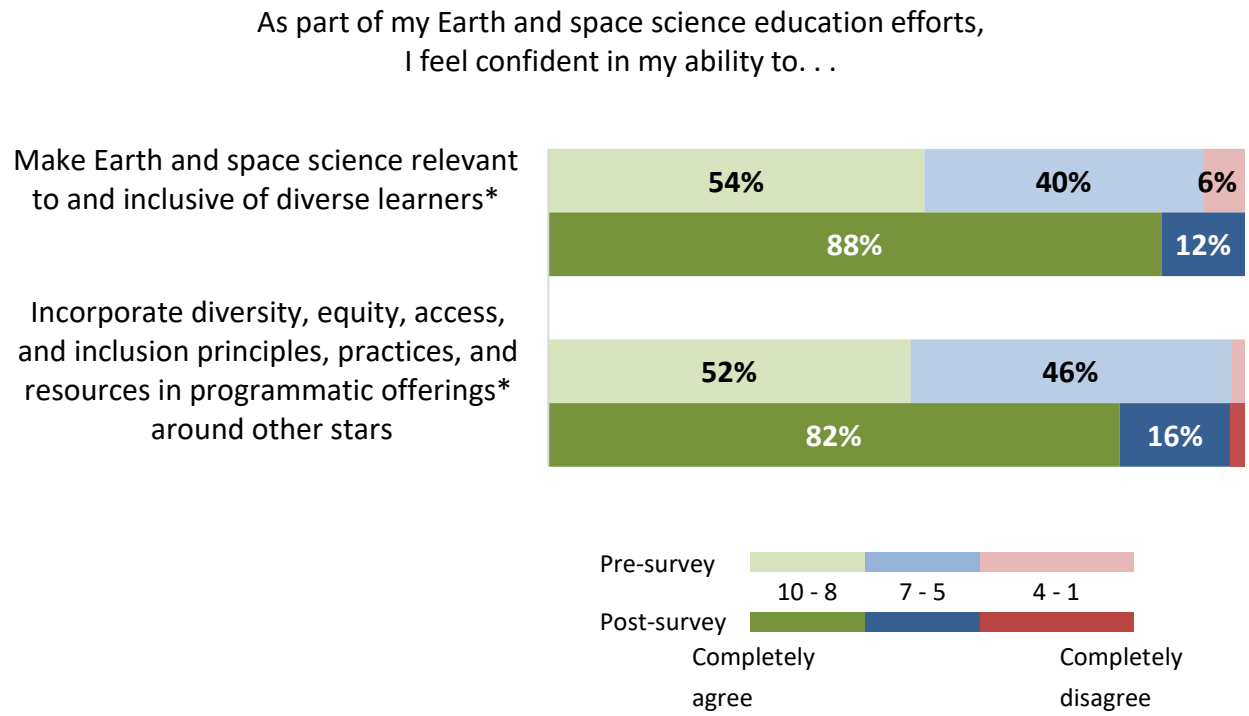
- **Peer-to-peer learning** through sharing projects and providing and/or receiving peer feedback.
- Monthly **online working meetings** on topics such as DEAI Practices and Tools; Making Earth and Space Content Relevant, and Community Collaborations and Working with Experts.

- **NISE Network guides and resources** highlighted during monthly online meetings, such as:
    - Diversity, Equity, Accessibility, and Inclusion (DEAI) Booklet;
    - Museum & Community Partnerships: Collaboration Guide and additional resources (e.g., Memorandum of Understanding and tips sheet); and
    - Working with STEM Experts: A Guide for Educators in Museums and Other Informal Learning Settings.
- **Plenary sessions** at the April Convening where keynote speakers focused on efforts to make Earth and space science more inclusive and relevant.
- **Concurrent sessions** at the April Convening in which many PLC members reported on their projects and discussed related work they had done.
- Additional **NISE Network online workshops** that happened both during the PLC and after its completion.

5.2 Professionals were significantly more confident using DEAI practices to engage audiences in Earth and space science after participating in the PLC.

PLC members were asked to rate their confidence in their ability to use DEAI practices to engage audiences in Earth and space science on both the pre- and post-surveys. Before the PLC, about 50% of professionals strongly agreed that they were confident in both their ability to make Earth and space science relevant to and inclusive of diverse learners and to incorporate DEAI principles, practices, and resources into programmatic offerings (Figure 5, light green bars). Professionals' ratings increased significantly to over 80% for each statement after the PLC (dark green bars). Individual's ratings displayed a wide range for the degree of change between the surveys, ranging from decreasing by 2 points on a 10-point scale (indicating becoming a little less confident) to increasing by up to 7 points (indicating becoming a lot more confident), with the average change in ratings between pre- and post-surveys being an increase of 1.28 points for making Earth and space content relevant (range: -2 to 7) and 1.18 points for incorporating DEAI practices (range: -2 to 7). The wide ranges of change indicated likely reflects where individual professionals were when they started, and how the resources presented aligned with their work.

Figure 5. Professionals' ratings of their confidence in their ability to use DEAI practices (N=50)[5]

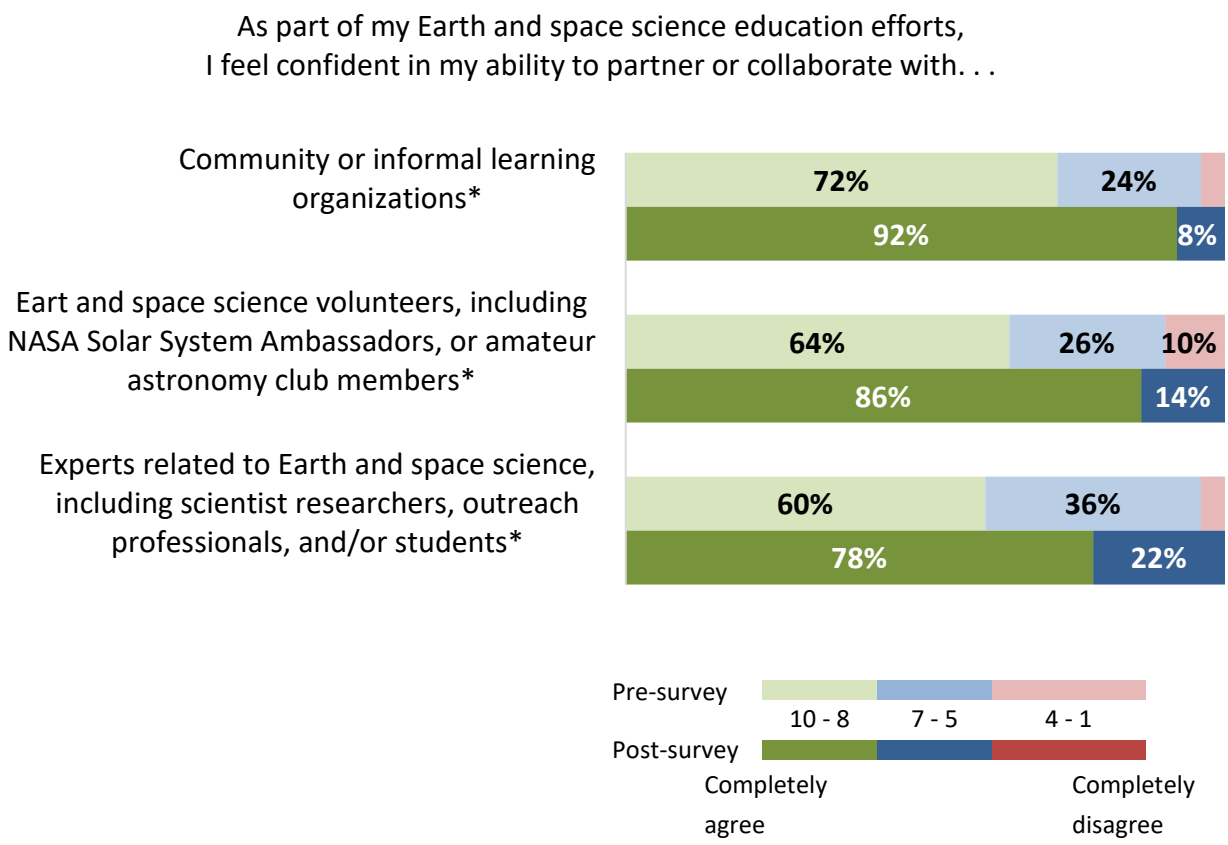


5.3 Professionals were significantly more confident in their ability to collaborate with each type of partner.

Many professionals initially indicated that they were confident collaborating with different types of partners. As shown in Figure 6, at least 60% of PLC members said in the pre-survey that they strongly agreed that they were confident working with each type of partner asked about: community or informal learning organizations (72%); Earth and space science volunteers including NASA Solar System Ambassadors, or amateur astronomy club members (64%); and experts related to Earth and space science including scientist researchers, outreach professionals, and/or students (60%). By the end of the PLC, professionals' confidence in working with each of these types of partners had significantly increased. In the post-survey, ratings at the low end of the rating scale (red bars) disappeared as all participants indicated they were at least moderately agreed that they were confident in working with these types of partners (blue and green bars).

[5] Make Earth and space science relevant and inclusive of diverse learners (p<0.001, Z=-4.782, r=0.68, N=50); Incorporate diversity, equity, access, and inclusion principles, practices, and resources in programmatic offerings (p<0.001, Z=-3.846, r=0.54, N=50)

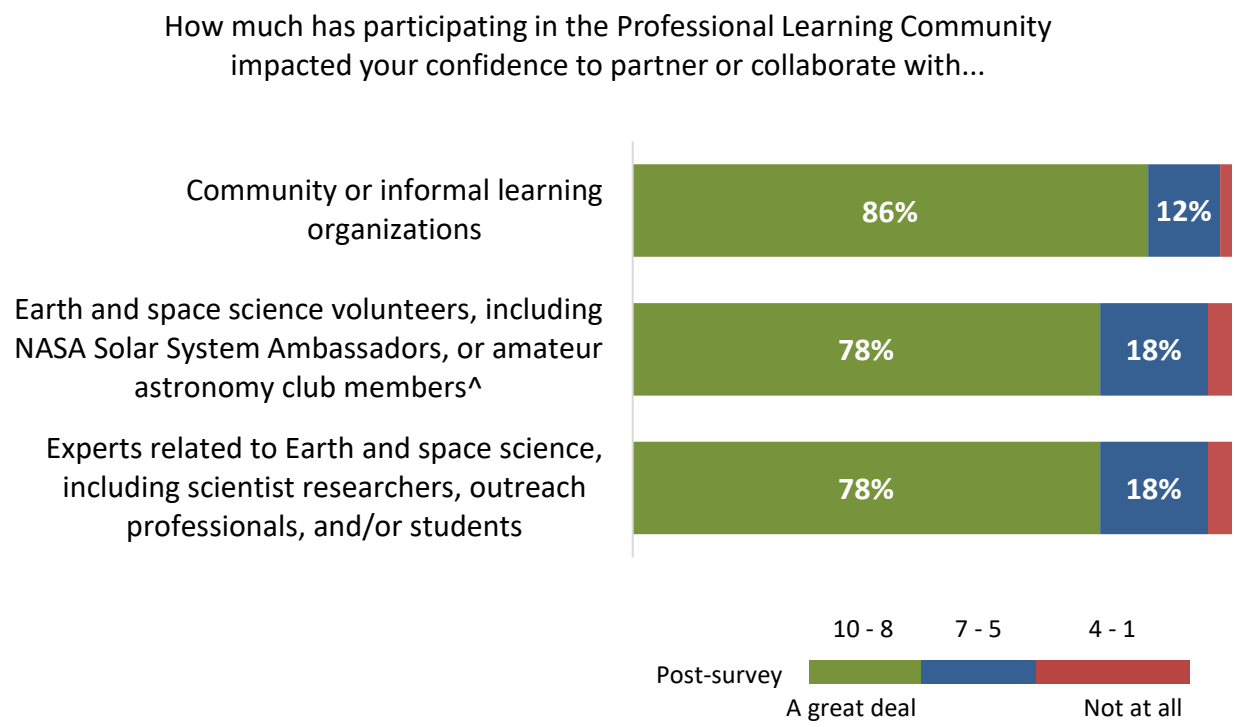
Figure 6. Professionals' ratings of their confidence in their ability to collaborate with different types of partners (N=50)[6]



Furthermore, when asked about how much the PLC impacted their confidence in their ability to collaborate with these types of partners, most respondents (78-86%) said that participating in the PLC had impacted their confidence "a great deal" in working with each type of partner as shown in the green bars in Figure 7, below. Thus, the PLC positively impacted professionals' confidence in collaborating with a variety of types of partners.

[6] Community or informal learning organizations (p=0.003, Z= -2.957, r=-0.42, N=50); Earth and space science volunteers, including NASA Solar System Ambassadors, or amateur astronomy club members (p=0.006, Z=-2.766, r=-0.39, N=50); Experts related to Earth and space science including scientist researchers, outreach professionals, and/or students (p=0.008; Z=-2.639, r=-0.37, N=50).

Figure 7. Professionals' rating of the impact of the PLC on their confidence in collaborating with partners (N=50, ^n=49)



5.4 Professionals had opportunities to explore and implement partnership-related practices through working on their PLC projects.

5.4.1 PLC members identified multiple ways the program impacted their partnerships, such as learning and working with peers and having dedicated time to focus on a project.

Through the open-ended questions on the post-survey, PLC members shared ways participating in the program supported their partnerships. When asked on the post-survey, "How, if at all, has participating in the Professional Learning Community impacted your work related to your local or community partners?", professionals most frequently described how they had learned from or refined ideas with colleagues (25%, n=52, Table 7). For example, one professional said, *"It helped to learn about all the different types of partners other groups worked with and the ways they organize[d] the work,"* and another professional said, *"I received feedback of how to reach out to partners."* The next most frequently identified categories were about learning how to work better with partners (21%), fostering new partnerships, (21%), and strengthening partnerships (19%). See Table 4 for a full list of categories identified in professionals' responses and example quotes.

Taken together these top categories describe having opportunities to explore partnership-related practices. For example, some professionals described an increase in their awareness of partnership practices gained through learning from and with colleagues, saying things like *"After hearing how others in the PLC have interacted with their community partners, this has*

provided us with additional ideas on how to maintain and strengthen our relationships," and, *"It has improved my confidence and knowledge/understanding of ways to reach out to potential partners and best practices for maintaining those connections."* For some, this exploration of partnership practices contributed to feeling inspired, confident, or affirmation of their own partnership work, with one professional saying *"…Learning, hearing, and seeing how other organizations partnered with their communities gave us confidence on building partnerships"*; another professional shared *"Being in the PLC has given us exposure to how other organizations approach these issues, and hearing about them has been inspirational"*; and a third professional reported, *"It has continued to reaffirm the work we are doing to support and develop our relationships."* The PLC, though, also provided professionals opportunities to implement partnership-related practices through their individual projects, such as one professional sharing that through their work with the PLC they were *"more proactive on the front end to consult our partner about our idea, resulting in a much better project for both orgs."*

Through the interviews, PLC members reiterated similar themes around how the PLC program impacted their partnerships. Broadly, interviewees shared that having space and time dedicated to working with their partners on a specific project, along with opportunities to learn about implementing practices or resources, helped them with their work. Five interviewees also talked about how participating in the PLC helped build momentum in their work, through ideas generated from conversations with peers for reaching out to or working with partners, as well as simply building confidence that they were able to reach out to partners. Some interviewees (4 of 9) talked specifically about seeing what their peers were doing and getting feedback on their plans impacted their partnerships. As one professional explained, *"just from talking with other people about how they had [conversations with partners] kind of gave me the mental tools to move forward with that."* Other themes that emerged were around conversations about resources that would support their partnerships, having focused time to work on their partnerships, and opportunities to incorporate new practices.

Table 4. Professionals' coded responses for the question "How, if at all, has participating in the Professional Learning Community impacted your work related to your local or community partners?" (n=52)

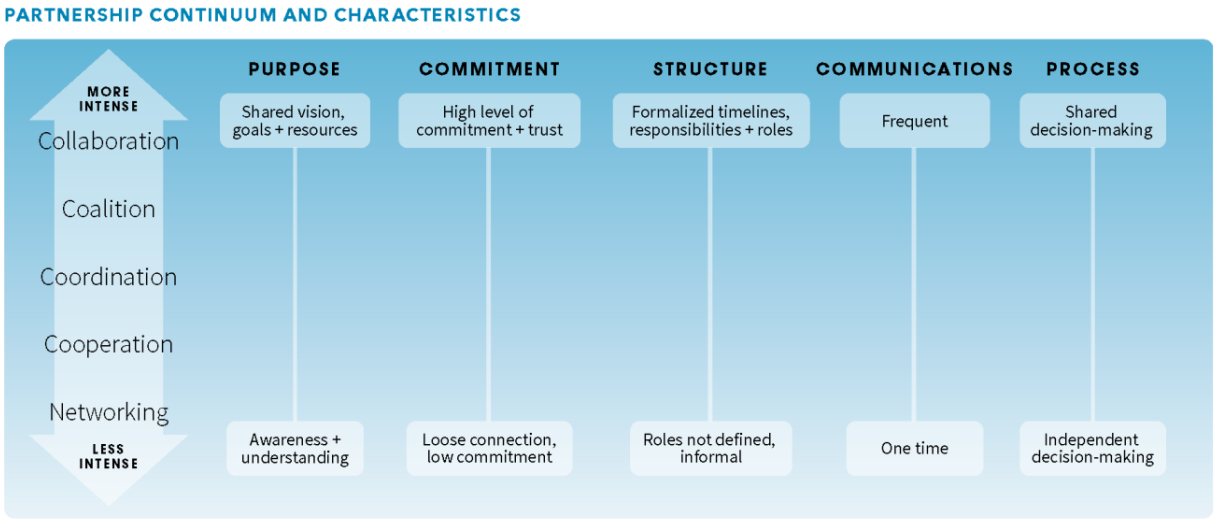
Code	Frequency	Response examples
Learned from or refined ideas with colleagues across the country	13 (25%)	*"After hearing how others in the PLC have interacted with their community partners, this has provided us with additional ideas on how to maintain and strengthen our relationships."*
Learned how to better work with my partner	11 (21%)	*"It has given me tools to help me make better connections with our partner and more inclusive language to use in our communications."*
Fostered new partnerships	11 (21%)	*"It opened us up to a new partnership that will hopefully continue to grow stronger."*
Strengthened partnership	10 (19%)	*"This PLC has helped build stronger relationships with state entities such as our university system. One outcome is instead of communicating only during projects/grants to create standing meetings just to keep each other updated and aware of new [opportunities]."*
Learned about strategies and resources from the PLC	8 (15%)	*"Positively; the document and discussions on working with community partners and working with experts have proven to be invaluable assets."*
Helped foster mutually beneficial partnerships	7 (13%)	*"The bond between my organization and our community partner has increased but would need continued "feeding" to grow stronger. Both sides observed the benefits of the other in a way that had not happened before this project."*
Helped us develop or expand programming opportunities	5 (10%)	*"...and it has allowed us to create new opportunities that I don't believe we would have otherwise had."*
Provided resources (time, money, etc.) to do work	4 (8%)	*"...Having a bit of extra resources helped me reach beyond our normal staff/volunteers to work with undergrad "future professionals" to work in the community and made a great inroad to future collaborations."*
Helped up make DEAI work a priority	2 (4%)	*"Creating a renewed sense of urgency for the development of a formal DEI plan."*

Code	Frequency	Response examples
Community of peers to learn from/with	1 (2%)	*"It has helped in terms of not feeling alone in the questions/concerns/challenges I face, and knowing that there is a community I can reach out to for help when needed. This definitely helps with confidence."*

5.4.2 *Changes in the intensity of partnerships primarily were attributed to professionals generally gaining a better understanding of their partners.*

In an attempt to understand the nuance of partnerships, professionals were asked to rate the intensity of their partnership. On the pre- and post-surveys, they indicated whether they were closer to one of two statements using a 10-point scale, with 1 being agreement with a low intensity statement and 10 being agreement with a high intensity statement for each of the following aspects: purpose, commitment, structure, communications, and process. The categories and statements were drawn from the NISE Network Collaboration Guide, shown in Figure 8.

Figure 8. Partnership Continuum from the NISE Network "Museum & Community Partnerships: Collaboration Guide and additional resources" (2015)

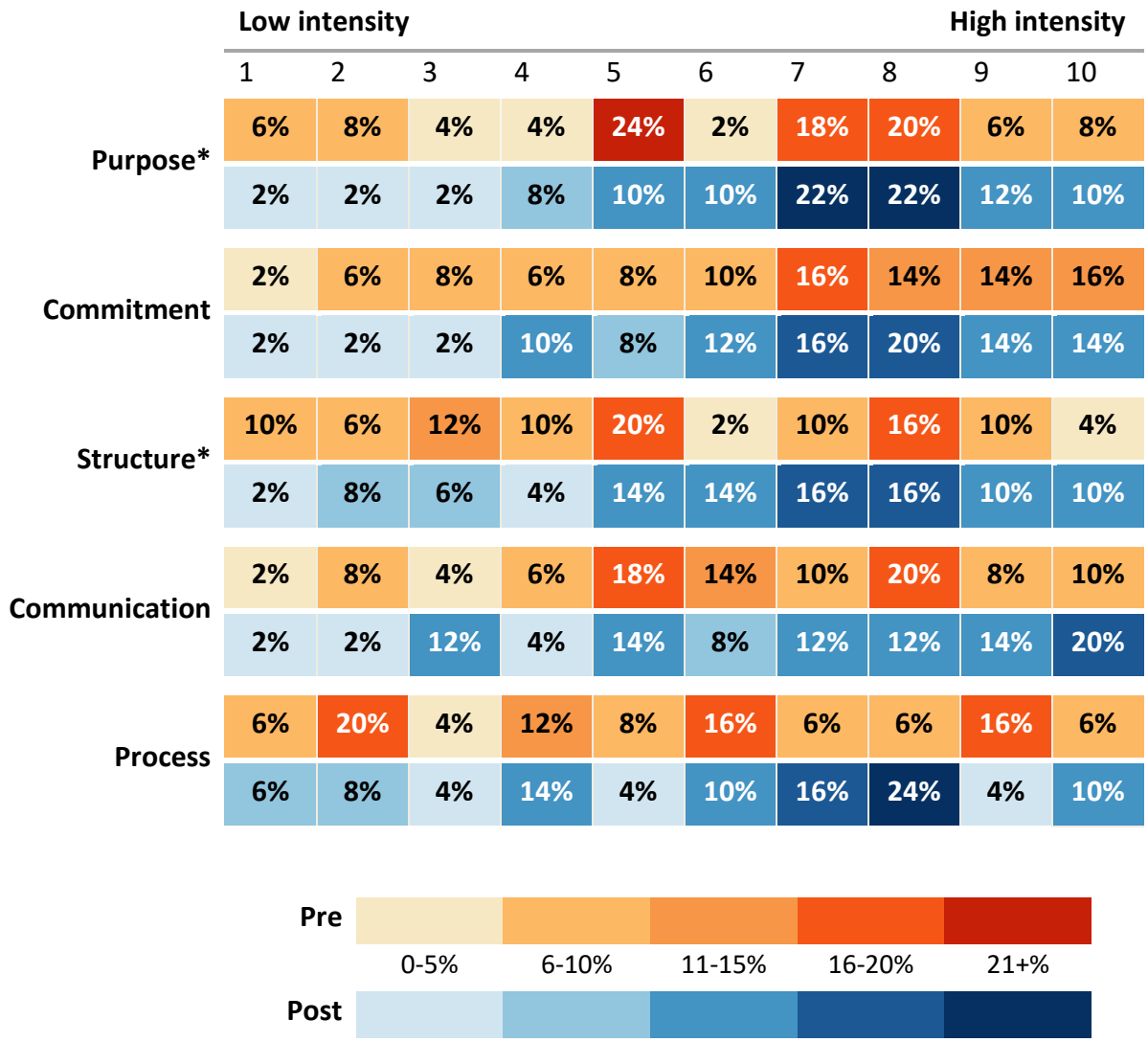


Increasing intensity of partnerships itself is not a measure of success. With increased understanding of ones' partner, partnership-practice, and organizations' capacity for partnering, the intensity of partnerships can fluctuate based on alignment of both partners' interests, needs, and resources. Thus, decreasing ratings on the scale presented could reflect an increase in awareness/understanding of one's own organization and partner relationship.

PLC members indicated a significant increase in partnership intensity around **purpose** and **structure** in partnerships. Figure 9 represents the aggregated responses for how professionals described the intensity of the five aspects of their partnerships drawn from the NISE Network Collaboration Guide (Figure 8), color coded to display their intensity before the PLC (orange gradient) and after (blue gradient). Overall, PLC members felt that they had higher intensity partnerships at the end of the program. Specifically, for understanding the purpose of the partnership (Figure 9), PLC members started from a range of familiarity with their partners, and by the end of the program partners were more likely to indicate being closer to having shared vision and goals. For this aspect, professionals' ratings rose from an average rating of 6.02 on the pre-survey to 6.92 on the post-survey, and the average change in ratings was an increase of 0.9 points. For defining structure in the partnerships (Figure 9), PLC members were generally split between the two ends of the spectrum in the beginning, and, by the end of the program, many of them had formalized roles with their partner. For this aspect, professionals' rating increased from an average rating of 5.38 on the pre-survey to an average of 6.36 on the post-survey, with an average change of increasing by 0.98 points. The full question, with scale anchors can be found in Appendix B (page 60).

In the interviews, PLC members were shown their pre- and post-survey responses to the question above and then prompted to reflect on why their responses might have changed or stayed the same. Seven of the nine interviewees attributed more intense aspects of their partnerships to communicating more frequently or more effectively with their partner(s). Other elements that contributed to more intense aspects included having a project to focus on, building better understanding and trust with their partners, taking time to work on their partnership, and being able to compensate their partner's time.

Figure 9. Aggregated responses of PLC members rating the intensity of their partnerships, comparing responses at the beginning and end of the program. (N=50)[7]



Focusing on one interviewee as an example, they started the program with medium intensity across the five aspects of partnerships and indicated that they were in more alignment with most of the more intense descriptors by the end. In their reflections, they talked about how the initial act of applying to the PLC program made them more aware of how they were interacting with their partner. In particular *"finding out what they need, and what they want as being an important part of the process."* They also talked about how they were more responsive to how their partner preferred to communicate, initially offering to go to the partner, who preferred Zoom meetings. Through those conversations they were able to *"really talk about this project,*

[7] Purpose (p=0.013, Z=-2.475, r=0.35, N=50); Structure (p=0.016, Z=-2.401, r=0.34, N=50)

what we were hoping to do and what were their ideas for it, and just had some good conversations about [it].”

Three interviewees talked about why they indicated that aspects of their partnerships were lower intensity at the end of the program than they were when they started. They attributed this decrease in intensity to better understanding their partner and their partner’s needs, or making substantial changes to their that impacted how they were partnering and with whom. One interviewee talked about their ratings not changing and attributed that to the fact that their partner was well established prior to the program, though noted that through the project they were able to focus their time on the fine grain details of the work they were doing together.

5.4.2 In summary, professionals learned new strategies and ideas to support their partnerships and were able to apply them through the program.

The PLC program provided the opportunity for professionals to work on a real project at their institution, while sharing and learning with peers doing similar work. Across the surveys and interviews, professionals indicated that they gained confidence in using partnership-related practices. Increased awareness and understanding of these practices, particularly from exploring or implementing these practices in their projects, likely contributed to this increased confidence. PLC members often attributed their confidence to learning new ideas from peers, being able to discuss or workshop ideas with peers, and being able to apply these ideas to their projects. Whether with long established or new partners, the PLC program professionals were able to implement some of the strategies they were learning about.

6. Findings: NISE Network & NASA-related products

The evaluation question around impacts of the PLC on professionals' utilization of NISE Network and NASA-related products was:

- How does the SEISE project impact partner professionals' use of SMD-related products and practices?

To investigate these effects, professionals were asked to rate their confidence in their ability to identify NISE Network and NASA-related products to enhance public engagement around Earth and space science on both the pre- and post-survey using the same scale as was described in Section 4.1 for content knowledge.

Findings are discussed in detail in the following sections, the key takeaways are:

- Professionals were significantly more confident identifying both NISE Network and NASA-related products to engage audiences in Earth and space science.
- Professionals were making greater use of NISE Network resources that support using kits and engaging audiences.

6.1 Opportunities for professionals to learn about or use NISE Network & NASA-related products

PLC members entered the program with some familiarity with **NISE Network products** since one of the application requirements was for professionals' organizations to have received at least one of the SEISE *Explore Science: Earth & Space* toolkits. Through the PLC, professionals had opportunities to learn more about NISE Network products or to use them in their practice through monthly online meetings which highlighted relevant NISE Network products and resources; and through work on their individual projects. Three of the monthly online meetings (see page 3 for additional details) specifically featured NISE Network products:

- **DEAI Practices and Tools,** highlighted the NISE Network's *DEAI Booklet*.
- **Making Earth and Space Content Relevant** introduced and reviewed the NISE Network *Earth & Space Learning and Content Frameworks*, along with how *Explore Science: Earth & Space* toolkit activities could be aligned with these frameworks.
- **Community Collaborations and Working with Experts** highlighted the NISE Network guides: *Museums & Community Partnerships: Collaboration Guide* and *Working with STEM Experts: A Guide for Educators in Museums and Other Informal Learning Settings*.

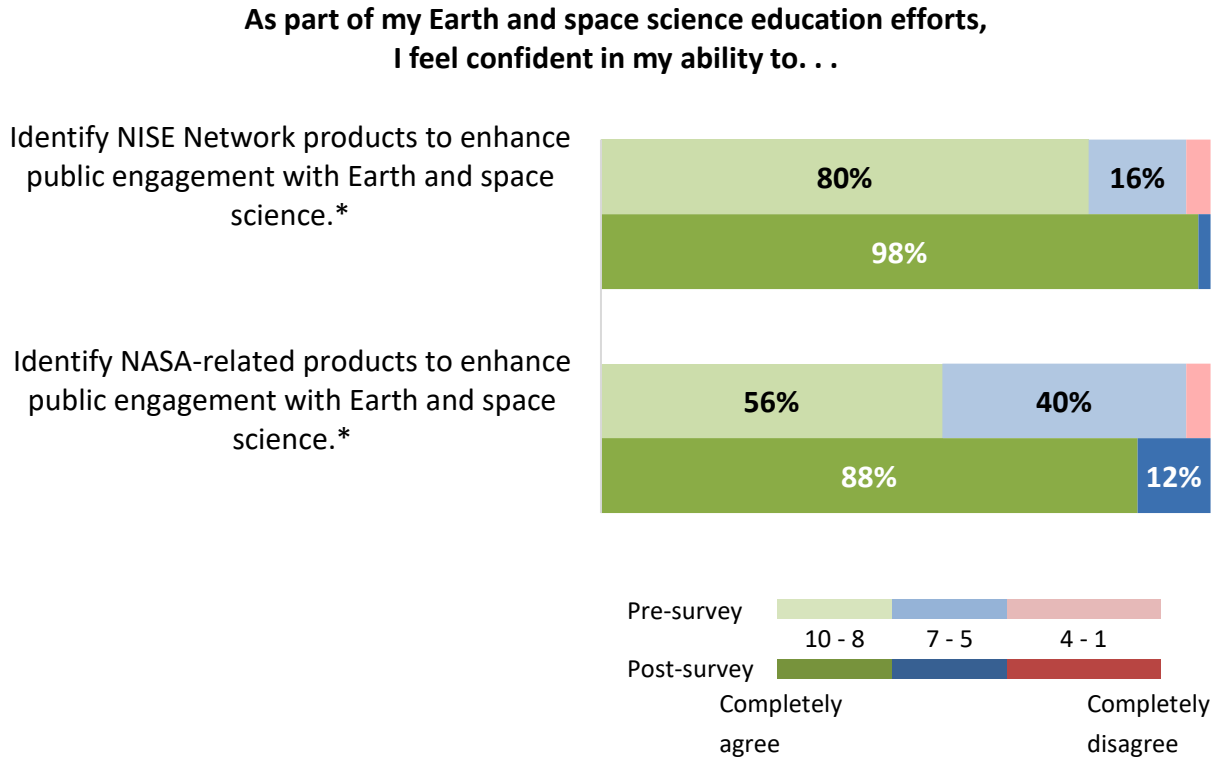
These sessions included time to discuss and work together on their projects which was intended to help PLC members to apply the practices outlined these guides to their projects.

Professionals also had opportunities to learn about or use **NASA-related products** through the PLC. Opportunities included the NASA showcase at the April Convening, in which a variety of NASA projects shared short videos of what they had to offer as well as participated in a virtual exhibit hall to network with PLC members; and learning about relevant NASA-related products through the PLC's community of practice via peer and project staff-feedback on their projects during the PLC and concurrent sessions at the April Convening during with many PLC members reported on their projects or related work.

6.2 Professionals were significantly more confident identifying both NISE Network and NASA-related products to engage audiences in Earth and space science.

On the pre- and post-surveys, PLC members were asked to rate their confidence in identifying NISE Network and NASA-related resources to enhance public engagement with Earth and space science. Professionals were initially very confident in their ability to identify NISE Network products with 80% selecting the rating "strongly agree" (36Figure 10). This is unsurprising as it was a pre-requisite for participating in the PLC that their institution had previously received a NISE Network kit. Therefore, PLC members' organizations at least already had some experience with NISE Network products. After the PLC, members reported small, but statistically significant increases in confidence becoming even more confident with 98% selecting "strongly agree" on the post-survey. In addition, professionals experienced growth in their confidence identifying NASA-related products. At the start of the PLC they were quite confident with 56% strongly agreeing (Figure 10). By the end of the PLC, this rose to 88% strongly agreeing.

Figure 10. Professional's ratings of their <u>confidence in using</u> NISE Network and NASA-related resources in engaging the public around Earth and space science (N=50)[8]



Increase reported by PLC members may be influenced by increased awareness of the respective resources and ways in which other professionals are using them. Increases in professionals' confidence in using NASA-related products may go hand in hand with increases in content knowledge (see Section 4) and from hearing how other members of the community were using NASA products, which could broaden professional's awareness of the range of products available and how they may be used to enhance public engagement around Earth and space science. Similarly, increased confidence in identifying NISE Network products may relate to increased use these products, described in Section 7, as using these products may lead to increased confidence in one's ability to identify applicable resources and potentially to more use of similar resources.

[8] NISE Network products ($p<0.001$, $Z=-4.305$, $r=0.61$, N=50); NASA-related products ($p<0.001$, $Z=-4.121$, $r=0.58$, N=50)

6.3 Professionals were making greater use of NISE Network resources that support using kits and engaging audiences.

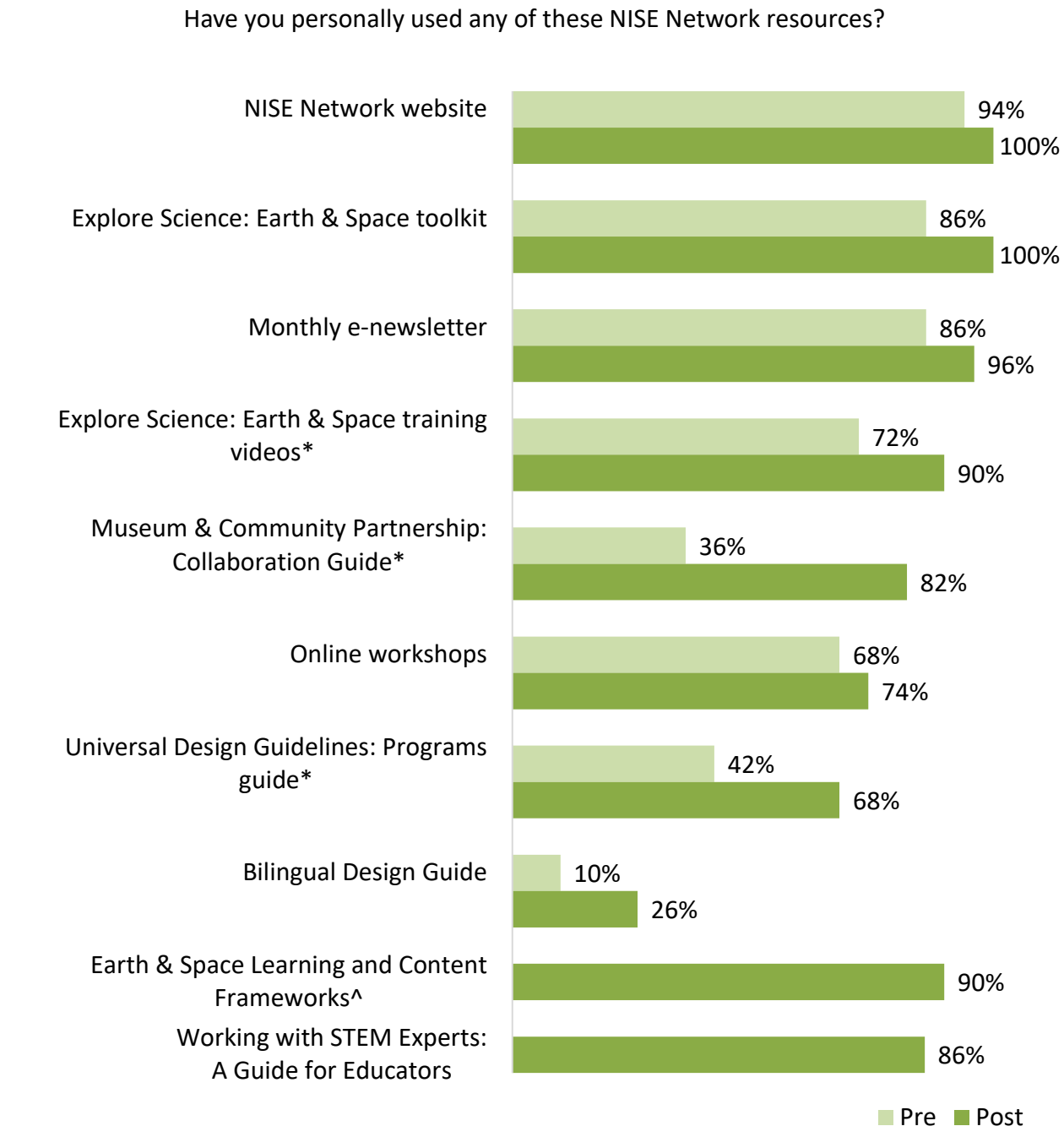
Overall, PLC members indicated that they were making greater use of the NISE Network resources that support using kits and engaging audiences, see Figure 11. Not surprisingly, the resources most frequently used initially were the website, the newsletters, and the toolkits. A requirement for being part of the PLC was that the professional's organizations had to have received at least one of the *Explore Science: Earth & Space* toolkits, and this opportunity was primarily advertised through the NISE Network website and newsletters. While by the end of the PLC, more professionals indicated using these resources, these increases were not statistically significant.

Statistically significant increases were seen around use of professional development resources that support using the toolkits or engaging audiences, such as the training videos and using the guides initially developed when NISE Network was focused on informal science education around nanoscale content like the *NISE Network Universal Design Guidelines: Programs Guide* (Programs Guide,) and the *NISE Network Museum & Community Partnership Guide: Collaboration Guide* (Collaboration Guide), see Figure 12.

Two resources were newly introduced during the PLC and therefore only have data for the post-survey (last two resources shown in Figure 12). High update of these resources is an indicator that they were useful to PLC members. Most PLC members reported using these resources, with 90% of participants personally using the *Earth & Space Learning and Content Frameworks*, and 86% using *Working with STEM Experts: A Guide for Educators in Museums and Other Informal Learning Settings* (Figure 12).

In sum, professionals reported widespread use of the newly created NISE Network resources as well as greater use of existing resources. Although professionals were at least somewhat familiar with the NISE Network prior to the program, it was interesting that there were statistically significant increases in use of some of the older existing NISE Network resources (e.g., Program Guide, Collaboration Guide). This suggests that future professional development could offer support in navigating older resources in addition to introducing new ones.

Figure 11. Professionals' use of NISE Network resources (N=50)[9]



[9] **Significant increase:** *Explore Science: Earth & Space* toolkit (p=0.063, n=48); *Explore Science: Earth & Space* training videos (p=0.008, n=48), Museum & Community Partnership: Collaboration Guide (p<0.001, χ^2=15.75, n=48); Universal Design Guidelines: Programs Guide (p=0.008, n=45). **Nonsignificant change:** NISE Network website and online workshops (N=50); Monthly e-newsletter (n=49); Bilingual Design Guide (n=46)
^New resources shared with the PLC—post-survey responses only (n=49)

7. Findings: Professional Learning Community Feedback

This section is focused on the community aspects of the PLC program, along with feedback about the structure and content of the program. These data can be used to understand the impacts of the program and inform future professional development opportunities with similar goals. The evaluation questions guiding this work were:

- How does the SEISE project impact partner professionals' sense of community within the Informal Science Education and/or NISE Network community?
- How can professional development deliverables be improved to better achieve goals for professional audiences?

Direct feedback about the program is drawn from PLC members who completed the post-survey (N=74) and or participated in interviews (N=9). Questions addressed the value and usefulness of the different aspects of the program. Additionally, this section includes open-ended feedback about what worked well and what could be improved about the program.

Findings are discussed in detail in the following sections, the key takeaways are:

- Professionals agreed that the program provided opportunities for them to learn together, and they highly valued these interactive community aspects.
- PLC members found DEAI practices and making Earth and space content relevant to be the most valuable topics and resources.
- Overall, the format of the program worked well for most PLC members.
- Professionals who participated in the PLC strongly felt like they were a part of the NISE Network community.

7.1 Program overview

The PLC program included monthly online meetings, resources to support PLC members working on their individual projects, guides and other supporting materials, and a culminating virtual convening. During the online meetings, after listening to a presentation on the theme for that session, PLC members split into smaller groups where they worked together to develop and refine their project plans and discuss homework assignments. New and existing resources were shared with PLC members to support their work on making Earth & Space science relevant and inclusive for their local communities. Additional details about the design of the PLC can be found in Section 1.2.3. 1.2.3 Program activities (page 3).

7.2 Professionals agreed that the program provided opportunities for them to learn together, and they highly valued these interactive community aspects.

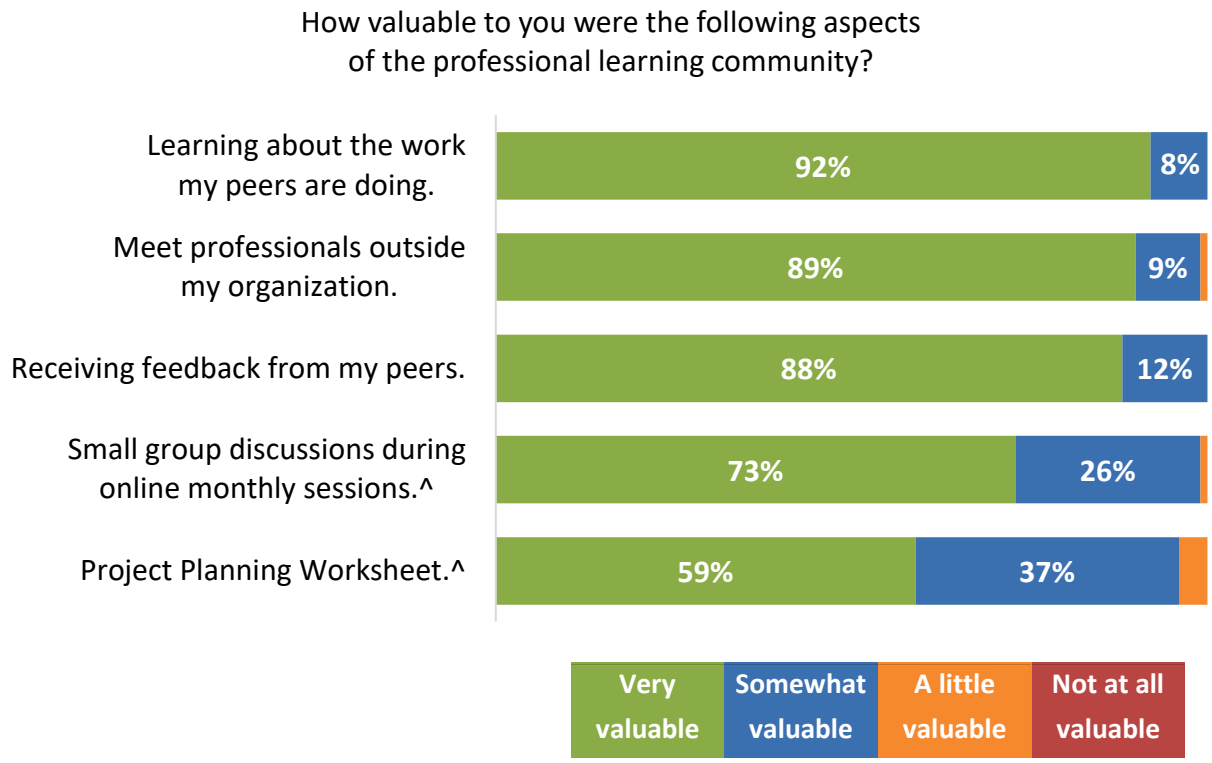
Professionals strongly agreed that the program provided opportunities to learn with others, as well as to support their work engaging audiences in Earth and space science. On the post-survey, PLC members were asked to rate their agreement on a 10-point scale from "strongly disagree" to

"strongly agree" for a series of statements related to the overall goals of the program. The statements with the strongest agreement ratings were about the PLC providing members opportunities to learn from others (97%) and to share with others how they do their work (93%), see Figure 12.

Figure 12. Professionals agreement with statements about opportunities provided in the PLC program (N=74, ^n=73)

Elements that supported community within the program were the most valuable parts of participating in the PLC for most professionals. Professionals were asked to rate how useful they found the different aspects of the program on a four-point scale, from "not at all useful" to "very useful". The top three aspects that were rated most favorably were learning about their peers' work (92%), meeting other professionals (89%), and receiving feedback from peers (88%), see Figure 13. About half of PLC members found the project planning worksheet to be very useful (59%).

Figure 13. Professionals rating of the value how valuable of different aspects of the PLC program (N=74, ^n=73)



Professionals were also asked to share what they felt was the most valuable thing about participating in the PLC through an open-ended question. The most common themes echoed responses from the close-ended question asking participants what was most useful, with the PLC members often writing in that they most valued being able to meet with, learn from, or work with peers, see Figure 13. Responses from the open-ended question are in Table 5, below, with example quotes from participants. Professionals valued connecting with peers from a variety of organizations, from both similar and different organizations (39%). They talked about these similarities and differences in terms of a variety of aspects, including location, whether local or spread out nationally, institution size, and project focus. As one professional explained, *"Connecting with peer institutions and colleagues is extremely valuable and the community provides that opportunity when we are all most in need with limited internal resources."*

Table 5. Professionals' responses to "What was the most valuable thing about participating in the Professional Learning Community?" (n=62)

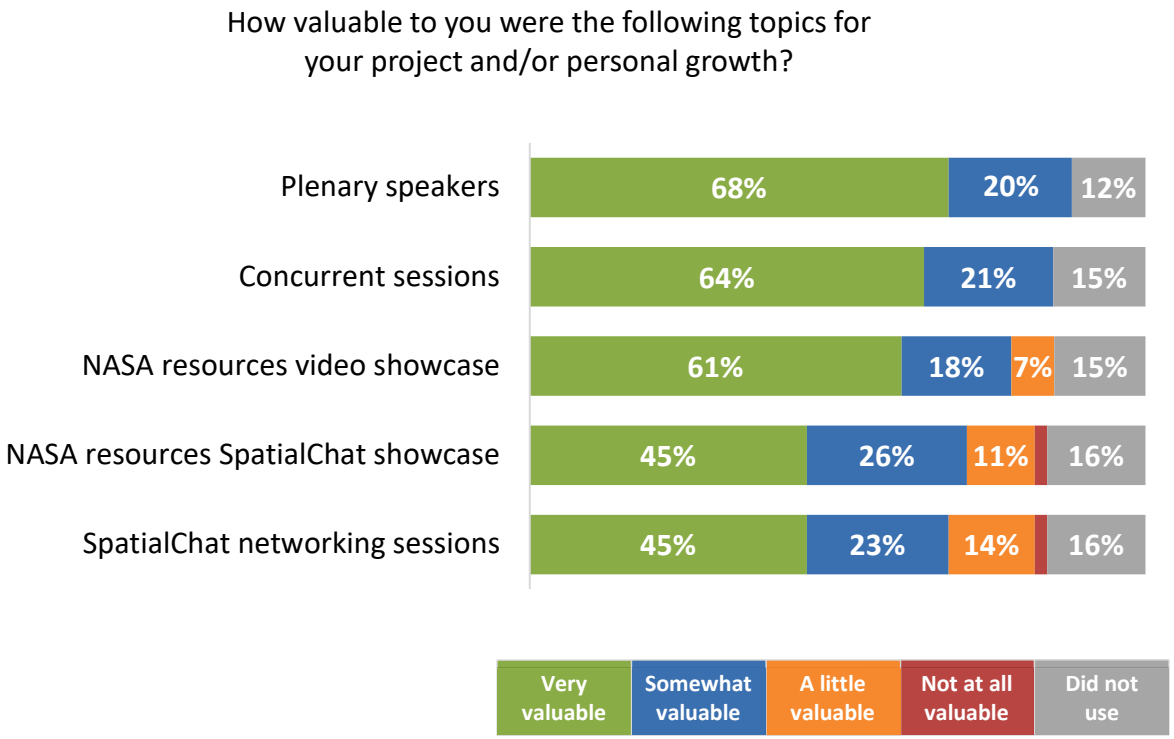
Code	Frequency	Response examples:
Connecting with peers from a variety of organizations (local, national, size, focus, etc.)	24 (39%)	*"Connecting with partners across the country working on similar projects."* *"Getting the chance to talk to other institutions (esp one similar to mine) that are doing different work."*
Learning from or refining ideas with colleagues	23 (37%)	*"The ability to communicate with peers in the field and compare ideas and projects."*
Learning about what other organizations are doing	22 (35%)	*"Seeing how they addressed similar problems to mine or even how they were meeting different community needs in a similar fashion."*
Access to resources	10 (16%)	*"All of the resources that were provided including websites, handouts, and speakers."*
Support from PLC staff	3 (5%)	*"… the encouragement the hub leaders give really makes the more challenging aspects of this profession easier. To feel seen and like you are making a difference in a bigger context has been really special."*
Resources to do the work (grant, time, etc.)	3 (5%)	*"It helped me make time to work on a project that I've wanted to do, but that I hadn't had time for."* *"It is the whole package, not one thing. The grant, the focus, the support, the connection. They all helped me professionally."*
Structured project work	2 (3%)	*"being part of a step by step process for this project was also very helpful."*
Plenary session or specific topics	2 (3%)	*"January's relevance discussion was definitely the most helpful for me. The presentation at the beginning positioned us for full and fruitful discussions in our breakout…"*

More specifically, PLC members felt that it was valuable to be able to learn from or refine ideas with their colleagues that went beyond just receiving feedback from their peers. About a third (37%, n=62) felt that it was very valuable being able to discuss and brainstorm while working with their peers (37%). As one PLC member explained, *"All of the feedback and discussion I*

think strengthened each person's project and, at least for me personally, helped to spark some ideas for the future." PLC members also valued learning about what other organizations were doing, whether that was tackling similar problems in different ways or just learning about projects that were very different (35%). Another PLC member shared that it was valuable to *"[learn] about other projects that were dissimilar to my own. This significantly helped me to identify ideas and opportunities that I would have missed due to a focus on my project's scope."* A few professionals also called attention to the value of having access to resources, such as the funding and resource guides.

While the community aspects were the most important elements of the program overall, aspects of the April Convening that most professionals found valuable to their work were the plenary speakers and concurrent sessions (Figure 14). Most participants of participants found the plenary speakers (68%) and concurrent sessions (64%) to be the very valuable aspect of the Convening (68%). During the concurrent sessions, many of the projects were able to share lessons learned from their work, which may be related to professionals' comments about learning from each other.

Figure 14. Professionals rating how valuable the different aspects of the April convening were (N=74)



7.3 PLC members found DEAI practices and making Earth and space content relevant to be the most valuable topics and resources.

Through the monthly meetings, PLC members engaged with five topic areas related to engaging audiences in Earth and space science. Overall, they found all the topics to be valuable, see Figure 15. In particular, most professionals found focusing on DEAI practices (81%) and making Earth and space content relevant (80%) to be very valuable. Overall, all the guides highlighted during monthly meetings were either somewhat or very useful to PLC members, see Figure 16. The resources that were most useful were those that supported the top-rated topics, the DEAI Booklet (68%) and Earth and Space Learning and Content Frameworks (68%).

Figure 15. Professionals rating how valuable the different topics included in the PLC program were (N=74)

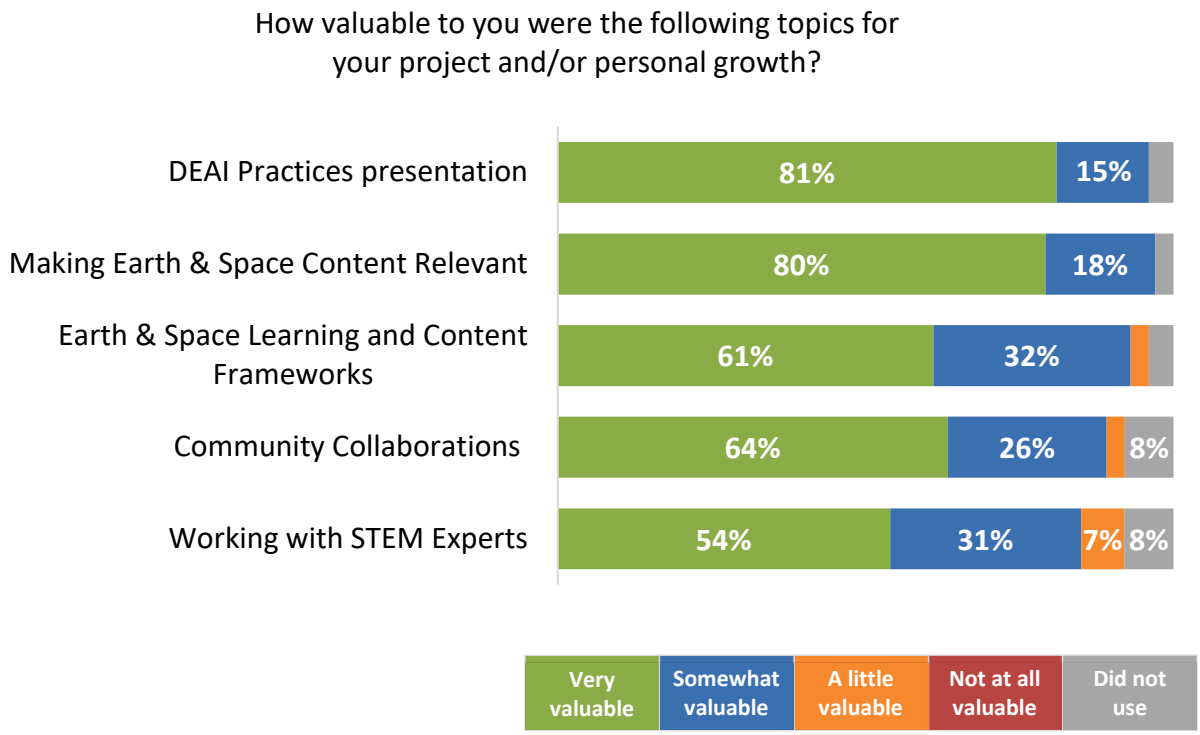
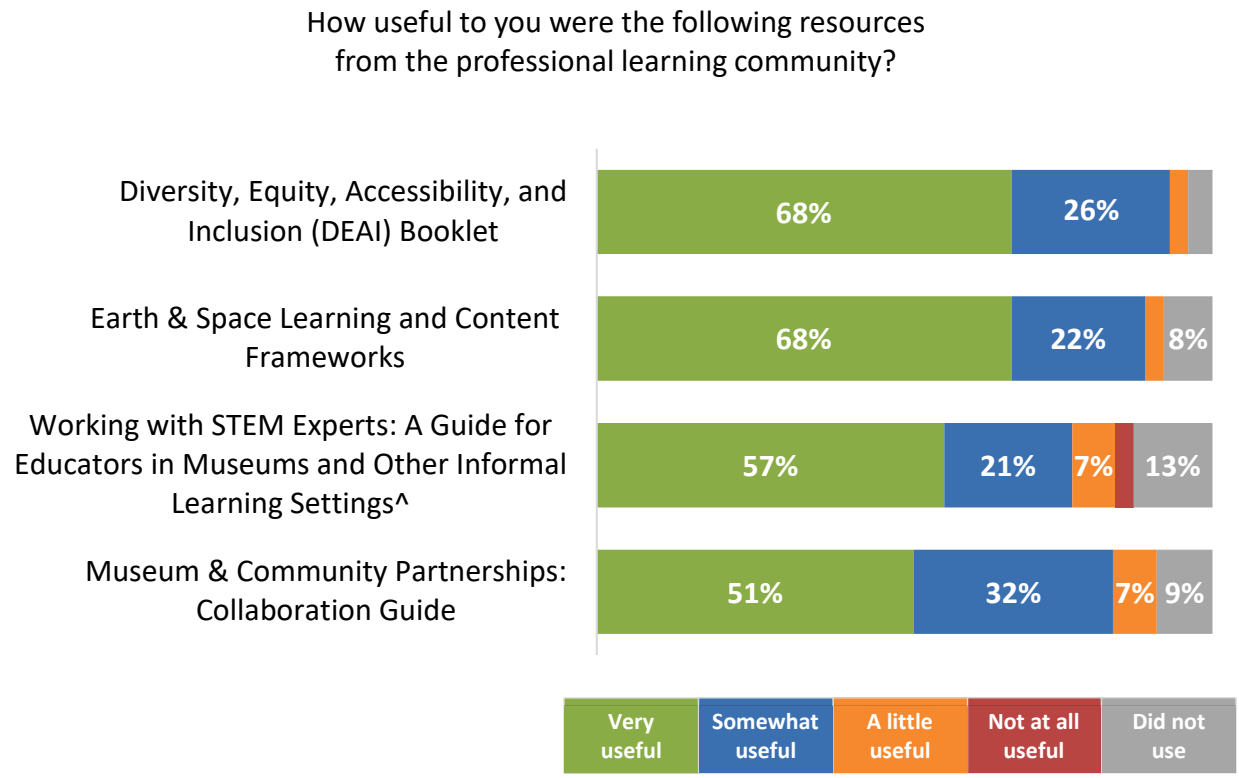


Figure 16. Professionals rating how useful the NISE Network resources were (N=74, ^n=72)



7.4 Overall, the format of the program worked well for most PLC members.

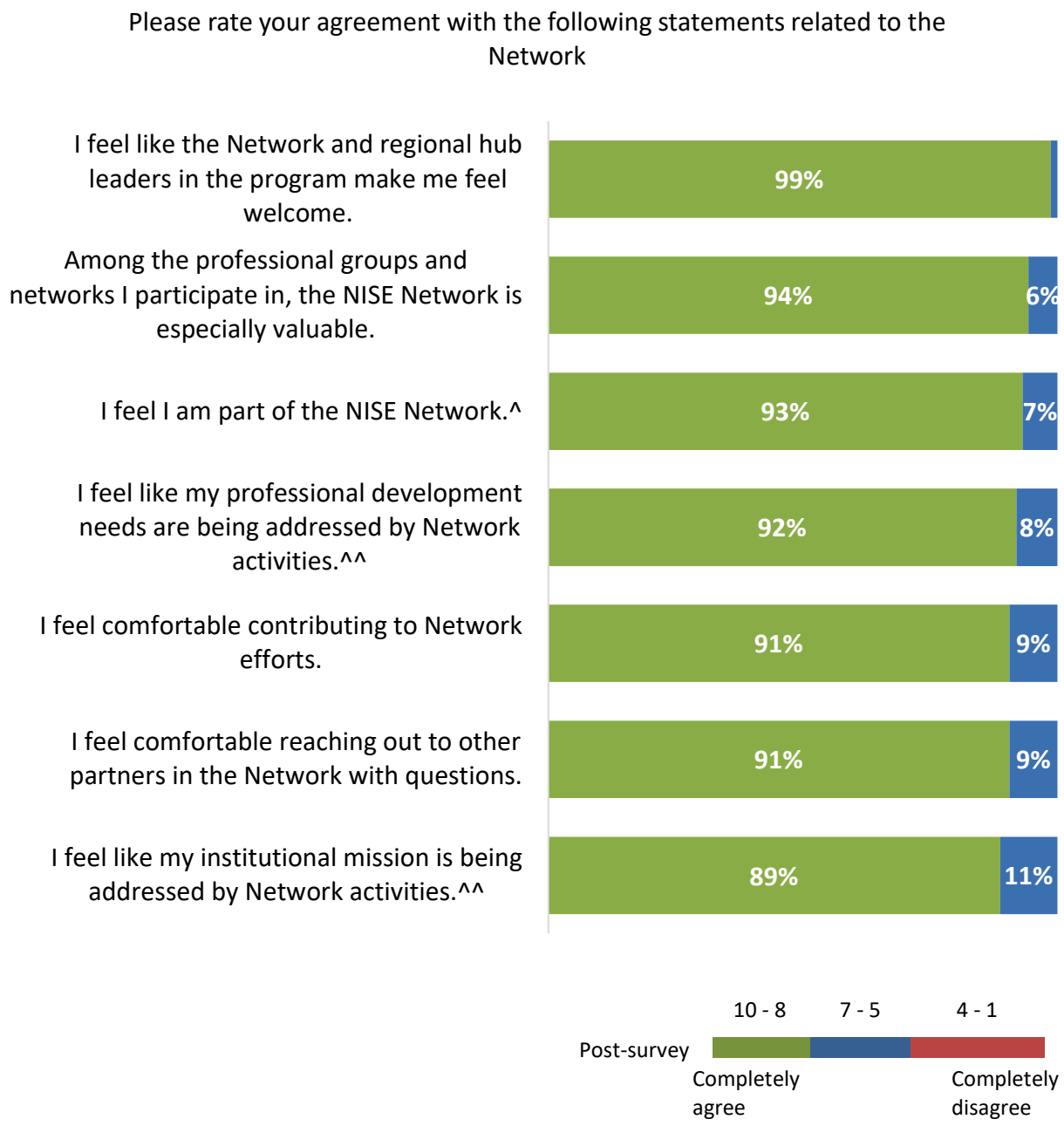
When asked what was one thing that could be improved about the program, recommendations were varied and most often proposed minor changes, suggesting that the PLC experience generally worked well for most, see Figure 17. A quarter of respondents either said that the program did not need improvement or shared praise about the experience (24%). PLC members most often shared that they wanted an opportunity to have an in-person element to the program, simultaneously recognizing and agreeing that due to COVID-19, the April Convening needed to be virtual (32%). Some professionals also gave feedback around the meeting structure, such as wanting to get away from Zoom meetings or doing more with SpatialChat (17%). Other professionals had suggestions for asynchronous communication that would replicate how they worked together in the meeting breakouts, such as having discussion boards or an open forum to interact and give each other feedback. Additional feedback involved a few PLC members indicating that they wanted to be matched with people doing more similar work; suggesting adjustments to the timeline, resources, or topics; requesting more technology help; and wanting to have an opportunity to have future in-person networking.

Figure 17. PLC member suggestions for improving the program (n=59)

7.4 Professionals who participated in the PLC strongly felt like they were a part of the NISE Network community.

Overwhelmingly, PLC members felt personally and professionally supported by the NISE Network. Professionals were asked to rate their agreement on a 10-point scale to statements about being part of the Network. These included statements about feeling like part of the NISE Network, along with asking whether the Network was addressing their professional and institutional needs. All participants rated their agreement as a 6 or higher, with the majority rating their agreement very highly, between 8 and 10, see Figure 19. Almost all PLC members strongly agreed that the Network and regional hub leaders made them feel welcome (99%).

Figure 18. Professionals' ratings for statements related to their sense of belonging and participation in the NISE Network (N=74, ^n=73, ^^n=71)



8. Conclusion

The Earth & Space Project-Based Professional Learning Community (PLC) brough together 146 informal science education professionals from 99 organizations to engage diverse audiences with Earth and space science. Through the program, PLC members worked on local projects while learning together. Overall, the evaluation demonstrated that the PLC program was able to successfully achieve its goals, by creating an experience for professionals from across different contexts and locations to learn from each other and then apply what they learned to a project at their own institution.

The summative evaluation of the PLC program addressed how participating impacted professionals' understandings of practices and resources to engage diverse audiences with Earth and space science, along with their sense of community within the NISE Network. The evaluation also asked questions about how professional development experiences could be improved to better achieve program goals. The study included data from pre- and post-surveys that all PLC members were invited to take. Additionally, a random subset of survey respondents were asked to take part in a more in-depth interview. The following summary provides an overview of the main findings from this evaluation report, and a discussion of how aspects of the SEISE project contributed to these results.

Through the program, professionals gained confidence in their abilities to engage diverse audiences in Earth and space science through the creation of a community of peers that could learn from and with each other.

After participating in the PLC, professionals were significantly more confident facilitating Earth & space content with general audiences across all content areas, with the most people indicating increases for Living with the Sun. They were initially less confident facilitating content with diverse audiences than with general audiences and indicated greater increases after participating in the PLC. While some PLC members talked about new Earth and space content or research they were introduced to, most interviewees emphasized their increased confidence was primarily due to having new ideas, whether from the presentations and resources shared by the PLC team or from other PLC members.

PLC members had multiple opportunities to engage with and learn about Earth and space content, as well as practices to support engaging audiences. The PLC program helped participants make connections to existing practices and resources through the monthly meetings, April Convening, and accompanying materials. These connections to practices and resources helped the participants develop their confidence for engaging diverse audiences, as they discussed how to put them in practice with their peers and integrated the practices with their projects.

After the PLC, professionals were significantly more confident identifying both NISE Network and NASA-related products to engage audiences in Earth and space science. They also indicated that they are making greater use of NISE Network resources that support using *Explore Science*

Earth & Space toolkits and engaging audiences. Through the PLC, professionals were introduced to (or reminded of) a variety of NISE Network and NASA resources, often accompanied by discussions of how to use these products to support their work with public audiences. Learning about content and resources, paired with real examples of how people or organizations had used them, appeared to be a driver for confidence in engaging diverse audiences in Earth and space science.

Professionals were able to explore and implement partnership-related practices by workshopping ideas with other PLC members while working on their individual projects.

Practices to engage diverse audiences with Earth and space science were a central theme of the PLC offerings, with a focus on DEAI- and partnership-related practices. Professionals were significantly more confident using DEAI practices to engage audiences in Earth and space science after participating in the PLC. They were also significantly more confident practices related to collaborating with other organizations, across different types of partners. Beyond broadly supporting PLC members' partnership-related practices, professionals indicated that the program impact their project-based partnerships. Ultimately, these impacts were nuanced and generally reflected opportunities to explore and implement the practice through their projects. PLC members identified multiple ways that program impacted their partnerships, such as learning and working with peers along with having dedicated time to focus on a project. Changes in the intensity of partnerships primarily were attributed to professionals generally gaining a better understanding of their partners.

Having funding and dedicated time to work on a project and strengthen or refine their professional practices was a valued aspect of the program. PLC members indirectly referenced these resources, talking about what they were able to do with the dedicated time and money provided by the project. In particular, the structured approach of the monthly meetings helped maintain momentum on the projects. The projects also catalyzed work that professionals indicated a desire to do but would often be set aside for other priorities. Additionally, peer-to-peer learning was fostered from having a project-based approach, where participants could discuss concrete examples and work through challenges together.

The SEISE project built on previous work of the NISE Network to foster a stronger community of professionals to reinforce what they learned through participating in the PLC.

The SEISE project has continued to build on the work of the NISE Network, leveraging organizations within a broad network of informal science education professionals to engage audiences in Earth and space science. These efforts were bolstered by the numerous public-facing materials and professional development resources created by the Network over the years.

The NISE Network produced four *Explore Science: Earth & Space* toolkits in the first five years of the SEISE project, which many PLC members integrated into the PLC projects. The toolkit activities can be helpful for professionals discussing different approaches for engaging diverse audiences, as many were already familiar with the activities, and everyone had full access to the

digital versions. The Network had also created a wide variety of materials to support professionals, including guides, templates, and curated resource lists. The breadth of what was offered means that sometimes professionals might not be familiar with all of the materials, however the PLC program provided an opportunity for professionals to be introduced to or reminded of what is available.

Beyond being able to draw attention to public and professional resources created by the Network, the opportunity to gather and workshop ideas with peers was core to what the PLC experience. The NISE Network has previously used peer-to-peer learning, ranging from individual online webinars to longer sustained professional cohorts such as the Sustainability and ChemAttitudes cohorts (Kollman & Weitzman, 2021). The cohort model was used in the PLC to build a community for professionals who are comfortable reaching out to each other, while working on local projects with a shared goal to engage audiences. Connecting with peers helped professionals to think about how work was being done by others, bringing up new ideas and approaches to working with a variety of audiences. Participants frequently reiterated that learning from their peers across the country, from either similar or different organizations and contexts, was valuable for refining their individual projects and sparking ideas for the future. Through the evaluation, professionals clearly expressed that these opportunities were valuable for their work in engaging audiences.

Final Thoughts

The PLC provided a space for professionals to work together and learn from each other through a shared goal and purpose. Virtual face time supported a feeling of connection and community between professionals. PLC members frequently reflected on the many ways that they were able to learn from colleagues, whether through the recognition of mutual challenges or simply learning about what others were doing. Additionally, having dedicated time to learn about resources and an actual project to work on provided professionals with the momentum to apply what they were learning about DEAI practices or Earth and space content to their work. Overall, the PLC was successful in increasing professionals' understanding and use of practices and products related to engaging audiences in Earth and space science.

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McCarthy, C. and Herring, B. (2015). Collaboration guide for museums working with community youth-serving organizations. www.nisenet.org/collaboration-guide

Patton, M. Q. (2002). *Qualitative research and evaluation methods*. Thousand Oaks, CA: Sage Publications, Inc.

Appendix A: PLC Organization Description

PLC members came from a variety of institution types, in terms of the environment they are working as well as their annual attendance and visitation While this is useful context for understanding that survey respondents were working on their projects within various contexts and constraints, these data were not used to analyze survey responses. Therefore, this appendix details the data summarized in Section 2.1.3.

Figure A1. Setting for PLC member organizations (Paired, N=50)

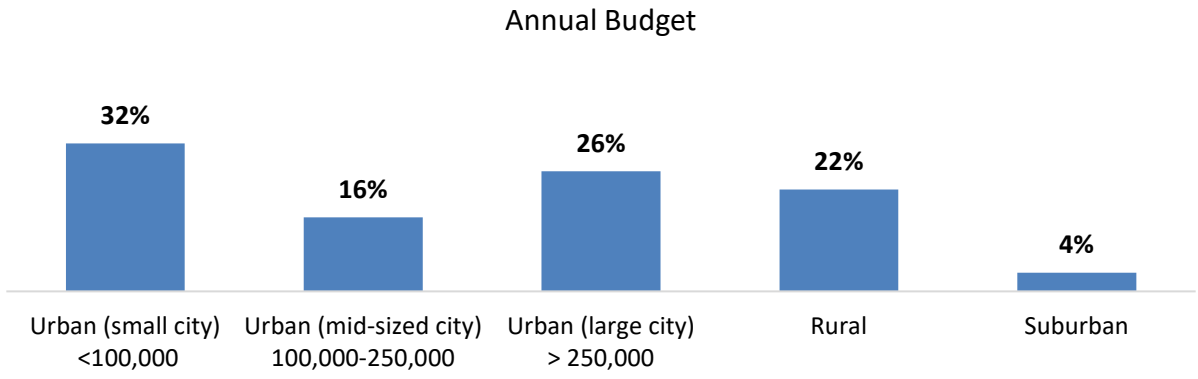


Figure A2. Annual attendance for PLC member organizations (Paired, N=50)

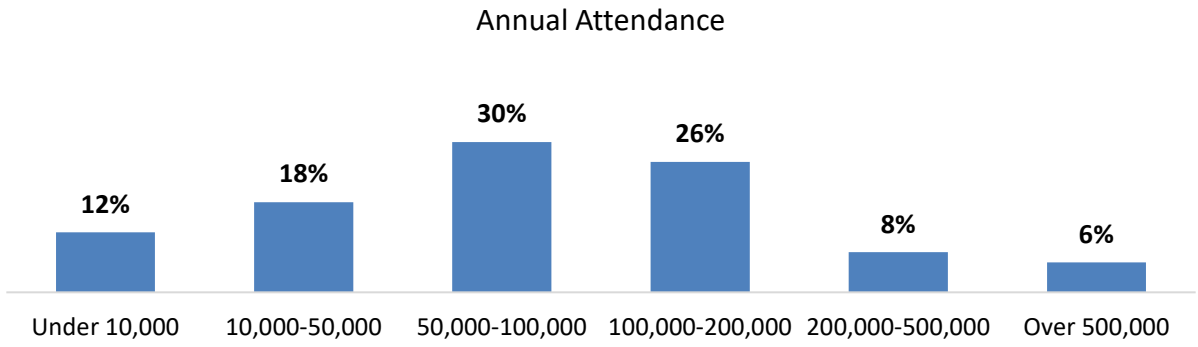
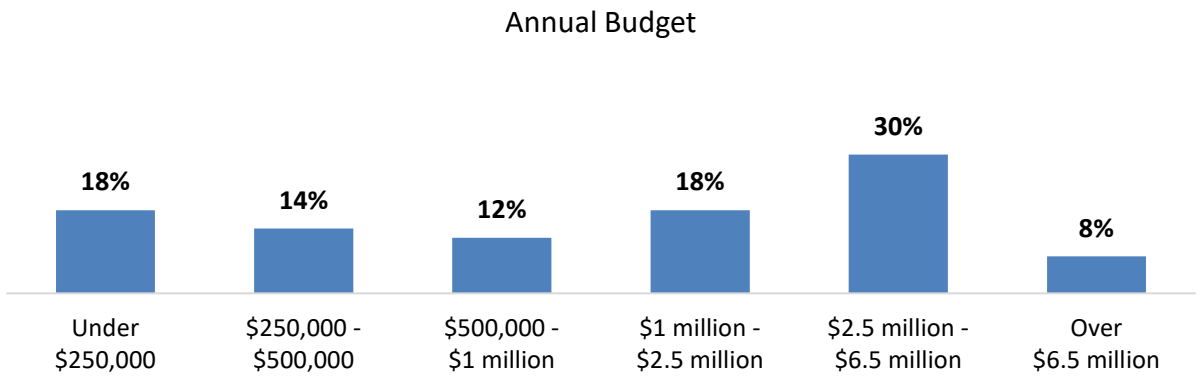
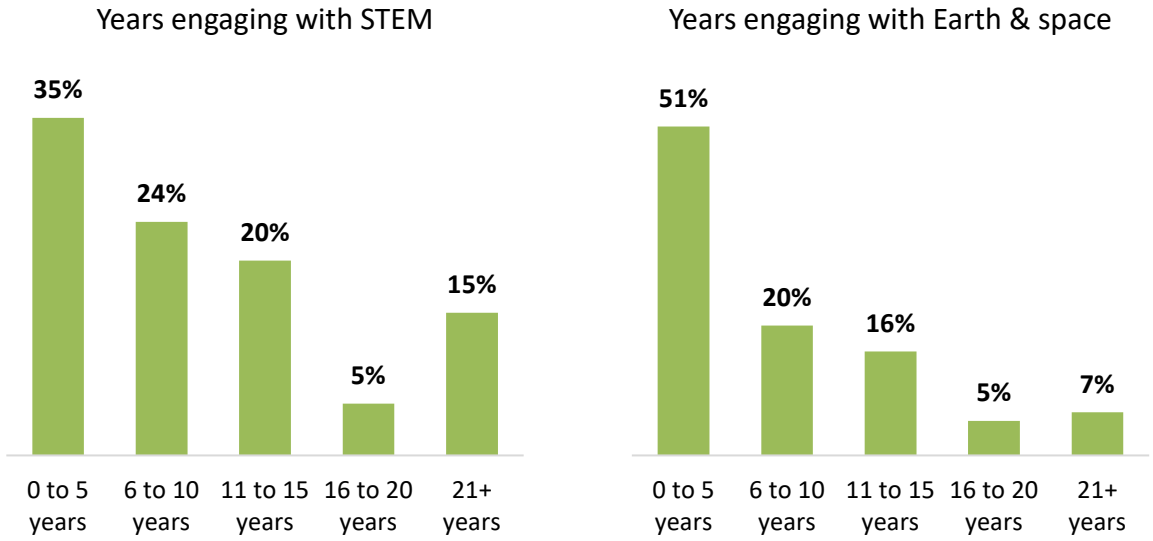


Figure A3. Annual budget for PLC member organizations (Paired, N=50)



The paired and post-only samples were similar distributed in terms of their

Figure A4. PLC member's experience engaging audiences with STEM or Earth & space content. (Post-only, N=74)



Appendix B: Instruments

The PLC summative evaluation included three instruments, a pre-survey, a post-survey, and interview. The two surveys have been merged, as most questions were asked the same way on both, with notations for questions that only appeared on one survey. They surveys were administered online and took approximately 15-20 minutes to complete. The interviews were conducted over zoom and took approximately one hour.

Pre/Post Survey

1) **How many years of experience do you personally have engaging public audiences in learning about STEM in informal education settings? This includes developing content.**
   [Question shown on post-survey if respondent had not completed the pre-survey]

   - 0 to 5 years
   - 6 to 10 years
   - 11 to 15 years
   - 16 to 20 years
   - 21+ years

2) **How many years of experience do you personally have engaging public audiences in learning about Earth & space science in informal education settings? This includes developing content.**
   [Question shown on post-survey if respondent had not completed the pre-survey]

   - 0 to 5 years
   - 6 to 10 years
   - 11 to 15 years
   - 16 to 20 years
   - 21+ years

3) For each Earth and space content area below, please rate your level of agreement or disagreement with the statement: "I feel confident in my ability to plan or facilitate learning experiences with the general public in informal education settings about..."

	Completely disagree (1) to Completely agree (10)									
Living with the Sun	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
The changing Earth	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Our solar system and planets around other stars	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Galaxies and beyond	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Forces and energy of the universe	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Connections between Earth and space research and our society	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

4) [Post-survey] **How much has participating in the Professional Learning Community impacted your confidence in planning or facilitating learning experiences with the general public in informal education settings about..."**

	Not at all (1) to A great deal (10)									
Living with the Sun	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
The changing Earth	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Our solar system and planets around other stars	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Galaxies and beyond	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Forces and energy of the universe	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Connections between Earth and space research and our society	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

5) For each Earth and space content area below, please rate your level of agreement or disagreement with the statement: "I feel confident in my ability to plan or facilitate relevant experiences with diverse audiences[10] in informal education settings about..."

	Completely disagree (1) to Completely agree (10)									
Living with the Sun	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
The changing Earth	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Our solar system and planets around other stars	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Galaxies and beyond	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Forces and energy of the universe	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Connections between Earth and space research and our society	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

[10] The phrase "diverse audiences" was clarified using rollover text:

NASA considers the following groups to be underrepresented in Earth and space science: "Black, Latino, and Indigenous and Native American persons, Asian Americans and Pacific Islanders and other persons of color; members of religious minorities; lesbian, gay, bisexual, transgender, and queer (LGBTQ+) persons; persons with disabilities; persons who live in rural areas; and persons otherwise adversely affected by persistent poverty or inequality."

6) [Post-survey] **How much has participating in the Professional Learning Community impacted your confidence in planning or facilitating learning experiences with diverse audiences in informal education settings about..."**

	Not at all (1) to A great deal (10)									
Living with the Sun	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
The changing Earth	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Our solar system and planets around other stars	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Galaxies and beyond	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Forces and energy of the universe	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Connections between Earth and space research and our society	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

7) As part of my Earth and space science education efforts, I feel confident in my ability to...*

	Completely disagree (1) to Completely agree (10)									
Identify NISE Network products to enhance public engagement with Earth and space science.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Identify NASA-related products to enhance public engagement with Earth and space science.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Make Earth and space science relevant to and inclusive of diverse learners.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Incorporate diversity, equity, access, and inclusion principles, practices, and resources in programmatic offerings.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

8) [Post-survey] **How much has participating in the Professional Learning Community impacted your confidence in…**

	Not at all (1) to A great deal (10)									
Identifying NISE Network products to enhance public engagement with Earth and space science.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Identifying NASA-related products to enhance public engagement with Earth and space science.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Making Earth and space science relevant to and inclusive of diverse learners.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Incorporating diversity, equity, access, and inclusion principles, practices, and resources in programmatic offerings.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

9) As part of my Earth and space science education efforts, I feel confident in my ability to partner or collaborate with…*

	Completely disagree (1) to Completely agree (10)									
Community or informal learning organizations.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Experts related to Earth and space science including scientist researchers, outreach professionals, and/or students.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Earth and space science volunteers, including NASA Solar System Ambassadors, or amateur astronomy club members.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

10) [Post-survey] **How much has participating in the Professional Learning Community impacted your confidence to partner or collaborate with…**

	Not at all (1) to A great deal (10)									
Community or informal learning organizations.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Experts related to Earth and space science including scientist researchers, outreach professionals, and/or students.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Earth and space science volunteers, including NASA Solar System Ambassadors, or amateur astronomy club members.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

11) Partnerships can be thought about or organized as a continuum of possibilities, ranging from informal networking (low intensity) to collaboration (high intensity). The intensity of a partnership and interdependence of a relationship between two organizations will typically vary over time and with different projects.

Thinking about your primary partner(s) for your project in the NISE Net Earth & Space Professional Learning Community, please use the slider bar to indicate where your partnership best fits on each continuum below.

Left Anchor	1 to 10 slider bar	Right Anchor
My organization is aware of our partner.	- - - - - - - - - -	My organization has shared vision, goals and resources with our partner.
My organization has a loose connection and has yet to build trust and commitment with our partner.	- - - - - - - - - -	My organization has a high level of commitment and trust with our partner.
Roles between my organization and our partner are informal and not defined.	- - - - - - - - - -	The timelines, responsibilities, and roles between my organization and our partner are formalized.
My organization and our partner rarely communicate.	- - - - - - - - - -	My organization and our partner frequently communicate with each other.
My organization and our partner make decisions independently.	- - - - - - - - - -	My organization and our partner share decision-making about our mutual work.

12) [Post-survey] **How, if at all, has participating in the Professional Learning Community impacted your work related to your local or community partners?**

13) Have you personally used any of these NISE Network resources?

	No	Yes	I don't know
NISE Network monthly e-newsletter	( )	( )	( )
NISE Network's one-hour online workshops	( )	( )	( )
NISE Network website	( )	( )	( )
Explore Science: Earth & Space training videos	( )	( )	( )
Explore Science: Earth & Space toolkit	( )	( )	( )
NISE Network Universal Design Guidelines: Programs guide	( )	( )	( )
NISE Network Museum & Community Partnership: Collaboration Guide	( )	( )	( )
NISE Network Bilingual Design Guide	( )	( )	( )

14)Are you aware of the following NISE Network resources?

[Each item displayed if "No" or "I don't know" selected in Q13]

	No	Yes
NISE Network monthly e-newsletter	( )	( )
NISE Network's one-hour online workshops	( )	( )
NISE Network website	( )	( )
Explore Science: Earth & Space training videos	( )	( )
Explore Science: Earth & Space toolkit	( )	( )
NISE Network Universal Design Guidelines: Programs guide	( )	( )
NISE Network Museum & Community Partnership: Collaboration Guide	( )	( )
NISE Network Bilingual Design Guide	( )	( )

15) Do you personally use any of these NASA resources for Earth and space science content? You may write in any resources you use that are not listed here.

	No	Yes
NASA newsletters	( )	( )
NASA's Eyes (e.g. Eyes on the Earth, Eyes on the Solar System, Eyes on Exoplanets, etc., Error! Hyperlink reference not valid.**)**	( )	( )
NASA Museum & Informal Education Alliance (informal.jpl.nasa.gov/museum)	( )	( )
ViewSpace (viewspace.org)	( )	( )
Night Sky Network of astronomy clubs (nightsky.jpl.nasa.gov)	( )	( )
Solar System Ambassadors (solarsystem.nasa.gov/solar-system-ambassadors)	( )	( )
GLOBE Observer (observer.globe.gov)	( )	( )
NASA Space Place (spaceplace.nasa.gov)	( )	( )
NASA.gov websites (e.g. science.nasa.gov, jpl.nasa.gov, nasa.gov/multimedia/imagegallery, etc.)	( )	( )

16) [Post-survey] **Participating in the Professional Learning Community gave me the opportunity to…**

	Completely disagree (1) to Completely agree (10) or N/A										
Learn from professionals outside my organization.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Share with other professionals how I engage the public in Earth and space science.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Make meaningful progress on my local project.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Foster local partnerships to engage the public in Earth and space science.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Develop strategies to engage diverse audiences	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

17) [Post-survey] **How useful were the following resources from the Professional Learning Community were to you:**

	Not at all useful	**A little useful**	**Somewhat useful**	**Very useful**
Earth & Space Learning and Content Frameworks	( )	( )	( )	( )
Museum & Community Partnerships: Collaboration Guide	( )	( )	( )	( )
Working with STEM Experts: A Guide for Educators in Museums and Other Informal Learning Settings	( )	( )	( )	( )
Inclusion Resources – DEAI Tools	( )	( )	( )	( )
Other: Write In	( )	( )	( )	( )

18) [Post-survey] **How valuable to you were the following aspects of the Professional learning community?**

	Not at all valuable	A little valuable	Somewhat valuable	Very valuable
Meet professionals outside my organization.	( )	( )	( )	( )
Receiving feedback from my peers	( )	( )	( )	( )
Learning about the work my peers are doing	( )	( )	( )	( )
Small group discussions during online monthly sessions	( )	( )	( )	( )
Project Planning Worksheet	( )	( )	( )	( )
Other: Write In	( )	( )	( )	( )

19)[Post-survey] **How valuable were the following topics for your project and/or professional growth?**

	Not at all valuable	A little valuable	Somewhat valuable	Very valuable
DEAI Practices presentation (December)	( )	( )	( )	( )
Making Earth & Space Content Relevant (January)	( )	( )	( )	( )
Earth & Space Learning and Content Frameworks (January)	( )	( )	( )	( )
Community Collaborations (February)	( )	( )	( )	( )
Working with STEM Experts (February)	( )	( )	( )	( )

20) [Post-survey] **How valuable to you were the following components of the April Convening?**

	Not at all valuable	A little valuable	Somewhat valuable	Very valuable
Plenary speakers	( )	( )	( )	( )
Concurrent sessions	( )	( )	( )	( )
NASA resources video showcase	( )	( )	( )	( )
NASA resources SpatialChat showcase	( )	( )	( )	( )
SpatialChat networking sessions	( )	( )	( )	( )
Other: Write In	( )	( )	( )	( )

21) [Post-survey] **Please rate your agreement with the following statements related to the Network.**

	Completely disagree (1) to Completely agree (10) or N/A										
I feel I am part of the NISE Network.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I feel comfortable contributing to Network efforts.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I feel comfortable reaching out to other partners in the Network with questions.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I feel like the Network and regional hub leaders in the program make me feel welcome.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I feel like my professional development needs are being addressed by Network activities.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
I feel like my institutional mission is being addressed by Network activities.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Among the professional groups and networks I participate in, the NISE Network is especially valuable.	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

22) [Post-survey] **What was the most valuable thing about participating in the Professional Learning Community?**

23) [Post-survey] **What is one thing that could be improved about the Professional Learning Community experience?**

Interview

KEY: Green and/or **bold** = PLC classroom data / survey data; Blue = Section intro, Red = other notes

Interview Questions:

[1:35] To start, we want to know a little about you and your project as part of the NISE Network Earth & Space Professional Learning Community, to help us understand your survey and interview responses better.

1. Please introduce yourself, including your role at your institution and anything else you'd like to share with us:

2. Please briefly describe your project for the PLC, or give us the "elevator pitch":
    a. What were/are your main goals?
    b. What audience(s) were you trying to reach?

3. *How, if at all, did you change or modify your project due to participating in the PLC?
    a. What contributed to these changes?

[1:45] Thanks! Next we want to talk about Earth and space content, which we have grouped into these 6 content areas:

- Living with the Sun
- The changing Earth
- Our solar system and planets around other stars
- Galaxies and beyond
- Forces and energy of the universe
- Connections between Earth and space research and our society

We will be referencing some of your survey responses, since we want to know more about why your confidence in an area may or may not have changed. We know that projects and institutions may focus on some or all of these topics, and that every topic may not be directly relevant to your work.

4. *On your survey, you indicated that you were **[more/less] confident** [X pre / X post out of 10] engaging general audiences in **[1-3 areas].** How, if at all, did participating in the PLC affect your confidence engaging general audiences that content area?
    a. Which presentations, resources, or other experiences in the PLC contributed to your confidence?

5. *On your survey, you indicated that you were **[more/less] confident** [X pre / X post out of 10] engaging general audiences in **[1-3 areas].** How, if at all, did participating in the PLC affect your confidence engaging diverse audiences in that content area?
    a. Which presentations, resources, or other experiences in the PLC contributed to your confidence?

6. Did you learn anything new about any of the other topic areas from participating in the PLC?
    a. [If yes] Which presentations, resources, or other experiences in the PLC did you learn new content from?

7. [If survey responses are notably different between general and diverse audiences]
   On your survey, you indicated that you had a larger increase in confidence with diverse audiences than you did with general audiences. What do you think contributed to that difference?

Next we want to talk about some general practices related to using available resources and efforts around diversity and inclusion.

8. On the survey, you indicated that you were **[more/same/less]** in identifying NISE Network [X pre / X post] or NASA-related products [X pre / X post] to enhance public engagement with Earth and space science. What, if anything, from your participation in the PLC has affected your confidence?
    a. Which presentations, resources, or other experiences in the PLC contributed to your confidence?

9. **Has anything changed since starting the PLC regarding your use of NASA resources or connections with NASA partners?
    a. [If yes] How, if at all, did participating in the PLC affect your use of those resources?

10. On the survey, you indicated that you were **[more/same /less]** confident in your ability to make Earth and space science relevant to and inclusive of diverse learners [X pre / X post] or incorporate DEAI principles, practices, and resources [X pre / X post]. What, if anything, from your participation in the PLC has affected your confidence?
    a. Which presentations, resources, or other experiences in the PLC contributed to your confidence?
    b. How, if at all, has what you have learned from the PLC helped you better engage visitors or support your project's work?

11. **How, if at all, have you used any of the NISE Network resources related to engaging diverse audiences in your work?

a. Which resources or learnings have you used?

Now we want to focus on partnership-related practices. This includes collaborating with different types of partners, such as:

- Community or informal learning organizations.
- Experts related to Earth and space science including scientist researchers, outreach professionals, and/or students.
- Earth and space science volunteers, including NASA Solar System Ambassadors, or amateur astronomy club members.

Partnerships can be thought about or organized as a continuum of possibilities, ranging from informal networking (low intensity) to collaboration (high intensity)

12. *On the survey, you indicated that you were **[more/less]** confident in partnering with **[1 partner type]**. What, if anything, from your participation in the PLC has affected your confidence?
    a. How, if at all, has your increased knowledge of working with **[partner type]** helped you better engage visitors or support your project's work?
    b. Did any specific PLC resources or experiences contribute to your confidence? If yes, which ones?

13. **Do your current or recent partnerships look any different after participating in the PLC from what you had done previously?
    c. How, if at all, did your participation in the PLC impact this partnership?
    d. How, if at all, have you used any NISE Net materials as part of this work? (i.e., products and/or partnership PD materials)

On the survey we asked you to describe your partnership for a few factors, ranging from informal networking to collaboration. I'm going to quickly share a slide with you that shows your response at the beginning and end of the program.

14. **[Pick 1-2 notable areas of change or describe the data].** What do you think contributed to that change?
    e. How, if at all, did your participation in the PLC impact this partnership?
    f. For the other areas, do you have any thoughts about why those might have changed or stayed the same?

Next, we want to talk broadly about your experience as part of the PLC

15. *What did you find most valuable about participating in the PLC for your work? Why?
    a. [Probe on **one** of the areas below, if they are not specific in their initial response]
        i. Resources (e.g. Learning & Content Frameworks, Collaboration Guide, Working with STEM Expert Guide, DEAI Guide)
        ii. PLC Aspects (e.g., Meeting professionals, Peer Feedback, Learning what peers' work, Small group discussions, Planning worksheet)
        iii. Presentation Topics (DEAI practices, Making E&S relevant, Learning & Content frameworks, Collaborations, Working with STEM Experts)
        iv. April Convening (Plenary, Concurrent sessions, NASA video showcase, SpatialChat showcase, Networking)

16. **How, if at all, will participating in the PLC experience influence your work going forward?
    a. Which practices or resources are you using or planning to use in your work?
    b. Which practices or resources you sharing or planning to share with your colleagues/staff?

17. **Looking forward, what connections or collaborations (individual or at the institution level) that were formed through your participation in the SEISE project do you plan to continue?
    a. This could be with PLC colleagues, local partners, SMEs, etc.

18. *In what ways do you feel connected with the NISE network and informal science education community?
    c. How has this been impacted by your participation with the PLC or the NISE Network Earth & Space project?
    d. What aspects of your experience with the PLC or NISE Network Earth & Space project contribute most to how connected you feel with the NISE Network and ISE community?

19. Anything else you'd like to share with us?